ESL Europe – Product Catalogue

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Capacitor Materials

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Capacitor dielectric X7R. Constants between 20 and 300.

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9516
Platinum/Silver conductive electrode material for use with 4150 series and 4200-C series of dielectrics.

9916
Silver conductive electrode material for use with 4150 series and 4200-C series of dielectrics.

ESL ELECTROSCIENCE
CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CAPACITOR DIELECTRIC 4100 Series

Capacitor Dielectric Pastes with Dielectric Constants Between 20 and 300

ESL 4100 Series is a group of thick film dielectrics developed for firing at 930°C to 980°C and exhibits the excellent properties as shown below. The hermetic nature of this capacitor dielectric series provides excellent performance on moisture testing. Laser trimming of capacitors made with these pastes can be performed for adjustment of value, with subsequent overglazing. Chip capacitors, capacitor arrays, delay lines, RC networks, etc., of superior quality can be made at significant cost saving over discreet monolithic chip capacitors. These materials meet the characteristics of X7R.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	4113	250 ± 50 Pa.s
	4113-H	250 ± 50 Pa.s
	4114	250 ± 50 Pa.s
	4115	250 ± 50 Pa.s
	4117	350 ± 50 Pa.s
Colour:		Yellow - Green
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325, 37.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		930 - 980°C (in air)
	Optimum:	980°C
	Time at peak:	10 - 15 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

	4113	4113-H	4114	4115	4117
Fired Thickness: (µm)	38 - 50	38 - 50	38 - 50	38 - 50	38 - 50
Dielectric Constant: (1 kHz, 25°C), K	90 -130	120 - 160	40 - 60	15 - 25	270 - 330
Dissipation Factor: (1 kHz, 25°C), %	≤ 0.50	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.50
Insulation Resistance: (100 V DC), Ω	≥ 10^{10}	≥ 10^{10}	≥ 10^{10}	≥ 10^{10}	≥ 10^{10}
Breakdown Voltage: (25°C in air), V/25 µm	≥ 300	≥ 300	≥ 600	≥ 1000	≥ 500
Finish:	Matte	Matte	Matte	Matte	Matte
ESL Conductor:	9635-B	9638	9635-B	9635-B	9638

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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HIGH K CAPACITOR DIELECTRICS 4150 Series

Low Temperature Capacitor Dielectric Pastes with Dielectric Constants Between 300 and 2400

ESL 4150 Series low firing temperature capacitor pastes are blendable to cover the range of dielectric constants from 300 to 2400 with X7S or X7T temperature characteristics and dissipation factors below 2%. The capacitors are compatible with low cost, all silver conductors such as ESL 9916. Optimum properties are achieved when the capacitors are overglazed to provide hermeticity.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	4151	260 ± 30 Pa.s
	4152	240 ± 30 Pa.s
	4153	220 ± 30 Pa.s
Colour:		Yellow - Tan
Shelf Life (4 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 mesh, 37.5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C (in air)
	Optimum:	900°C
	Time at peak:	10 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401
Screen Cleaner:		acetone, isopropanol, polar organic solvents

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

(Properties based on capacitors of 1mm x 1mm electrode area)

	4151	4152	4153
Fired Thickness: (µm)	40 - 55	40 - 55	40 - 55
Dielectric Constant: (1 kHz, 25°C), K	300 ± 10%	1,000 ± 10%	2,400 ± 10%
EIA Designation:	X7S	X7S	X7T
Dissipation Factor: (1 kHz, 25°C), %	≤ 2.0	≤ 2.0	≤ 2.0
Insulation Resistance: (100 V DC), Ω	≥ 10^9	≥ 10^9	≥ 10^9
Breakdown Voltage: (25°C in air), V/25 µm	≥ 200	≥ 200	≥ 200
Recommend Conductors:	ESL 9916, 9516		
Overglaze: (2 layers separately fired)	Acid plating resistant G-481 (green) or G-482 (black), fired at 600°C		
∆C: (G-481 overglaze)	≤ -5%	≤ -5%	≤ -5%

Note:

X7S: C Range = ±22%, -55°C to +125°C

X7T: C Range = +22%, -33%, -55°C to +125°C

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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HIGH K CAPACITOR DIELECTRICS 4160 Series

Lead-Free Low Temperature Capacitor Dielectric Pastes for Burying in LTCC Tape with Dielectric Constants between 50 and 250

ESL 4160 Series low firing temperature capacitor pastes are designed to be used for capacitors buried in LTCC tape. The range of dielectric constant achievable depends on the firing schedule and host tape but is approximately 50 - 250. The dissipation factors are about 1- 3% and exhibit X7R temperature characteristics.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	4162	250 ± 50 Pa.s
	4163	250 ± 50 Pa.s
	4164	250 ± 50 Pa.s
Colour:		Yellow - Tan
Shelf Life (4 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 mesh, 37.5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 900°C (in air)
	Optimum:	875°C (Determined by LTCC tape)
	Time at peak:	10 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401
Screen Cleaner:		acetone, isopropanol, polar organic solvents

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

(Properties based on capacitors of 1mm x 1mm electrode area)

	4162	4163	4164
Fired Thickness: (µm)	35 - 50	40 - 55	40 - 55
Dielectric Constant (K) at 1 kHz: (Fired at 875°C, 9916 conductor, at 25°C)	50 ± 50%	100 ± 50%	250 ± 50%
EIA Designation:	X7R	X7R	X7R
Dissipation Factor: (1 kHz, 25°C), %	≤ 1.0	≤ 2.0	≤ 3.0
Breakdown Voltage: (25°C in air), V/25 µm	≥ 200	≥ 200	≥ 200
Recommend Conductors:		ESL 9916	

Note: **X7R:** T.C.C Range = ±15%, -55°C to +125°C

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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HIGH K CAPACITOR DIELECTRICS 4200-C Series

Low Temperature Firing Capacitors with K Values Ranging From 2,000 To 12,000

ESL 4200-C Series is a blendable series of low-temperature firing, screen-printable, high capacitance density pastes that provide dielectric constants in the range of 2,000 to 12,000. These materials are compatible with a wide range of ESL conductors, but best results are obtained when the dielectrics are terminated with specially developed silver or gold based conductors (see recommended conductors on second page). Optimum properties are achieved when the capacitors are overglazed to provide hermeticity.

PASTE DATA:

Rheology:	Thixotropic, screen-printable pastes
Viscosity: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5 ± 0.5 °C)	210 ± 30 Pa.s
Colour:	yellow-tan
Shelf Life: (at 4°C)	6 months

PROCESSING

Screen Mesh/Emulsion:	200 / 37.5 µm
Leveling Time:	10-15 minutes
Drying at 125°C:	10-15 minutes
Firing Temperature Range:	850°C-930°C
Optimum:	900°C
Time at Peak:	10 minutes
Total Firing Cycle:	60 minutes
Substrate for Calibration:	96% alumina
Thinner:	ESL 401
Screen Cleaner:	acetone, isopropanol, and polar organic solvents

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

(Properties based on measurements of 1 mm x 1 mm test capacitors.)

Fired Thickness:	**4202-C**	**4212-C**
	40 - 55 µm	35 - 50 µm

Dielectric Constant (k) at 1kHz:
(Fired at 900°C, 9516 conductor, measured at 25°C)

	Nominal Value	**Capacitance Density**
4202-C	2,000±300	500 pf/mm^2
4212-C	12,000±1500	3,200 pf/mm^2

Dissipation Factor at 1 kHz: (25°C)	≤ 3.0%
Insulation Resistance at 100 VDC: (as fired)	≥ 10^9 Ω
Insulation Resistance at 100 VDC: (overglazed with 2 layers of G-481)	≥ 10^{10} Ω
Breakdown Voltage: (VDC/25 µm, 25°C in air, as fired)	≥ 100
Breakdown Voltage: (VDC/25 µm, 25°C in air, overglazed with 2 layers of ESL G-481)	≥ 200
Recommended Conductors:	ESL 9916, 9516, 8816
Overglazes: (2 layers separately fired)	ESL G-481

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
www.electroscience.com

CONDUCTIVE ELECTRODE MATERIAL 9516

Platinum Silver Conductor Designed for use with 4150 Series and 4200-C Series of Dielectrics

ESL 9516 is a platinum silver based conductor specially developed for use as an electrode with 4150 Series and 4200-C Series of dielectrics. ESL 9516 may also be used with the 4100 Series of dielectrics. When used with ESL 4150 Series and 4200-C Series dielectrics, this conductor provides the optimum performance of the systems. The typical properties of these conductors were derived from printing and firing directly on alumina.

PASTE DATA

Rheology:	Thixotropic, screen printable paste
Viscosity: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Shelf Life: (25°C)	6 months

PROCESSING

Screen Mesh/Emulsion:	325/25 µm
Leveling Time: (25°C)	5-10 minutes
Drying at 125°C:	10-15 minutes
Firing Temperature Range:	850 - 900°C
Optimum:	900°C
Time at Peak:	10 minutes
Rate of Ascent/Descent:	60 - 100 °C / minute
Substrate of Calibration:	96% alumina
Thinner:	ESL 401 or 413

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:	12.5 ± 2.5 µm
Printing Resolution: (line / space)	125 µm / 125 µm
Resistivity:	≤ 3.2 mΩ/sq.
Solder Leach: (No. of 10 sec. dips to double resistance of 0.25 mm wide x 100 mm long conductor, 62 Sn/36 Pb/2 Ag, 220 ± 5 °C)	≥ 10
Adhesion: (90° pull, 2.0 mm x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220 ±5 °C)	
Initial pull strength:	≥ 7.6 kg
Aged 48 hours at 150°C:	≥ 5.1 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
www.electroscience.com

CONDUCTIVE ELECTRODE MATERIAL 9916

Silver Based Conductor Designed for use with the 4150 Series and 4200-C Series of Dielectrics

ESL 9916 is a silver based conductor specially developed for use as an electrode with 4150 Series and 4200-C Series of dielectrics. ESL 9916 may also be used with the 4100 Series of dielectrics. When used with ESL 4150 Series and 4200-C Series dielectrics, this conductor provides the optimum performance of the systems. The typical properties of these conductors were derived from printing and firing directly on alumina.

PASTE DATA

Rheology:	Thixotropic, screen printable paste
Viscosity: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5 ± 0.5°C)	200 ± 25 Pa.s
Shelf Life: (25°C)	6 months

PROCESSING

Screen Mesh/Emulsion:	325/25 µm
Leveling Time: (25°C)	5-10 minutes
Drying at 125°C:	10-15 minutes
Firing Temperature Range:	850°C-900°C
Optimum:	900°C
Time at Peak:	10 minutes
Rate of Ascent/Descent:	60 - 100 °C/minute
Substrate of Calibration:	96% alumina
Thinner:	ESL 401 or 413

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ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:	12.5 ± 2.5 µm
Printing Resolution: (Line/Space)	125 µm / 125 µm
Resistivity:	≤ 2.0 mΩ/sq.
Solder Leach: (No. of 10 sec. dips to double resistance of 0.25 mm wide x 100 mm long conductor, 62 Sn/36 Pb/2 Ag, 220 ± 5 °C)	≥ 7
Adhesion: (90° pull, 2.0 mm x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220 ± 5 °C)	
Initial pull strength:	≥ 8.2 kg
Aged 48 hours at 150°C:	≥ 6.6 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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Dielectrics

4612-B
An alkali-and lead-free dielectric material, of the crystallizing glass-ceramic type, designed to match the T.C.E. of 96% alumina.

4905-C
Non-porous blue multilayer dielectric with excellent T.C.E to match 96% alumina. Able to support 3900 series resistors.

4905-CH
Non-porous blue multilayer dielectric with excellent T.C.E to match 96% alumina.

4911
Multilayer dielectric with a low dielectric constant and a T.C.E to match 96% alumina.

4913-G
Cadmium, lead and nickel free non porous multilayer dielectric for alumina substrates.

4913-G2
Non-porous multilayer dielectric for use on alumina substrates.

4913-I
Non-porous multilayer dielectric for use on alumina substrates.

4916
Dielectric composition for insulating unoxidised 304 type austenitic steels. Provides excellent breakdown voltage.

4917
Cadmium, lead and nickel free multilayer dielectric used to combat the battery effect when using mixed metal conductors.

4920
Cadmium, lead and nickel free non porous multilayer dielectric for alumina substrates.

4924
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Cadmium, Lead, Nickel and Barium free.

4926-R
Dielectric paste designed to be co-fired with ESL 40010, 40011 and 40012 Ferrite tape. Can be used to increase the breakdown voltage between elements of transformers.

4929-G
Non-porous blue multilayer dielectric with an excellent TCE match to 96% alumina.

4931
Dielectric paste designed to insulate unabraded, unoxidised, ferritic steels.

4932
Dielectric paste with a green glossy finish and high green strength.

4932-A
Dielectric paste with a clear glossy finish and high green strength.

4956
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Produces minimum bowing of substrate.

4986
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Designed for Co-firing Applications. RoHS Compliant, Nickel and Barium free.

4987
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Cadmium, Lead and Nickel-free.

4987-S
A low viscosity, fast-print version of 4987 designed to insulate unabraded, unoxidised, ferritic steels.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

DIELECTRIC COMPOSITION 4612-B

RoHS Compliant*

ESL 4612-B is an alkali and lead-free crystallising dielectric material designed to match the T.C.E. of 96% alumina. It is similar to ESL 4612 but may be used where fine lines and good via retention are required.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	400 ± 35 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 38µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		800 - 930°C (in air)
	Optimum:	850°C
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: (2 layers)	43 ± 5 µm
Dielectric Constant (K) at 1 kHz: (at 25°C)	7 - 14
Dissipation Factor at 1 kHz: (at 25°C, depending upon conductor)	≤ 0.6%
Printing Resolution: (Minimum printable via size)	250 - 300 µm
Breakdown Voltage: (at 25°C in air)	>900 VDC / 25 µm
Insulation Resistance: (at 100V DC)	>1 x 10^{10} Ω

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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MULTILAYER DIELECTRIC COMPOSITION

4905-C
4905-CH
4905-CD

The ESL 4905-C Series dielectrics are nonporous blue multilayer dielectrics with an excellent TCE match to 96% alumina. It is possible to print and fire many layers of these dielectrics with minimal distortion of the substrate. Substrate sizes up to 150 mm x 100 mm x 1 mm have been used successfully with multiple large area prints of 4905-CD. Screen gaps up to 1.8 mm are used with the large area screens (300 mm x 300 mm) necessary to print large circuits. These dielectrics can be used in multilayer builds using gold or silver based products. Typical systems in use are 9695/4905-CH/9633-B and 8836/4905-CD/8836. Via filling should be carried out using 8835-VF in gold based multilayer systems and with 9697 in mixed metallurgy systems. It is possible to resolve 175 µm vias using 4905-CD. Both gold based and silver based conductors may be used as the resistor termination on top of the dielectric, but different resistor values and TCR shifts will be observed.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity:	4905-C:	325 ± 25 Pa.s
(Brookfield RVT, 10rpm,	4905-CH:	325 ± 25 Pa.s
ABZ spindle, 25.5 ± 0.5 °C)	4905-CD:	450 ± 25 Pa.s
Colour:		Blue
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:	Gold bearing conductor:	325 S/S, 25 µm
	Silver bearing conductor:	200 S/S, 25 µm
Levelling Time (20°C):		5 - 10 min
Drying at 125°C:		10 - 15 min
Firing Temperature Range:		850 - 950°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:
(at least 2 layers between Au conductors on 96% alumina)

Gold based system	35 - 40 µm
Silver based system	45 - 50 µm

Approximate Coverage:
(40µm thickness) 60 - 70 cm^2/g

Dielectric Constant (K) at 1 kHz:
(at 25°C) 7 - 10

Dielectric Constant (K) at 1 MHz:
(at 25°C) 6 - 8

Dissipation Factor at 1 kHz:
(depending upon conductor, at 25°C) <0.25%

Insulation Resistance:
(at 100V DC) $>10^{11}\ \Omega$

Salt Test:
Leakage current (10V DC in 1M KCl) <1µA

Breakdown Voltage:
(at 25°C in air) > 1000V / 50µm

Via Definition:		
	4905-C	250µm x 250µm
	4905-CH	250µm x 250µm
	4905-CD	175µm x 175µm

Solder Wettability of Conductors over 4905-C Series Dielectrics:
(RMA flux, 5sec. dip, 62Sn/36Pb/2Ag, at 220°C)

9633-B (Ag/Pd)	95 %
5837 (Pt/Au)	85 - 90 %
9695 (Ag/Pd)	85 - 90 %

For other information please see the relevant conductor data sheet

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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DIELECTRIC COMPOSITION 4911

ESL 4911 is a developmental low dielectric constant (K) multilayer dielectric whose coefficient of thermal expansion (T.C.E) is closely matched to 96% alumina. This dielectric is dense firing and yields a transparent blue layer.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	300 ± 50 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	930°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers between Au conductors on 96% alumina)	40 - 50 µm
Approximate Coverage: (40µm thickness)	60 - 70 cm^2/g
Dielectric Constant (K) at 1 kHz: (at 25°C)	4.3 ± 5%
Dielectric Constant (K) at 1 MHz: (at 25°C)	4.2 ± 5 %
Dissipation Factor at 1 kHz: (at 25°C)	0.05 %
Dissipation Factor at 1 MHz: (at 25°C)	0.26 %
Insulation Resistance: (at 100V DC)	$> 10^{11}$ Ω
Pressure Cooker Test: (IR after 15 min at 2 atmospheres steam pressure)	$> 10^{12}$ Ω
Breakdown Voltage: (at 25°C in air, total thickness > 45µm)	> 1000 V DC / 40 µm
Via Definition:	300 µm x 300 µm
Leakage Current: (1M NaCl solution / 10V DC Bias / 5 min)	<1µA / cm^2
Warpage: (400 µm thick layer on 12.7 mm x 12.7 mm x 0.625 mm 96% alumina substrate)	< 10 µm / cm
Conductor Compatibility:	ESL 8836-D, 8884

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MULTILAYER DIELECTRIC COMPOSITION 4913-G

RoHS Compliant*

Dielectric composition 4913-G is a cadmium-free, lead-free, and nickel-free non porous multilayer dielectric for use on alumina substrates. This dielectric may be used with selected silver or gold based conductors or combinations of these metals.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 37 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers between conductors on 96% alumina)	40 - 55 µm
Dielectric Constant (K) at 1 MHz: (at 25°C)	8 - 11
Dissipation Factor at 1 MHz: (at 25°C)	< 0.5%
Insulation Resistance: (at 100V DC)	$>1 \times 10^{11}\Omega$
Breakdown Voltage: (at 25°C in air)	≥800 V DC / 25 µm
Leakage Current: (In 1M NaCl solution/10 VDC bias/5 minutes)	$< 1\ \mu A/cm^2$

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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MULTILAYER DIELECTRIC COMPOSITION 4913-G2

Cadmium, Lead and Nickel-Free*

ESL 4913-G2 is a cadmium, lead and nickel-free non-porous multilayer dielectric for use on alumina substrates. This dielectric may be used with selected silver or gold-based conductors or combinations of these metals.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 37 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers between conductors on 96% alumina)	30 - 50 µm
Dielectric Constant (K) at 1 MHz: (at 25°C)	6 - 10
Dissipation Factor at 1 MHz: (at 25°C)	< 0.4%
Insulation Resistance: (at 100V DC)	>1 x $10^{11}\Omega$
Breakdown Voltage: (at 25°C in air)	>1250 V DC / 35 µm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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MULTILAYER DIELECTRIC COMPOSITION 4913-I

RoHS Compliant*

ESL 4913-I is a cadmium, lead and nickel-free non-porous multilayer dielectric for use on alumina substrates. This dielectric may be used with selected silver or gold-based conductors or combinations of these metals.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	450 ± 30 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 37 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers between conductors on 96% alumina)	30 - 50 µm
Dielectric Constant (K) at 1 MHz: (at 25°C)	6 - 10
Dissipation Factor at 1 MHz: (at 25°C)	< 0.4%
Insulation Resistance: (at 100V DC)	>1 x $10^{11}\Omega$
Breakdown Voltage: (at 25°C in air)	>1250 V DC / 35 µm

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INSULATING COMPOSITION 4916

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

FOR 304 TYPE AUSTENITIC STEEL

ESL 4916 is a dielectric composition designed to insulate unoxidised 304 type austenitic steels. Three separately fired layers of 4916, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves that all printing is carried out in clean room conditions. ESL 29XXX-A Series resistors are recommended for use as the heating elements with ESL 9695 (Pd/Ag) terminations. The heater should be protected by using an additional layer of 4916.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	125 ± 25 Pa.s
Solids content:	77.0 ± 2.0 %
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Drying Time (at 125°C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		120 grit, unoxidised 304 stainless steel
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 304 stainless steel measured using an Elcometer 345 thickness gauge) > 70 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2/g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1500 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 V DC at 25 °C in air)

After storage at 93 ± 2 % RH, 25 ± 2 °C for 48 hrs.	$> 10^9\Omega$
At 300°C	$> 10^9\Omega$

A wide range of ESL materials are compatible with 4916 permitting the fabrication of other COS (Circuits on Steel)®.

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DIELECTRIC COMPOSITION 4917

Cadmium, Lead and Nickel-Free* Multilayer Dielectric Designed To Combat The Battery Effect When Using Mixed Metal Conductors

ESL 4917 dielectric is designed to be free of battery effects when used in circuits containing mixed metal conductors. Metal migration under conditions that normally produce the battery effect have been effectively controlled by employing an alkali and lead-free glass system that partially crystallizes during standard thick film processing at 850°C. The 4917 is non-porous and the TCE is matched to 96% alumina. Recommended conductor systems for mixed metal multilayers include 9695-G Pd/Ag for buried layers, 9697-G Ag/Pd via fill, and 8844-G or 8846-G Au and 5837-G as the solderable top conductor.

ESL 4917 has a high voltage breakdown and is excellent for use as a crossover dielectric.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 & 325 S/S, 40 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C (in air)
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers between Au conductors on 96% alumina)		35 - 50 µm
Dielectric Constant (K) at 1 kHz: (at 25°C)		8 - 11
Dissipation Factor at 1 kHz: (at 25°C, depending upon conductor)		<0.4%
Breakdown Voltage: (at 25°C in air)		>1500 VDC / 25 µm
Insulation Resistance: (at 100V DC)		>1 x 10^{11} Ω
Via Definition:		250 µm x 250 µm
Thermal Coefficient of Expansion (TCE):		
	(25°C - 500°C x ppm / °C)	6.3
	(25°C - 700°C x ppm / °C)	6.6
Solder Wettability (Top layer): (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	5837-G	90 - 95 %

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

MULTILAYER DIELECTRIC COMPOSITION 4920

Cadmium, Lead & Nickel-Free

ESL 4920 is a cadmium, lead and nickel-free non-porous multilayer dielectric for use on alumina substrates. This dielectric may be used with selected silver or gold based conductors or combinations of these metals. This is intended for applications for which a thinner printing dielectric is needed.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	300 ± 50 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 37.5µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		850°C
	Time at peak:	10 minutes
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

(measured on 5 mm x 5 mm capacitors using 9695 Ag/Pd terminations)

Fired Thickness: (at least 2 layers between Ag/Pd conductors on 96% alumina)	30 - 40 µm
Dielectric Constant (K) at 1 MHz: (at 25°C)	7 - 10
Dissipation Factor at 1 MHz: (at 25°C)	< 0.75%
Insulation Resistance: (at 100V DC)	$\geq 10^{10}\Omega$
Breakdown Voltage: (at 25°C in air)	≥ 1250V / 25µm
Leakage Current: (In 1M NaCl solution / 10 VDC bias / 5 minutes, leakage test pattern)	< 1 µA / cm^2

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

INSULATING COMPOSITION 4924

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead, Nickel and Barium-Free*

ESL 4924 is a dielectric composition designed to insulate unabraded, unoxidised, ferritic steels. The 4924 is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4924, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves and that printing is carried out in clean-room conditions. With 9695 or 9501-CH terminations and 29XXX resistors used as the heating elements, 4924 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17 stainless steel
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage: 40 cm²/g
(80 µm thickness)

Breakdown Voltage:
(measured on an 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) ≥ 1800 V AC

Insulation Resistance:
(measured on an 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93 ± 2% RH, 25 ± 2°C for 48 hrs.	$> 10^9\Omega$
At 300°C	$> 10^9\Omega$

A wide range of ESL materials are compatible with 4924 permitting the fabrication of other COS (Circuits on Steel)®

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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DIELECTRIC COMPOSITION 4926-R

Dielectric Composition Compatible with Ferrite Tape

ESL 4926-R dielectric paste is designed to be co-fired with ESL 40010, 40011 and 40012 Ferrite tape. The 4926-R can be used to increase the breakdown voltage between elements of transformers. The recommended dried print thickness is equal to or greater than 35 micrometers.

PASTE DATA

Rheology:	Thixotropic, screen printable paste
Viscosity: (Brookfield RVT, #6 Spindle, 10 rpm, 25.5 ± 0.5 °C)	12 ± 6 Pa.s
Colour:	Beige
Shelf Life: (25°C)	3 months

PROCESSING

Screen Mesh/Emulsion:	200/37 µm
Leveling Time:	5 - 10 seconds
Drying at 125°C: (Depending upon substrate volume)	5 minutes
Firing Temperature:	885°C
Time at Peak:	180 minutes
Thinner:	ESL 401
Compatible Materials:	ESL 903-J, 903-B conductors, 40010, 40011, 40012 tape

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

MULTILAYER DIELECTRIC COMPOSITION 4929-G

RoHS Compliant*

ESL 4929-G dielectric is a non-porous blue multilayer dielectric with an excellent TCE match to 96% alumina. It is possible to print and fire many layers of this dielectric with minimal distortion of the substrate. Substrate sizes up to 150 mm x 100 mm x 1 mm can be used successfully with multiple large area prints of 4929-G. Screen gaps up to 1.8 mm are used with the large area screens (300 mm x 300 mm) that are necessary to print large circuits. This dielectric can be used in multilayer builds using gold or silver based products. Typical systems in use are 9695-G/4929-G/9635-G and 8844-G/4929-G/8846-G. Via filling should be carried out using 8835-VFG in gold based multilayer systems and with 9695-G in mixed metallurgy systems. It is possible to resolve 175 µm vias using 4929-G. Both gold based and silver based conductors may be used as the resistor termination on top of the dielectric, but different resistor values and TCR shifts will be observed.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm,: ABZ spindle, 25.5 ± 0.5 °C)	375 ± 25 Pa.s
Colour:	Light blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	Gold bearing conductor:	325 S/S, 25 µm
	Silver bearing conductor:	200 S/S, 25 µm
Levelling Time (20°C):		5 - 10 min
Drying at 125°C:		10 - 15 min
Firing Temperature Range:		850 - 950°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:
(at least 2 layers between conductors on 96% alumina)

Gold based system	35 - 40 µm
Silver based system	45 - 50 µm

Approximate Coverage:
(40µm thickness) 60 - 70 cm^2/g

Dielectric Constant (K) at 1 kHz:
(at 25°C) 7 - 10

Dielectric Constant (K) at 1 MHz:
(at 25°C) 6 - 8

Dissipation Factor at 1 kHz:
(depending upon conductor, at 25°C) <0.4%

Insulation Resistance:
(at 100V DC) $>10^{11}\ \Omega$

Breakdown Voltage:
(at 25°C in air) > 1000V / 50µm

Via Definition:
175µm x 175µm

Solder Wettability of Conductors over 4929-G Dielectric:
(RMA flux, 5sec. dip, 62Sn/36Pb/2Ag, at 220°C)

9635-G (Ag/Pd)	95 %
5837-G (Pt/Au)	85 - 90 %
9695-G (Ag/Pd)	85 - 90 %

For other information please see the relevant conductor data sheet

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

INSULATING COMPOSITION 4931

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

RoHS Compliant*

Dielectric composition ESL 4931 is designed to insulate unabraded, unoxidised, ferritic steels. 4931 is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4931, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves at all times in clean room conditions. ESL 9695 and 9501-CH terminations and ESL 29xxx resistors are recommended for use as the heating elements. 4931 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time:		5 - 10 min
Drying Time (at 125 °C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air) > 10^9 Ω

A wide range of ESL materials are compatible with 4931 permitting the fabrication of other COS (Circuits on Steel)®.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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OVERGLAZE COMPOSITION 4932

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4932 is a cadmium and lead-free, glossy finish, high green strength overglaze.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		150 ± 25 Pa.s
Colour:		Green
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 °C
	Time at peak:	10 min
Total Firing Cycle:		60 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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T: 610-272-8000
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OVERGLAZE COMPOSITION 4932-A

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4932-A is a cadmium and lead-free, glossy finish, high green strength overglaze.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Clear
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 °C
	Time at peak:	10 min
Total Firing Cycle:		60 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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INSULATING COMPOSITION 4956

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

RoHS Compliant*

ESL 4956 is a dielectric composition designed to insulate unabraded, unoxidised, ferritic steels. The 4956 is non-porous and produces minimum bowing of substrate as its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4956, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves and that printing is carried out in clean-room conditions. With 9695 or 9501-CH terminations and 29XXX resistors used as the heating elements, 4956 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17 stainless steel
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness:
(at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage: 40 cm²/g
(80 µm thickness)

Breakdown Voltage:
(measured on an 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) ≥ 1800 V AC

A wide range of ESL materials are compatible with 4956 permitting the fabrication of other COS (Circuits on Steel)®

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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INSULATING COMPOSITION 4986

HOS Heaters on Steel® • Designed for Co-firing Applications

RoHS Compliant*

Dielectric composition ESL 4986 is designed to insulate unabraded, unoxidised ferritic steels. The product 4986 is non-porous and its TCE closely matches that of 430 S17 grade stainless steels. It may be co-fired using a regular 850°C furnace/1 hour profile providing that care is taken with settling, drying and cooling times between prints. It is essential that the steel is only handled using protective gloves at all times in a Clean Room environment. Excellent breakdown voltage between top conductive prints and the steel base can be achieved with a minimum thickness of 80µm in three layers. ESL 29XXX-B resistors with 9695 terminations are recommended for use as the heating elements. ESL 4986 is recommended as an 850°C overglaze whilst 4771-P1 may be used as a low-temperature overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications. In addition a wide range of ESL materials are compatible with 4986 permitting the fabrication of other COS (Circuits on Steel)®

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	165 S/S, 0 µm
Levelling Time (at 25°C):	5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)	> 15 min
Firing Temperature Range:	850°C - 930°C in air
Optimum:	850°C
Time at peak:	10 min
Total Firing Cycle:	1 hour
Substrate For Calibration:	Unabraded, unoxidised 430 S17 122.5 mm diameter x 1.2 mm
Thinner:	ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2/g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25 °C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93 ± 2 % RH, 25 ± 2 °C for 48 hrs.	$> 10^9 \Omega$
At 300°C	$> 10^9 \Omega$

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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INSULATING COMPOSITION 4987

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-Free*

Dielectric composition ESL 4987 is designed to insulate unabraded, unoxidised, ferritic steels. 4987 is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4987, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves at all times in clean room conditions. ESL 9695 and 9501-CH terminations and ESL 29XXX resistors are recommended for use as the heating elements. 4987 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time:		5 - 10 min
Drying Time (at 125 °C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air) > 10^9 Ω

A wide range of ESL materials are compatible with 4987 permitting the fabrication of other COS (Circuits on Steel)®.

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CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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INSULATING COMPOSITION 4987-S

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-Free*

Dielectric composition ESL 4987-S is low viscosity/fast-print version of 4987 designed to insulate unabraded, unoxidised, ferritic steels. 4987-S is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4987-S, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves at all times in clean room conditions. ESL 9695 and 9501-CH terminations and ESL 29XXX-C resistors are recommended for use as the heating elements. 4987-S is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	27.5 ± 2.5 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Drying Time (at 125 °C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93 ± 2% RH, 25 ± 2°C for 48 hrs.	> 10^9 Ω
At 300°C	> 10^9 Ω

A wide range of ESL materials are compatible with 4987-S permitting the fabrication of other COS (Circuits on Steel)®.

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Fuel Cell Materials

2323 & 2323-HV

Brazing Paste

Silver-copper (Ag-Cu) fluxless and fritless, screen-printable paste or ink, for use in SOFC and other fuel cell applications

42400

YSZ Electrolyte Tape (~20µm)

Yttria stabilized zirconia tape (thickness 15-25µm, 8 mol% Y_2O_3), for use in SOFC and other fuel cell applications

42401

YSZ Electrolyte Tape (~125µm)

Yttria stabilized zirconia tape (nominal thickness 125µm, 8 mol% Y_2O_3), for use in SOFC and other fuel cell applications

42402

ScSZ Electrolyte Tape (~125µm)

Scandia stabilized zirconia tape (nominal thickness 125µm, 6 mol% Sc), for use in SOFC and other fuel cell applications

42405

ScSZ Electrolyte Tape (~20µm)

Scandia stabilized zirconia tape (thickness 15-25µm, 6 mol% Sc), for use in SOFC and other fuel cell applications

42420

Anode Tape (~20µm)

YSZ/NiO anode tape (nominal thickness 20µm), for use in SOFC and other fuel cell applications

42421

Porous Anode Tape (~180µm)

Porous YSZ/NiO anode tape (nominal thickness 180µm), for use in SOFC and other fuel cell applications

42510-x

Zirconia Cover Plates

Porous fired zirconia, available in various sizes

42520-x

Alumina Cover plates

Porous fired alumina, available in various sizes

4343

Gadolinium Doped Ceria Paste

Gadolinium doped ceria (GDC) screen-printable paste or ink, for use in SOFC electrolytes, and other fuel cell applications

4345

Zirconium Oxide Paste (Scandia Stabilized)

6mol% scandia stabilized zirconia (6ScSZ) screen-printable paste or ink, for use in SOFC electrolytes, and other fuel cell applications

4410

Nickel Oxide Paste

Nickel oxide screen-printable paste or ink, for use in SOFC anodes, and other fuel cell applications

4411

Nickel Oxide Paste with Pore-Former

Nickel oxide screen-printable paste or ink, with added pore-former to enhance porosity, for use in SOFC anodes, and other fuel cell applications

4412

Nickel Oxide / Zirconia Paste

Nickel oxide (50wt% NiO) and zirconia (50wt% 8YSZ) screen-printable paste or ink, for use in SOFC anodes, and other fuel cell applications

4416

Nickel Oxide / Zirconia Paste

Nickel oxide (65wt% NiO) and zirconia (35wt% 8YSZ) screen-printable paste or ink, for use in SOFC anodes, and other fuel cell applications

4420

Lanthanum Strontium Manganite Paste

Lanthanum strontium manganite (LSM, $La_{0.8}Sr_{0.2}MnO_{3-\delta}$) screen-printable perovskite paste or ink, for use in SOFC cathodes, and other fuel cell applications

4421

Lanthanum Strontium Cobalt Ferrite Paste

Lanthanum strontium cobalt ferrite (LSCF, $La_{0.8}Sr_{0.2}Co_{0.2}Fe_{0.8}O_3$) screen-printable perovskite paste or ink, for use in SOFC cathodes, and other fuel cell applications

4422

Lanthanum Strontium Manganite / Zirconia Paste

Lanthanum strontium manganite (50wt% LSM) and zirconia (50wt% 8YSZ) screen-printable paste or ink, for use in SOFC cathodes, and other fuel cell applications

4440

Porosity-Forming Paste

Fugitive screen-printable paste or ink, for use in SOFC and other fuel cell applications

4460

Sealing Glass Paste

Vitreous glass screen-printable paste or ink, for use in SOFC and other fuel cell applications

4480

Doped Lanthanum Chromite Paste

Doped lanthanum chromite (LCC or $La_{0.8}Ca_{0.2}CrO_3$) screen-printable perovskite paste or ink, for use in SOFC cathodes, and other fuel cell applications

4481

Zirconium Oxide Paste (Yttria Stabilized)

8mol% yttria stabilized zirconia (8YSZ) screen-printable paste or ink, for use in SOFC electrolytes, and other fuel cell applications

4482

Lanthanum Strontium Cobalt Chromite Paste

Lanthanum strontium cobalt chromite (LSCC, $La_{0.9}Sr_{0.1}Co_{0.1}Cr_{0.9}O_3$) screen-printable perovskite paste or ink, for use in SOFC cathodes, and other fuel cell applications

5542

Interconnect Paste

Platinum (Pt) screen-printable paste or ink, for use in SOFC and other fuel cell applications

8884-G

Interconnect Paste

Gold (Au) screen-printable paste or ink, for use in SOFC and other fuel cell applications

9512-G

Interconnect Paste

Silver-platinum (Ag-Pt) screen-printable paste or ink, for use in SOFC and other fuel cell applications

9627

Interconnect Paste

Silver palladium (Ag-Pd) conductor designed for use as a current collector for solid oxide fuel cells.

9647

Interconnect Paste

Silver palladium (Ag-Pd) screen-printable paste or ink, for use in SOFC and other fuel cell applications

9907

Interconnect Paste

Silver (Ag) conductor designed for use as a current collector for solid oxide fuel cells.

9912-G

Interconnect Paste

Silver (Ag) screen-printable paste or ink, for use in SOFC and other fuel cell applications

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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COPPER CONDUCTOR

2323
2323-HV

RoHS Compliant*

ESL 2323 is a 72% Ag / 28% Cu fluxless and frit-less eutectic brazing alloy available in paste form, suitable for screen printing, and syringe application. Typical uses are for joining metal parts to moly-manganese or nickel-metallised ceramic, package fabrication, and making high-temperature interconnects for SOFC and other fuel cells, where the joint will see temperatures greater than the melting point of soft solders. The metal parts should be nickel plated for best results.

ESL 2323-HV is a higher viscosity version of 2323 and is designed to provide better printing definition and for syringe application.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	2323	65 ± 5 Pa.s
	2323-HV	80 ± 5 Pa.s
Solids:	2323	93 ± 1 %
	2323-HV	94 ± 1 %
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:	200 - 325 S/S, 25 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Time (at 125 °C):	10 - 15 min
Firing Temperature Range:	810°C spike, 10 -20 seconds
Brazing Atmosphere:	Wet hydrogen, forming gas, cracked ammonia
Melting Point (Eutectic):	779°C

Compatibility:
Can be brazed to moly-manganese or hydrogen-fired thick-film nickel (e.g., ESL 2505-H2). Not compatible with most air-firing thick-film metallisations, since this process will cause lower adhesion of the metallization when exposed to reducing atmospheres at high temperatures.

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

ELECTROLYTE TAPE 42400

RoHS Compliant* High Temperature 8 mol% YSZ Tape for use in SOFC and other Fuel Cells, Gas Sensors and Pressure Sensors

The ESL42400 is an 8 mol% yttria stabilized zirconia (YSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are fabrication of SOFC and other fuel cells, high-temperature ceramic gas sensors and pressure sensors. In these applications, this electrolyte is designed to be an excellent ionic conductor and a poor electronic conductor at operating temperatures.

STABILIZING AGENT:	8 mol% Y_2O_3
GREEN TAPE THICKNESS:	15 µm ± 5 µm
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa @ 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute ramp to 650°C
	2.5°C/minute ramp to 1450 to 1550°C
	2-hour soak at peak temperature to achieve full density
FIRED DENSITY: (1450°C for 30 minutes)	> 98% of theoretical

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ELECTROLYTE TAPE 42401

RoHS Compliant* High Temperature 8 mol% YSZ Tape for use in SOFC and other Fuel Cells

The ESL42401 is an 8 mol% yttria stabilized zirconia (YSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are composite fabrication of SOFC and other fuel cells. The electrolyte is designed to be an excellent ionic conductor and poor electronic conductor at operating temperatures. This tape may be used as an electrolyte or a support in SOFC fuel cells.

STABILIZING AGENT:	8 mol% Y_2O_3
GREEN TAPE THICKNESS:	125µm ±10%
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa @ 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute to 650°C
	2.5°C/minute to 1450-1550°C
	2 hour soak at peak temperature
FIRED SHRINKAGE:	X,Y: 18-26 %
	Z: 18-22 %
FIRED DENSITY: (1450°C for 30 minutes)	> 98% of theoretical

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ELECTROLYTE TAPE 42402

RoHS Compliant* High Temperature 6 Mol% ScSZ Tape for Use In SOFC And Other Fuel Cells

The ESL 42402 electrolyte is a 6 mol% scandia stabilized zirconia (ScSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are fabrication of SOFC and other fuel cells. The electrolyte is designed to be an excellent ionic conductor and poor electronic conductor at operating temperatures.

STABILIZING AGENT:	6 mol% Sc_2O_3
GREEN TAPE THICKNESS:	125µm ± 10%
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa @ 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute to 650°C
	2.5°C/minute to 1350-1450°C
	2 hour soak at peak temperature
FIRED SHRINKAGE:	X, Y: 18-26 %
	Z: 18-22 %
FIRED DENSITY: (1450 °C for 30 minutes)	> 98% of theoretical

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ELECTROLYTE TAPE 42405

RoHS Compliant* High Temperature 6 Mol% ScSZ Tape for use in SOFC and Other Fuel Cells

The ESL 42405 electrolyte is a 6 mol% scandia stabilized zirconia (ScSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are fabrication of SOFC and other fuel cells. The electrolyte is designed to be an excellent ionic conductor and poor electronic conductor at operating temperatures.

STABILIZING AGENT:	6 mol% Sc_2O_3
GREEN TAPE THICKNESS:	20 µm ± 5µm
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa at 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute to 650°C
	2.5°C/minute to 1350 -1450°C
	2 hour soak at peak temperature
FIRED SHRINKAGE:	X, Y: 18-26 %
	Z: 18-22 %
FIRED DENSITY: (1450 °C for 30 minutes)	> 98% of theoretical

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ANODE TAPE 42420

RoHS Compliant* High Temperature YSZ-Cermet Tape for use in SOFC and other Fuel Cells.

This anode cermet is a blend of nickel oxide and yttria stabilized zirconia (YSZ) in tape form, designed to sinter to near full density as part of the composite structure used in SOFC and other fuel cells. Its purpose is to insure thermal coefficient of expansion (TCE) match between adjacent electrolyte and porous anode layers in the composite assembly, and thus it is chemically compatible with these materials. It is prepared by tape casting a slurry containing the YSZ powder, a thermoplastic binder and surfactant. The slurry is cast on a polyester carrier film which is coated with a release agent.

LAMINATING:	21 MPa @ 70˚C
GREEN TAPE THICKNESS:	15 ± 5 µm
GREEN TAPE DENSITY:	nominal 3.04 g/cm^3, depending on solids loading
GREEN TAPE COLOR:	dark green (typical)
TYPICAL SINTERING CYCLE:	0.7°C/minute ramp to 650°C 2.5°C/minute ramp to 1450 to 1550°C 2-hour soak at peak temperature to achieve full density
FIRED SHRINKAGE: (3 layers using lamination parameters of 3 kpsi – 70°C – 20 minutes) nominal	X, Y: 25% Z: 25%
FIRED DENSITY: (1450°C for 120 minutes)	> 90% of theoretical

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POROUS ANODE TAPE 42421

RoHS Compliant* High Temperature YSZ-Cermet Tape for use in SOFC and other Fuel Cells

The porous anode cermet is a blend of nickel oxide and yttria stabilized zirconia (YSZ) in tape form. It provides the catalytic activity required to promote the reaction necessary to produce fuel ions, such as hydrogen or CO. It is porous so that fuel gas can reach the three-phase boundary present near the electrolyte. In SOFC anode-supported cells, thick anode layers are required to provide mechanical strength for the cell. It is prepared by tape casting a slurry containing the YSZ powder, a thermoplastic binder and surfactant. The slurry is cast on a polyester carrier film which is coated with a release agent.

LAMINATING:	21 MPa @ 70˚C
GREEN TAPE THICKNESS:	nominal 180 µm
GREEN TAPE DENSITY:	nominal 3.2 g/cm^3, depending on solids loading
GREEN TAPE COLOR:	dark green – gray (typical)
TYPICAL SINTERING CYCLE:	0.7°C/minute ramp to 650°C 2-1/2°C/minute ramp to 1450 to 1550°C 2-hour soak at peak temperature to achieve full density
FIRED SHRINKAGE: (3 layers using lamination parameters of 3 kpsi – 70°C – 20 minutes), nominal	X, Y: 21% Z: 21%
FIRED DENSITY: (1450 °C for 120 minutes)	< 85 % of theoretical

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POROUS ZIRCONIA COVER PLATE 42510-x

RoHS Compliant*

ESL 42510 is a porous, fired zirconia ceramic plate used to cover green ceramic parts during firing. The weight of the porous plate enhances the flatness of fired parts while retaining gas permeability during organic removal, thus allowing single firing. The plate may also be used as a setter to promote more uniform burnout of binders during firing. Uses include Fuel Cell applications such as SOFC electrolyte substrates, and other processing of ceramic tape.

ESL cover plates are available in several standard sizes as shown below, and in customer-specific configurations.

DATA:

THICKNESS:	1 mm nominal or as required
THICKNESS TOLERANCE	mean ± 10%
CAMBER (parallel plate gauge)	0.5 mm/100 mm
MAXIMUM USE TEMPERATURE	up to 1550°C
RECOMMENDED USE TEMPERATURE	up to 1450°C
RE-FLATTENING TEMPERATURE	1550°C

SIZES AVAILABLE (mm)

42510-2 50 x 50

42510-3 75 x 75

42510-4 100 x 100

42510-5 125 x 125

42510-6 150 x 150

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POROUS ZIRCONIA COVER PLATE 42520-x

RoHS Compliant*

ESL 42520 is a porous, fired zirconia ceramic plate used to cover green ceramic parts during firing. The weight of the porous plate enhances the flatness of fired parts while retaining gas permeability during organic removal, thus allowing single firing. The plate may also be used as a setter to promote more uniform burnout of binders during firing. Uses include Fuel Cell applications such as SOFC electrolyte substrates, and other processing of ceramic tape.

ESL cover plates are available in several standard sizes as shown below, and in customer-specific configurations.

DATA:

THICKNESS:	1 mm nominal or as required
THICKNESS TOLERANCE	mean ± 10%
POROSITY:	40% nominal
CAMBER (parallel plate gauge)	0.5 mm/100 mm
MAXIMUM USE TEMPERATURE	up to 1550°C
RECOMMENDED USE TEMPERATURE	up to 1450°C
RE-FLATTENING TEMPERATURE	1550°C

SIZES AVAILABLE (mm)

42520-2 50 x 50

42520-3 75 x 75

42520-4 100 x 100

42520-5 125 x 125

42520-6 150 x 150

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GADOLINIA DOPED CERIA PASTE 4343

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4343 is an electrolyte paste composition that contains 20 mol% gadolinia doped ceria. It is a screen-printable or dispensable conductive thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Colour:	off white
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25.4 - 38 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Firing Temperature:	1200 - 1300 °C
Thinner:	ESL 401

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SCANDIA STABILIZED ZIRCONIA PASTE 4345

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4345 is an electrolyte paste composition that contains 6 mol% ScSZ. It is a screen-printable or dispensable conductive thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min

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ANODE PASTE 4410

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4410 is a nickel oxide-based anode paste composition used in fuel cell manufacture. The ESL 4410 is porous and is well suited for high-temperature, cofire conditions. It can be screen-printed or dispensed. If ESL 4410 is used in a thick-layer configuration, it can provide strength to the cell and support for the electrolyte.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 50 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	>15 min
Thinner:	ESL 401

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POROUS ANODE PASTE 4411

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4411 is a nickel oxide composition that contains pore-former to enhance porosity. It is a screen- printable or dispensable conductive thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 50 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Thinner:	ESL 401

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ANODE PASTE 4412

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4412 is an anode composition that contains 50/50 ratio of NiO and 8 mol% YSZ. It is a screen-printable or dispensable thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25.4 - 38 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	>15 min
Thinner:	ESL 401

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ANODE PASTE 4416

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4416 is an anode composition that contains a 65/35 ratio of NiO and 8 mol% YSZ. It is a screen-printable or dispensable thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25.4 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Thinner:	ESL 401

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CATHODE PASTE 4420

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4420 is a cathode paste composition that contains lanthanum strontium manganese oxide ($La_{0.80}Sr_{0.2}MnO_3$). It is a screen-printable or dispensable thick-film paste that is catalytic as well as porous.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	100 ± 50 Pa.s
Colour:	Black
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	>15 min

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CATHODE PASTE 4421

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4421 is a cathode composition that contains LSCF ($La_{0.8}Sr_{0.2}Fe_{0.8}Co_{0.2}$Oxide). It is a screen-printable or dispensable thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	100 ± 50 Pa.s
Colour:	Black
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min

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CATHODE PASTE 4422

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4422 is a cathode composition that contains a 50/50 ratio of LSM/YSZ $(La_{0.8}Sr_{0.2})_{0.98}MnO_{3-x}$/8YSZ. It is a screen-printable or dispensable thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Colour:	Black
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Thinner:	ESL 401

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FUGITIVE PASTE 4440

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4440 is a FUGITIVE paste composition which should burn out at 850°C. This paste can be used to form channels in multilayer tape structures or, when mixed with other inks, to increase porosity. It is a screen-printable or dispensable thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	400 ± 50 Pa.s
Colour:	Black
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min

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SEALING GLASS PASTE 4460

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4460 is a sealing glass composition for use with YSZ ceramic and various stainless steels. It is a screen-printable or dispensable thick-film paste. ESL 4460 provides excellent breakdown voltage and is ideally printed to a thickness of 80 µm in three separately fired layers.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (depending on substrate volume)		> 15 min
Firing Temperature Range:		850 - 930°C
	Optimum:	850°C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		50 - 60°C / min
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: 40 - 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print
on a 120 mm diameter area of dielectric at
25°C in air using a standard Clare Flash Tester) 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 120 mm
diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93% ± 2% RH, 25˚C ± 2˚C for 48 hours	10^{10} Ω
At 300˚C	10^{10} Ω

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

DOPED LANTHANUM CHROMITE INTERCONNECT PASTE 4480

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4480 is a ceramic interconnect paste composition that contains lanthanum calcium chromite ($La_{0.8}Ca_{0.2}CrO_3$). It is a screen-printable or dispensable conductive thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Colour:	Brown
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	>15 min

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YTTRIA STABILIZED ZIRCONIA PASTE 4481

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4481 is an electrolyte paste composition that contains 8 mol% YSZ. It is a screen-printable or dispensable conductive thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25.4 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min

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DOPED LANTHANUM CHROMITE INTERCONNECT PASTE 4482

RoHS Compliant* • For SOFC & Other Fuel Cells

ESL 4482 is a ceramic interconnect paste composition that contains lanthanum strontium cobalt chromite ($La_{0.9}Sr_{0.1}Cr_{0.9}Co_{0.1}$ Oxide). It is a screen-printable or dispensable conductive thick-film paste.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min

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CERMET PLATINUM CONDUCTOR 5542 5542-DG

RoHS Compliant* Platinum Conductor for SOFC, Sensors, etc.

ESL 5542 is a fritless platinum paste that may be applied by screen-printing or dipping (5542-DG) to form electrodes on zirconia substrates for oxygen sensor and fuel cell applications.

5542 and 5542-DG are stable up to 800 - 900°C and resist oxidation.

PASTE DATA

Rheology:	5542: Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	5542: 85 ± 15 Pa.s
(Brookfield RVT, 10rpm, No. 3 spindle, 25.5 ± 0.5 °C)	5542-DG: 5.5 ± 0.5 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 100 °C):		10 -15 min
Firing Temperature Range:		980 - 1400°C in air
	Optimum:	980°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:	5542: 5.0 ± 1.0 µm
Resistivity:	5542: 65 - 85 mΩ/□

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CERMET GOLD CONDUCTOR 8884-G

RoHS Compliant*

ESL 8884-G is a fritless (MICRO-LOK®) cadmium, nickel and lead-free, high-conductivity gold conductor for use on top of alumina and 4913-G dielectric.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		10 - 12 µm
Approximate Coverage:		80 - 85 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)		2 - 3 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength:	> 4.5 kg
Thermosonic Au Wire bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 19 g
Aged Au 38 µm Bond: (24 hours at 200°C; 100% wire breaks)		> 15 g
Ultrasonic Al Wire bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 10 g
Aged Al 25 µm Bond: (48 hours at 150°C; 100% wire breaks)		> 6 g
Ultrasonic Al Wire Bond: (380 µm wire)		> 1200 g

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CERMET SILVER/PLATINUM CONDUCTOR 9512-G

RoHS Compliant*

ESL 9512-G is a newly developed silver/platinum conductor, which can also be used as an interconnect paste in SOFC and other fuel cells. It exhibits excellent conductivity, adhesion to 96% alumina and tape-cast materials, and solder leach resistance. It is compatible with 4920 dielectric and tape-cast materials that are similarly free of alkali ions and the above metals.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Optimum:	850 °C
	Time at peak:	10 - 12 min
Total Firing Cycle:		50 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness:	10 - 15 µm
Resistivity: (at 12.5 µm fired thickness)	< 4.0 mΩ/□
Printing Resolution: (line/space)	0.075 mm / 0.075 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	>95% Coverage
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	10 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)

Initial pull strength:	> 7.0 kg
Aged 200 hours at 150°C:	> 7.0 kg

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CERMET SILVER/PALLADIUM CONDUCTOR 9627

RoHS Compliant* Conductor for use with Fuel Cells

ESL 9627 is a silver/palladium conductor designed for use as a current collector for solid oxide fuel cells.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield HBT, 10 rpm, SC-14 spindle, 25.5 ± 0.5 °C)	65 ± 25 Pa.s
Bonding Mechanism:	Fritless
Colour:	Grey
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	325 S/S, 15 - 25 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Substrate for Calibration:	ESL 41010
Thinner:	ESL 401

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TYPICAL PROPERTIES

Fired Thickness: 5 - 10 µm

Resistivity:
(when normalized @ 20 µm & co-fired with ESL 41010 tape) ≤100 mΩ/sq.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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PALLADIUM SILVER CONDUCTOR 9647

RoHS Compliant* Conductor with Excellent Adhesion, Solderability, and Wire bondability

ESL 9647 is a palladium silver conductor with approximately a 3:1 Ag to Pd ratio. It is designed to have good initial adhesion and good thermal aging adhesion after an extended period of time at temperature. This conductor also has excellent large-diameter aluminium wire bondability. ESL 9647 is lead, cadmium, and nickel free.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers 96% alumina)	10 ± 3 µm
Resistivity:	≤25 mΩ/sq
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 60Sn/40Pb at 250°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 60Sn/40Pb at 250°C)	≥ 2 dips
Peel Adhesion: (2 mm x 2 mm pads, 60Sn/40Pb solder)	
Initial pull strength:	> 2.0 kg
Aged 1000 hours at 150°C:	> 1.8 kg
Wire Bondability: (250µm Al wire, 100% wire breaks)	≥ 450 g

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
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CERMET SILVER CONDUCTOR 9907

RoHS Compliant* Conductor for use with Fuel Cells

ESL 9907 is a silver conductor designed to be used as a current collector for solid oxide fuel cells (SOFC). It can be screen-printed and is also available in syringes for dispensing.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	75 ± 25 Pa.s
Bonding Mechanism:	Fritless
Colour:	Grey
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 15 - 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Optimum: Time at peak:	850 °C 10 - 12 min
Total Firing Cycle:		45 - 60 min
Substrate for Calibration:		ESL 41010
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness: 9 - 17 µm

Resistivity:
(when normalized @ 20 µm & co-fired with ESL 41010 tape) < 2 mΩ/sq.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR 9912-G

RoHS Compliant*

ESL 9912-G is a silver fuel cell and interconnect paste exhibiting excellent conductivity, adhesion to 96% alumina, fuel cell and other tape-cast materials, and excellent solder leach resistance. Its main use is as a ground plane conductor and SOFC Interconnect. It is compatible with 4920 dielectric and SOFC tape-cast materials.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:		850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100 °C / min
Total Cycle:		50 min
Substrate for Calibration:		96 % alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness: 12.5 ± 2.5 µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) ≤3 mΩ / sq.

Printing Resolution:
(line/space) 0.075 mm / 0.075 mm

Solder Wettability:
(RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C) > 95 %

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220 °C) 10 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	> 7.5 kg
Aged 48 hours at 150 °C:	> 7.5 kg

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Gold Conductors

802
Gold conductor paste specially developed for use with ESL low temperature co-fired ceramic tapes (LTCC). This material is designed as a via-fill metallization.

803
Pb/Cd/Ni-free gold, for use in LTCC systems

8813-G
Gold conductor especially formulated for aluminium nitride.

8831-UF
Unfluxed gold conductor developed for use as a conductive coating on other fired conductor films.

8835 (520°C)
Fritted, high conductivity gold conductor for soda-lime glass substrates.

8835-1A
Mixed bonded, high conductivity gold conductor for alumina substrates. Well suited for resistor terminations and microwave applications.

8835-1B
Mixed bonded, high conductivity gold conductor for alumina substrates. Well suited for resistor terminations and microwave applications.

8835-1BH
Mixed bonded, high conductivity gold conductor for alumina substrates. Well suited for resistor terminations and microwave applications.

8835-1D
Mixed bonded, high conductivity gold conductor for aluminium nitride substrates.

8835 VF-G
Lead and cadmium-free, high solids content gold conductor used for filling via posts in complex multilayer circuits.

8835 Via Fill
High solids gold conductor for filling vias in complex multilayer circuits. Suitable for through hole printing of laser drilled holes.

8836
Mixed bonded, gold conductor for thin printing. Well suited for automatic thermosonic wire bonding.

8836-D
Fritless, gold conductor (MICRO-LOK®) for 4905-CD dielectric. It exhibits excellent wire bond characteristics used in multilayers.

8836-F
Economical, general-purpose gold conductor for use on alumina and 4901 and 4905 Series dielectrics.

8837-G
Lead, Cadmium and Nickel-free gold conductor. Very thin printing (1-2 µm), wire bondable.

8844
Cadmium-free gold conductor that fires at 850°C. Excellent adhesion on both alumina and beryllia.

8844-G
Lead, Cadmium and Nickel-free general-purpose gold conductor designed to give thin, smooth and dense films.

8844-K
Economical, general-purpose gold conductor for use on alumina and over 4913-G dielectric.

8846-G
General-purpose alloyed gold conductor for use on ESL 4913-G dielectric and alumina. Lead, Cadmium and Nickel-free.

8846-GH
Higher solids version of 8846-G gold conductor suitable for large diameter wire bonding. Lead, Cadmium and Nickel-free.

8847
Exhibits excellent line definition, surface smoothness, printability and gold wire bonding properties.

8880
MICRO-LOK® gold conductor developed to give the best adhesion properties possible when printed and fired on a range of ceramic substrates.

8880-G
Lead, Cadmium and Nickel-free gold conductor. Exhibits excellent wire bonding and conductivity. Fritless, firing at 980°C.

8880-H
Higher solids version of 8880.

8881-B
Thin printing MICRO-LOK® gold paste for 96% alumina or 4905-C dielectric.

8881-BA
An alloyed gold version of 8881-B designed for use on 96% alumina substrates or with 4905-C dielectric to give high coverage.

8884 & 8884-A
Fritless 850°C firing gold conductors (MICRO-LOK®) that exhibit excellent adhesion on both alumina and beryllia. 8884-A is an alloyed version to give superior aged aluminium wire bond results.

8884-G
Lead, Cadmium and Nickel-free gold conductor. Exhibits excellent wire bonding and conductivity. Fritless, firing at 850°C.

8886
Fritless gold conductors providing a dense film approximately 1µ thick. Suitable for etching very fine patterns.

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GOLD CONDUCTOR 802

Conductor for Low Temperature Co-fired Ceramic Tapes

ESL 802 is a gold conductor paste specially developed for use with ESL low temperature co-fired ceramic tapes (LTCC). This material is designed as a via-fill metallization.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield RVT, ABZ spindle, 10 rpm, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
SOLIDS CONTENT:	87.5 ± 1.5 %
SHELF LIFE: (at 25 °C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325 / 25 ± 12 µm
LEVELING TIME: (at 25°C)	5 - 10 min
DRYING TIME: (at 80°C)	10 -15 min
FIRING TEMPERATURE:	Co-fired with LTCC
RATE OF ASCENT/DESCENT:	60°C - 100°C/minute
SUBSTRATE FOR CALIBRATION:	ESL 41010
THINNER:	ESL 401

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TYPICAL PROPERTIES

FIRED THICKNESS:
(measured on a 2 mm x 2 mm pad) 15 - 25 µm

RESISTIVITY:
(measured on a 100 mm x 0.25 mm conductor track) ≤ 30 mΩ/square

NOTES: All data was collected using ESL 41010 or similar tape, co-fired at 850ºC.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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GOLD CONDUCTOR 803

Conductor for Low Temperature Co-fired Ceramic Tapes

ESL 803 is a gold conductor paste specially developed for use with ESL low temperature co-fired ceramic tapes (LTCC). This material is designed for use as an inner layer or top layer metallization.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield RVT, ABZ spindle, 10 rpm, 25.5 ± 0.5 °C)	225 ± 50 Pa.s
SOLIDS CONTENT:	77.0 ± 1.5 %
SHELF LIFE: (at 25 °C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325 / 25 ± 12 µm
LEVELING TIME: (at 25°C)	5 - 10 min
DRYING TIME: (at 80°C)	10 -15 min
FIRING TEMPERATURE:	Co-fired with LTCC
RATE OF ASCENT/DESCENT:	60°C - 100°C/minute
SUBSTRATE FOR CALIBRATION:	ESL 41010
THINNER:	ESL 401

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TYPICAL PROPERTIES

FIRED THICKNESS: (measured on a 2 mm x 2 mm pad)	6 - 12 µm
RESISTIVITY: (measured on a 100 mm x 0.25 mm conductor track at 9 µm fired thickness)	≤ 10 mΩ/square
SOLDER WETTABILITY: (80 Au / 20 Sn solder)	Good
WIREBONDABILITY: (25 µm Au wire) **INITIAL PULL STRENGTH:**	≥ 10 grams
ADHESION: (90º pull, 2.0 mm x 2.0 mm pads) **INITIAL PULL STRENGTH:**	≥ 13 N

NOTES: All data was collected using ESL 41010 or similar tape, co-fired at 850ºC.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CEREMT GOLD CONDUCTOR 8813-G

RoHS Compliant* • For use with Aluminium Nitride Substrates

ESL 8813-G is a newly developed gold conductor especially formulated for AlN. It can be used for 25 and 50 micrometer gold wire bonding. ESL 8813-G is designed to not dry on the screen and can be printed with 125 micrometer lines and spaces.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	285 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		850°C
	Time at peak:	12 min
Total Cycle Time:		50 min
Substrate for Calibration:		aluminium nitride
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

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TYPICAL PROPERTIES

Fired Thickness:		10 - 14 µm
Resistivity:		< 6.0 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Thermosonic Au Wire Bond:		
	25 µm wire	≥ 9 g
	50 µm wire	≥ 25 g

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CEREMT GOLD CONDUCTOR 8831-UF

RoHS Compliant* • Unfluxed Gold Conductor

ESL 8831-UF is an unfluxed gold conductor developed for use as a conductive coating on other fired conductor films. It can be used to enhance wire bondability, to increase conductivity, and to provide an area for device attachment. In addition, it has been found useful as a ductile buffer layer for pin and lead frame attachment in packaging applications with low temperature co-fire tape. ESL 8831-UF has virtually no adhesion to bare alumina and therefore must be used on top of other conductors which supply the required adhesion properties.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	400 ± 30 Pa.s
Bonding Mechanism:	None
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 980°C
	Optimum:	980°C
	Time at peak:	10 - 15 min
Rate of Ascent/Descent:		60 - 100°C / min
Thinner:		ESL 401

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***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CEREMT GOLD CONDUCTOR 8835 (520°C)

For use on soda-lime glass substrates

ESL 8835 (520C) is a fritted, high conductivity gold conductor for use on soda-lime glass substrates. This material can be fired at 520°C with 15 minutes at peak temperature giving good adhesion to the glass. The conductor can also be used in applications requiring wire bonding and eutectic die attachments. It is suitable for liquid crystal watch manufacturing for shorting the top and bottom conductors.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Fritted
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		520°C
	Time at peak:	10 - 15 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		Soda-lime glass
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:		10 - 15 µm
Approximate Coverage:		55 - 70 cm²/g
Resistivity:		≤ 5 mΩ/□
Printing Resolution: (line/space)		0.100 mm / 0.125 mm
Solder Wettability: (80Au / 20Sn, RMA Flux, 5 sec. dip)		Excellent
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength:	3 - 5 kg
Thermosonic Au Wire Bond: (25 µm wire; bond temperature 150°C; 25g force)		4 - 7 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET GOLD CONDUCTOR 8835-1A

ESL 8835-1A is a mixed-bonded, high-conductivity gold material for use on alumina that gives excellent adhesion and is well suited for use as resistor terminations and for microwave applications. 8835-1A exhibits superior line definition.

The 8835-1A is an alloyed version of 8835-1B, and is designed to minimize the Al-Au intermetallic compound formed during elevated temperature aging of aluminium ultrasonic wire bonds.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 Months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:	Optimum: Time at peak:	850 °C in air 10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 8 - 15 µm

Approximate Coverage: 55 - 70 cm^2/g

Resistivity: 2 - 3 mΩ/□
(measured on a 100 mm x 0.25 mm conductor track)

Printing Resolution:
(line/space) 0.100 mm / 0.100 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80 Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	3.8 - 7.0 kg
Aged 48 Hours at 150°C:	2.5 - 6.0 kg

Ultrasonic Al Wire Bond:
(25 µm wire; Bond length 1 mm,
100% Wire breaks) 8 - 10 g

Thermosonic Au Wire Bond:
(25 µm wire; Bond length 1 mm,
100% Wire breaks) 6 - 9 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET GOLD CONDUCTOR

8835-1B
8835-1BH

ESL 8835-1B and 8835-1BH are mixed-bonded, high-conductivity gold materials for use on alumina that give excellent adhesion and are well suited for use as resistor terminations and for microwave applications. 8835-1B exhibits superior line definition.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 Months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 980°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 12.5 ± 2.5 µm

Approximate Coverage: 55 - 70 cm^2/g

Resistivity: ⩽4 mΩ/□
(measured on a 100 mm x 0.25 mm conductor track)

Printing Resolution:

(line/space)		
	8835-1B	0.075 mm / 0.075 mm
	8835-1BH	0.100 mm / 0.100 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80 Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	3.8 - 7.0 kg
Aged 48 Hours at 150°C:	2.5 - 6.0 kg

Ultrasonic Al Wire Bond:
(25 µm wire; Bond length 1 mm,
100% Wire breaks) 7 - 12 g

Thermosonic Au Wire Bond:
(38 µm wire; Bond length 1 mm,
100% Wire breaks) 12 - 20 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET GOLD CONDUCTOR 8835-1D

ESL 8835-1D is a mixed-bonded gold conductor specially formulated for use on aluminium nitride substrates, exhibiting good conductivity and adhesion. The paste can also be used for dotting applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000 °C in air
	Optimum:	850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100 °C / min
Substrate for Calibration:		AlN
Thinner:		ESL 431 or 429

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured AlN) 9.0 ± 1.0 µm

Approximate Coverage: 70 - 90 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) <4 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80Au/20Sn and 62Sn/36Pb/2Ag)
Initial pull strength: 2.5 - 3.5 kg

Thermosonic Au Wire Bond:
(25 µm wire; bond length 1 mm;
100% wire breaks) 8 - 12 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET GOLD CONDUCTOR 8835 VF-G

RoHS Compliant*

ESL 8835 VF-G has been designed as a high solids content gold conductor and is used for filling via posts in complex multilayer circuits. This conductor is compatible with the 4913 series dielectrics and will not shrink or crack when subjected to multiple firing.
8835-VFG may also be used for through-hole printing to provide connection through laser drilled holes in 96% alumina.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 or 200 S/S, 15 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	20 ± 5 µm
Approximate Coverage:	95 cm²/g
Resistivity:	< 30 mΩ/□

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET GOLD CONDUCTOR 8835 Via Fill

ESL 8835 Via Fill has been designed as a high solids content gold conductor and is used for filling via posts in complex multilayer circuits. This conductor is compatible with the 4905-C Series dielectrics and will not shrink or crack when subjected to multiple firing. It is available in two different viscosities and is therefore able to fulfil a wide range of customer requirements.

The lower viscosity version of 8835 Via Fill can also be used for through hole printing in laser drilled holes and does not exhibit shrinkage cracking or adhesion problems after firing.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 30 Pa.s 275 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 15 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	20 ± 5 µm
Approximate Coverage:	95 cm²/g
Resistivity:	< 30 mΩ/□

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
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CERMET GOLD CONDUCTOR 8836

Thin-Printing, General-Purpose Gold

ESL 8836 is an economical, general-purpose gold conductor for use on alumina and over ESL series' dielectrics 4901, 4905 and 4913. It has been specifically designed to give thin, smooth and dense films (6 - 9 µm fired thickness) and may be used as resistor terminations, preferably with 3900-Au Series resistors. Excellent results are obtained with both ultrasonic aluminium and thermosonic gold wire bonding.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 980°C in air
	Optimum:	850 °C
	Time at peak:	10 - 12 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		6 - 9 µm
Approximate Coverage:		80 - 85 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 8µm fired thickness)		< 6.0 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength: Aged 48 hours at 150°C:	> 4.0 kg > 3.0 kg
Ultrasonic Al Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 9 g
Thermosonic Au Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 8 g
Aged Au Wire Bond: (24 hours at 200°C)		> 5 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET GOLD CONDUCTOR 8836-D

Fritless Gold For Use On Dielectric

ESL 8836-D is a fritless, 850°C firing gold conductor (MICRO-LOK®) that has been designed for use on 4905-CD dielectric. It exhibits excellent wire bond characteristics (38µm Al and 50µm Au) and is extensively used in multilayer systems.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 9 - 14 µm

Approximate Coverage: 80 - 85 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 4 mΩ/□

Printing Resolution:
(line/space) 0.100 mm / 0.100 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	> 5.0 kg
Aged 48 hours at 150°C:	> 3.5 kg

Ultrasonic Al Wire Bond:
(38µm wire over 4905-CD,
bond length 1 mm, 100% wire breaks) > 16 g

Aged Al Wire Bond:
(24 hours at 200°C; 100% wire breaks) > 9 g

Thermosonic Au Wire Bond:
(50µm wire, over 4905-CD,
bond length 1 mm, 100% wire breaks) > 30 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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CERMET GOLD CONDUCTOR 8836-F

ESL 8836-F is an economical, general-purpose gold conductor for use on alumina and 4901 and 4905 Series dielectrics. It has been specifically designed to give thin, smooth and dense films (9 - 12 µm fired thickness). The conductor may be used as a resistor termination, preferably with 3900-Au Series resistors. Excellent results are obtained with thermosonic gold wire bonding (33 µm).

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 20 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 9 - 12 µm

Approximate Coverage: 80 - 85 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) <6.0 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	> 4.5 kg
Aged 48 hours at 150°C:	⩾2.4 kg

Thermosonic Au Wire Bond:
(33 µm wire; bond length 1 mm;
100% wire breaks) ⩾11 g

Aged Au Wire Bond:
(24 hours at 200°C) ⩾8.5 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET GOLD CONDUCTOR 8837-G

RoHS Compliant* Thin Printing Gold Conductor

ESL 8837-G is a very thin print gold conductor.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 50 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		400 S/S, 12 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Screen Mesh, Emulsion:		400 S/S, 12 µm
Fired Thickness:	1 print	2 - 3 µm
	2 prints	3 - 4 µm
	3 prints	4 - 6 µm
Approximate Coverage:		150 cm^2/g
Resistivity:	1 print	34 - 50 mΩ/sq.
	2 prints	11 - 17 mΩ/sq.
	3 prints	8 - 14 mΩ/sq.
Solder Wettability: (80 Au/20 Sn)		100%
Adhesion: (90° pull, 2.5 x 2.5mm pads, 80 Au/20Sn and 62Sn/36Pb/2Ag)	1 print	≥ 3.0 kg
	2 prints	≥ 4.0 kg
	3 prints	≥ 6.0 kg
Thermosonic Au Wire Bond: (25µm wire)	1 print	≥ 5.0 g
	2 prints	≥ 9.0 g
	3 prints	≥ 9.0 g

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET GOLD CONDUCTOR 8844

Cadmium-Free

ESL 8844 is an economical, general-purpose gold conductor for use on alumina and 4913-G dielectric. It has been specifically designed to give thin, smooth and dense films (7 - 9 µm fired thickness). Excellent results are obtained with thermosonic gold wire bonding.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	375 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 402

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 7 - 9 µm

Approximate Coverage: 80 - 85 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm
conductor track at 8 µm fired thickness) <7.5 mΩ/□

Printing Resolution:
(line/space) 0.075 mm / 0.075 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	>4.5 kg
Aged (48 hours at 150°C)	>1.7 kg

Thermosonic Au Wire Bond:
(25 µm wire; bond length 1 mm;
100% wire breaks) >7 g average

Aged Au Wire Bond:
(24 hours at 200°C) >5 g average

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET GOLD CONDUCTOR 8844-G

RoHS Compliant*

ESL 8844-G is an economical, general-purpose gold conductor for use on alumina and over 4913-G dielectric. It has been specifically designed to give thin, smooth and dense films (7 - 9 µm fired thickness). Excellent results are obtained with both ultrasonic aluminium and thermosonic gold wire bonding.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		7 - 9 µm
Approximate Coverage:		80 - 85 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 8 µm fired thickness)		< 6.0 mΩ/□
Printing Resolution: (line/space)		0.075 mm / 0.075 mm
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength: Aged 48 hours at 150°C:	> 6.0 kg > 4.0 kg
Ultrasonic Al Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 8 g
Aged Al Wire Bond: (48 hours at 150°C)		> 6 g
Thermosonic Au Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 8 g
Aged Au Wire Bond: (24 hours at 200°C)		> 7 g

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET GOLD CONDUCTOR 8844-K

RoHS Compliant*

ESL 8844-K is an economical, general-purpose gold conductor for use on alumina and over 4913-G dielectric. It has been specifically designed to give thin, smooth and extremely dense films (7 - 9 µm fired thickness). Excellent results are obtained with both ultrasonic aluminium and thermosonic gold wire bonding.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		7 - 9 µm
Approximate Coverage:		80 - 85 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 8 µm fired thickness)		< 6.0 mΩ/□
Printing Resolution: (line/space)		0.075 mm / 0.075 mm
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength: Aged 48 hours at 150°C:	> 6.0 kg > 4.0 kg
Ultrasonic Al Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 8 g
Aged Al Wire Bond: (48 hours at 150°C)		> 6 g
Thermosonic Au Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 8 g
Aged Au Wire Bond: (24 hours at 200°C)		> 7 g

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CERMET GOLD CONDUCTOR 8846-G

RoHS Compliant*

ESL 8846-G is a general-purpose alloyed gold conductor for use on alumina and 4913-G dielectric. It has been specifically designed to give thin, smooth and dense films (7 - 9 µm fired thickness). Excellent results are obtained with both thermosonic gold and aluminium wire bonding. This alloyed gold conductor gives superior aged aluminium wire-bond performance.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96 % alumina)		7 - 9 µm
Approximate Coverage:		80 - 85 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)		<7.5 mΩ/□
Printing Resolution: (line/space)		0.100 mm / 0.100 mm
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength: Aged 48 hours at 150 °C	> 6.0 kg > 4.0 kg
Thermosonic Au Wire Bond: (25 µm wire; bond length 1 mm; 100 % wire breaks)		> 8 g average
Aged Au Wire Bond: (24 hours at 200 °C)		> 7 g average
Ultrasonic Al Wire Bond: (25 µm wire; bond length 1 mm; 100 % wire breaks)		> 9 g average
Aged Al Wire Bond: (48 hours at 150 °C) (1000 hours at 150 °C)		> 6.0 g average > 4.5 g average

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CERMET GOLD CONDUCTOR 8846-GH

Large-Diameter Wire Bonding • RoHS Compliant*

ESL 8846-GH is an alloyed gold conductor suitable for large-diameter wire bonding for use on alumina and over lead-free dielectrics. It has been designed to give smooth, dense films and exhibits excellent wire bondability with both aluminium and gold wire.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	375 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 / 325 S/S, 20 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness:
Single layer - measured on a 2 mm x 2 mm pad on 96 % alumina: 9 - 13 µm

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track
at 12.0 µm fired thickness) <6.0 mΩ/□

Printing Resolution:
(line/space) 0.100 mm / 0.100 mm

Adhesion:

(90° pull, 2 mm x 2 mm pads,	Initial pull strength:	>6.0 kg
80Au/20Sn and 62Sn/36Pb/2Ag)	Aged 48 hours at 150 °C:	>4.0 kg

Thermosonic Au Wire Bond:

(50 µm wire; bond length 1 mm)	Initial pull strength:	>35 g average
	Aged 24 hours at 200 °C:	>35 g average

Ultrasonic Al Wire Bond:

(38 µm wire; bond length 1 mm)	Initial pull strength:	>17 g average
	Aged 48 hours at 150 °C:	>11 g average
(250 µm wire; bond length 4 mm)	Initial pull strength:	>650 g average
	Aged 48 hours at 150 °C:	>625 g average

Large-diameter wire bonding use requires double layer with 325 mesh screen: > 17 µm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CEREMT GOLD CONDUCTOR 8847

RoHS Compliant* • Thin printing

ESL 8847 is a cermet gold paste designed for printing on 96% alumina substrates. The conductor exhibits excellent line definition, surface smoothness, printability and gold wire bonding properties.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 50 Pa.s
Bonding Mechanism:	Fritless
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm or 400 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		850°C
	Time at peak:	10 - 15 min
Total Cycle Time:		50 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness:		8 ± 2 µm
Resistivity:		
(8 µm fired thickness)		< 5 mΩ/□
Printing Resolution:		
(line/space)		0.100 mm / 0.100 mm
Thermosonic Au Wire Bond:		
(25 µm wire on alumina)	Initial	≥ 8 g
	1000 hours @ 150°C	≥ 6 g
(50 µm wire on alumina, fired thickness >10 µm, 100% wire breaks)	Initial	≥ 40 g
	1000 hours @ 150°C	≥ 35 g

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET GOLD CONDUCTOR

8880
8880-H

Fritless Gold Conductor for High Reliability Applications And with High Reliability Wire Bondability

ESL 8880 and 8880-H (MICRO-LOK®) gold conductors have been developed to give the best adhesion properties possible when printed and fired on a range of ceramic substrate materials. This is achieved by a reactive bonding mechanism that does not require glass frit. Both these conductors have high conductivity and excellent wire bondability properties due to the absence of glass in the bonding mechanism. A version of 8880-H for aluminium large diameter wire bonding is available upon request.

The 8880-H conductor is a higher solids version of 8880 and has been successfully used on 99.5% alumina and Ferrite substrates for thick film microwave applications. These golds may be etched using KI/I_2 solutions for fine line definition to give lowest attenuation in microwave circuits using frequencies up to 20 GHz. Note that even small amounts (<10 ppm) of halogenated hydrocarbons in the furnace atmosphere will severely degrade the adhesion of these products.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	400 ± 30 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (20°C):		5 - 10 min
Drying at 125°C:		10 -15 min
Firing Temperature Range:		930 - 1000°C in air
	Optimum:	980 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 12.5 ± 2.5 µm

Approximate Coverage: 65 - 85 cm^2/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 3.0 mΩ/□

Printing Resolution:
(line/space)

8880	0.125 mm / 0.125 mm
8880-H	0.075 mm / 0.075 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80 Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	> 6.0 kg
Aged 48 hours at 150°C:	> 4.0 kg

Thermosonic Au Wire Bond:
(50 µm wire; bond length 1 mm) > 30 g average

Ultrasonic Al Wire Bond:

8880 (25 µm wire; bond length 1 mm)	> 8 g
8880-H (32 µm wire; bond length 1 mm)	> 15 g

Aged Al Wire Bond:

8880 (48 hours at 150 °C)	> 5 g
8880-H (168 hours at 150 °C)	> 8 g

Large Diameter Wire Bonding:
(380 µm wire; bond length 5 mm)

8880-H	Initial pull strength:	> 1000 g
	Aged 40 hours at 200°C:	> 900 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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ESL ELECTROSCIENCE
CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
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CERMET GOLD CONDUCTOR 8880-G

RoHS Compliant*

ESL 8880-G is a fritless (MICRO-LOK®) cadmium, nickel and lead-free, high-conductivity gold conductor for use on top of alumina and ESL 4913 dielectric.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 -15 min
Firing Temperature Range:		850 - 1000 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	10 - 12 µm
Approximate Coverage:	80 - 85 cm² / g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	2 - 3 mΩ / □
Printing Resolution: (line/space)	50 µm on 127µm spiral
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag) Initial pull strength:	> 4.5 kg
Thermosonic Au Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)	> 19 g
Aged Au 38 µm Bond: (24 hours at 200°C; 100% wire breaks)	> 15 g
Ultrasonic Al Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)	> 15 g
Aged Al 25 µm Bond: (48 hours at 150°C; 100% wire breaks)	> 6 g
Ultrasonic Al Wire Bond: (380 µm wire)	> 1200 g

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T: 610-272-8000
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CERMET GOLD CONDUCTOR 8881-B

ESL 8881-B is a thin printing fritless (MICRO-LOK®) gold paste designed for use on 96% alumina substrates or with 4905-C dielectric to give high coverage. The fired film exhibits strong adhesion to both bare alumina and 4905-C dielectric and may be easily etched using KI/I_2 solutions. Fired films of 8881-B are very dense with no centre line depression and give excellent line definition. 8881-B exhibits excellent wire bondability is a mixed-bonded, high-conductivity gold material for use on alumina.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 15 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 7.0 ± 1.0 µm

Approximate Coverage: 80 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 5.0 mΩ/□

Printing Resolution:
(line/space) 0.075 mm / 0.075 mm
Special screen: 0.050 mm / 0.050 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads,
80Au/20Sn and 62Sn/36Pb/2Ag)

Initial pull strength:	> 5.0 kg
Aged 48 Hours at 150°C:	> 3.6 kg

Ultrasonic Al Wire Bond:
(25 µm wire; bond length 1 mm;
100% wire breaks) > 8 g

Thermosonic Au Wire Bond:
(25 µm wire; bond length 1 mm;
100% wire breaks) > 8 g

Aged Au Wire Bond:
(25 µm wire; 24 hours at 150°C) > 6 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET GOLD CONDUCTOR 8881-BA

ESL 8881-BA is an alloyed gold version of 8881-B designed for use on 96% alumina substrates or with 4905-C dielectric to give high coverage. The fired film exhibits excellent Al wire bond retention and strong adhesion to both bare alumina and 4905-C dielectric. Fired films of 8881-BA are very dense with no centre line depression and give excellent line definition.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 15 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 8.0 ± 1.0 µm

Approximate Coverage: 80 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 5.0 mΩ/□

Printing Resolution:
(line/space) 0.075 mm / 0.075 mm

Solderability: Solderable with 80Au/20Sn alloy solder

Ultrasonic Al Wire Bond:

Initial (25 µm wire)	> 8 g
Aged 48 hours at 150°C	> 6 g
Initial (250 µm wire)	> 450 g
Aged 48 hours at 150°C	> 400 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET GOLD CONDUCTOR

8884
8884-A

The ESL 8884 and 8884-A are fritless 850°C firing gold conductors (MICRO-LOK®) that exhibit excellent adhesion on both alumina and beryllia. They are commonly used for high reliability, power hybrid modules. 8884-A is an alloyed version to give superior aged aluminium wire bond results; especially with large diameter wire.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	400 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 Months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 980°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:		
(measured on a 2 mm x 2 mm pad on 96% alumina)		12.5 ± 2.0 µm
Approximate Coverage:		60 - 70 cm^2/g
Resistivity:	8884	2.5 - 3.0 mΩ/□
(measured on a 100 mm x 0.25 mm conductor track)	8884-A	3.5 - 5.5 mΩ/□
Printing Resolution:		
(line/space)		0.125 mm / 0.125 mm
Adhesion:		
(90° pull, 2 mm x 2 mm pads,	Initial pull strength:	6.0 - 9.0 kg
80 Au/20Sn and 62Sn/36Pb/2Ag)	Aged 48 Hours at 150°C:	5.0 - 8.0 kg
Ultrasonic Al Wire Bond:		
(50 µm wire)	8884-A	90 g
(500 µm wire)	8884-A	2,000 g
Thermosonic Au Wire Bond:		
(25 µm wire)	8884 & 8884-A	≥ 8 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET GOLD CONDUCTOR 8884-G

RoHS Compliant*

ESL 8884-G is a fritless (MICRO-LOK®) cadmium, nickel and lead-free, high-conductivity gold conductor for use on top of alumina and 4913-G dielectric.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		10 - 12 µm
Approximate Coverage:		80 - 85 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)		2 - 3 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Adhesion: (90° pull, 2 mm x 2 mm pads, 80Au/20Sn and 62Sn/36Pb/2Ag)	Initial pull strength:	> 4.5 kg
Thermosonic Au Wire bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 19 g
Aged Au 38 µm Bond: (24 hours at 200°C; 100% wire breaks)		> 15 g
Ultrasonic Al Wire bond: (25 µm wire; bond length 1 mm; 100% wire breaks)		> 10 g
Aged Al 25 µm Bond: (48 hours at 150°C; 100% wire breaks)		> 6 g
Ultrasonic Al Wire Bond: (380 µm wire)		> 1200 g

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET GOLD CONDUCTOR 8886

ESL 8886 is a fritless gold conductor that has been developed for very fine line interconnect by print and etch processing in applications where higher conductivity rather than organo-metallic thin film gold is required. When printed using the recommended screen, a very dense, 1 µm thick film is obtained. When two layers are printed, the gold film is 100% dense and may be etched with KI/I_2 solutions to give fine line definition without discontinuities in the conductive paths. 8886 should be printed on top of high temperature glazes (Code 129) which are employed to confer smooth surface characteristics on standard 96% Al_2O_3 substrates. This combination of materials is recommended in applications such as thick film thermal printheads where very fine line resolution may be obtained by print and etch techniques. The gold conductor is also compatible as a termination for 8084 organo-metallic gold.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, #4 spindle, 25.5 ± 0.5 °C)	20 ± 5 Pa.s
Bonding Mechanism:	Fritless
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 or 400 S/S, minimum emulsion
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		glazed alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness:		
(on glazed alumina)	1 layer	1.1 ± 0.1 µm
	2 layers	2.2 ± 0.2 µm
Approximate Coverage:		254 cm^2/g
Resistivity:	1 layer	30 - 40 mΩ/□
	2 layers	20 - 25 mΩ/□
Printing Resolution:		
(line/space)		designed for print and etch
Solids Content:		50 - 55 %

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Heaters On Steel (HOS)

29xxx Series
Series of low value resistor materials for heating elements on stainless steel substrates insulated with 4924 dielectric.

29xxx-A Series
Series of low value resistor materials for heating elements on austenitic steel substrates insulated with 4916 dielectric.

29xxx-B Series
Series of low value resistor materials for heating elements on stainless steel substrates insulated with 4986 dielectric.

29xxx-C Series
Series of low value resistor materials for heating elements on ferric steel substrates insulated with 4987 dielectric.

4916
Dielectric composition for insulating unoxidised 304 type austenitic steels. Provides excellent breakdown voltage.

4924
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Cadmium, Lead, Nickel and Barium free.

4931
Dielectric paste designed to insulate unabraded, unoxidised, ferritic steels.

4932
Dielectric paste with a green glossy finish and high green strength.

4932-A
Dielectric paste with a clear glossy finish and high green strength.

4956
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Produces minimum bowing of substrate.

4986
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Designed for Co-firing Applications. RoHS Compliant, Nickel and Barium free.

4987
Dielectric composition for insulating unabraded, unoxidised, ferritic steels. Cadmium, Lead and Nickel-free.

4987-S
A low viscosity, fast-print version of 4987 designed to insulate unabraded, unoxidised, ferritic steels.

9501-CH
Silver/palladium conductor for terminations in HOS applications.

9695
Silver/palladium with a wide firing range. Featuring low cost, excellent adhesion, good solderability and high conductivity. Also for use on PES.

PTC-2611-I Special
Thermistor paste designed for making positive temperature coefficient thermistor films.

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET RESISTOR 29XXX Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-free*

ESL 29XXX Series are low value resistors designed for use as heating elements on stainless steel substrates in combination with ESL's insulating dielectrics. They are available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		ESL 4924 on 96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Dried Thickness:
(427 mm x 2.4 mm resistor track with 9695 terminations over 4924 dielectric) 21 ± 1 µm

Approximate Coverage: 80 cm^2 / g

Resistivity & TCR:

Table 1: Resistor Properties								
Product Number	29106	29206	29109	29115	29215	29130	29230	29515
Resistivity (mΩ/sq) ± 10%	100	200	100	100	200	100	200	500
Average TCR (ppm/°C) ± 50	600	600	900	1500	1500	3320	3320	1500

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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CERMET RESISTOR 29XXX-A Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-free*

ESL 29XXX-A Series are low value resistors designed for use as heating elements on austenitic stainless steel substrates insulated with ESL 4916 insulating dielectric. 29XXX-A is available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		ESL 4916 on 96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Dried Thickness:
(427.2 mm x 2.4 mm resistor track with 9695 terminations over 4916 Glaze) 21 ± 1 µm

Approximate Coverage: 80 cm^2 / g

Resistivity & TCR:

Table 1: Resistor Properties

Product Number	29103-A	29106-A	29206-A	29109-A	29209-A	29115-A	29215-A	29130-A	29230-A	29515-A
Resistivity (mΩ/sq) ± 10%	100	100	200	100	200	100	200	100	200	500
TCR (ppm/°C)	350	600	600	900	900	1500	1500	3250	3250	1500
TCR Tolerance (ppm/°C)	50	50	50	50	50	50	50	250	250	50

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
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CERMET RESISTOR 29XXX-B Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-free*

ESL 29XXX-B Series are low value resistors designed for use as heating elements on stainless steel substrates insulated with ESL's 4986 insulating dielectrics. 29XXX-B is available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		4986 on 96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Dried Thickness:
(427.2 mm x 2.4 mm resistor track with 9695 terminations over 4986 dielectric) 21 ± 1 µm

Approximate Coverage: 80 cm^2/g

Resistivity & TCR:

Table 1: Resistor Properties

Product Number	29103-B	29106-B	29206-B	29109-B	29209-B	29115-B	29215-B	29130-B	29230-B	29515-B
Resistivity (mΩ/sq) ± 10%	100	100	200	100	200	100	200	100	200	500
TCR (ppm/°C)	350	600	600	900	900	1500	1500	3250	3250	1500
TCR Tolerance (ppm/°C)	50	50	50	50	50	50	50	250	250	50

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CERMET RESISTOR 29XXX-C Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-Free*

ESL 29XXX-C Series are low value resistors designed for use as heating elements on ferritic stainless steel substrates insulated with ESL 4987 insulating dielectric. 29XXX-C is available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		225 ± 25 Pa.s
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		4987 on 96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Dried Thickness:
(427.2 mm x 2.4 mm resistor track with 9695 terminations over 4987 Glaze) 21 ± 1 µm

Approximate Coverage: 80 cm^2/g

Resistivity & TCR:

Table 1: Resistor Properties

Product Number	29103-C	29106-C	29206-C	29109-C	29209-C	29115-C	29215-C	29130-C	29230-C	29515-C
Resistivity (mΩ/sq) ± 10%	100	100	200	100	200	100	200	100	200	500
TCR (ppm/°C)	350	600	600	900	900	1500	1500	3250	3250	1500
TCR Tolerance (ppm/°C)	50	50	50	50	50	50	50	250	250	50

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INSULATING COMPOSITION 4916

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

FOR 304 TYPE AUSTENITIC STEEL

ESL 4916 is a dielectric composition designed to insulate unoxidised 304 type austenitic steels. Three separately fired layers of 4916, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves that all printing is carried out in clean room conditions. ESL 29XXX-A Series resistors are recommended for use as the heating elements with ESL 9695 (Pd/Ag) terminations. The heater should be protected by using an additional layer of 4916.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	125 ± 25 Pa.s
Solids content:	77.0 ± 2.0 %
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Drying Time (at 125°C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		120 grit, unoxidised 304 stainless steel
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 304 stainless steel measured using an Elcometer 345 thickness gauge) > 70 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2/g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1500 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 V DC at 25 °C in air)

After storage at 93 ± 2 % RH, 25 ± 2 °C for 48 hrs.	$> 10^9\Omega$
At 300°C	$> 10^9\Omega$

A wide range of ESL materials are compatible with 4916 permitting the fabrication of other COS (Circuits on Steel)®.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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INSULATING COMPOSITION 4924

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead, Nickel and Barium-Free*

ESL 4924 is a dielectric composition designed to insulate unabraded, unoxidised, ferritic steels. The 4924 is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4924, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves and that printing is carried out in clean-room conditions. With 9695 or 9501-CH terminations and 29XXX resistors used as the heating elements, 4924 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17 stainless steel
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:
(at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage: 40 cm²/g
(80 µm thickness)

Breakdown Voltage:
(measured on an 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) ≥ 1800 V AC

Insulation Resistance:
(measured on an 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93 ± 2% RH, 25 ± 2°C for 48 hrs.	$> 10^9\Omega$
At 300°C	$> 10^9\Omega$

A wide range of ESL materials are compatible with 4924 permitting the fabrication of other COS (Circuits on Steel)®

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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INSULATING COMPOSITION 4931

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

RoHS Compliant*

Dielectric composition ESL 4931 is designed to insulate unabraded, unoxidised, ferritic steels. 4931 is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4931, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves at all times in clean room conditions. ESL 9695 and 9501-CH terminations and ESL 29xxx resistors are recommended for use as the heating elements. 4931 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time:		5 - 10 min
Drying Time (at 125 °C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air) > 10^9 Ω

A wide range of ESL materials are compatible with 4931 permitting the fabrication of other COS (Circuits on Steel)®.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
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OVERGLAZE COMPOSITION 4932

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4932 is a cadmium and lead-free, glossy finish, high green strength overglaze.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		150 ± 25 Pa.s
Colour:		Green
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 °C
	Time at peak:	10 min
Total Firing Cycle:		60 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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OVERGLAZE COMPOSITION 4932-A

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4932-A is a cadmium and lead-free, glossy finish, high green strength overglaze.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Clear
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 °C
	Time at peak:	10 min
Total Firing Cycle:		60 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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INSULATING COMPOSITION 4956

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

RoHS Compliant*

ESL 4956 is a dielectric composition designed to insulate unabraded, unoxidised, ferritic steels. The 4956 is non-porous and produces minimum bowing of substrate as its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4956, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves and that printing is carried out in clean-room conditions. With 9695 or 9501-CH terminations and 29XXX resistors used as the heating elements, 4956 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17 stainless steel
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:
(at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage: 40 cm²/g
(80 µm thickness)

Breakdown Voltage:
(measured on an 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) ≥ 1800 V AC

A wide range of ESL materials are compatible with 4956 permitting the fabrication of other COS (Circuits on Steel)®

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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INSULATING COMPOSITION 4986

HOS Heaters on Steel® • Designed for Co-firing Applications

RoHS Compliant*

Dielectric composition ESL 4986 is designed to insulate unabraded, unoxidised ferritic steels. The product 4986 is non-porous and its TCE closely matches that of 430 S17 grade stainless steels. It may be co-fired using a regular 850°C furnace/1 hour profile providing that care is taken with settling, drying and cooling times between prints. It is essential that the steel is only handled using protective gloves at all times in a Clean Room environment. Excellent breakdown voltage between top conductive prints and the steel base can be achieved with a minimum thickness of 80µm in three layers. ESL 29XXX-B resistors with 9695 terminations are recommended for use as the heating elements. ESL 4986 is recommended as an 850°C overglaze whilst 4771-P1 may be used as a low-temperature overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications. In addition a wide range of ESL materials are compatible with 4986 permitting the fabrication of other COS (Circuits on Steel)®

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	165 S/S, 0 µm
Levelling Time (at 25°C):	5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)	> 15 min
Firing Temperature Range:	850°C - 930°C in air
Optimum:	850°C
Time at peak:	10 min
Total Firing Cycle:	1 hour
Substrate For Calibration:	Unabraded, unoxidised 430 S17 122.5 mm diameter x 1.2 mm
Thinner:	ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2/g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25 °C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93 ± 2 % RH, 25 ± 2 °C for 48 hrs.	$> 10^9 \Omega$
At 300°C	$> 10^9 \Omega$

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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INSULATING COMPOSITION 4987

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-Free*

Dielectric composition ESL 4987 is designed to insulate unabraded, unoxidised, ferritic steels. 4987 is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4987, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves at all times in clean room conditions. ESL 9695 and 9501-CH terminations and ESL 29XXX resistors are recommended for use as the heating elements. 4987 is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Levelling Time:		5 - 10 min
Drying Time (at 125 °C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air) > 10^9 Ω

A wide range of ESL materials are compatible with 4987 permitting the fabrication of other COS (Circuits on Steel)®.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
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INSULATING COMPOSITION 4987-S

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-Free*

Dielectric composition ESL 4987-S is low viscosity/fast-print version of 4987 designed to insulate unabraded, unoxidised, ferritic steels. 4987-S is non-porous and its TCE closely matches that of 430 S17 grade stainless steel. Three separately fired layers of 4987-S, having a minimum total thickness of 80 µm, provide excellent breakdown voltage between top conductive prints and the steel base. It is essential that the steel is only handled using protective gloves at all times in clean room conditions. ESL 9695 and 9501-CH terminations and ESL 29XXX-C resistors are recommended for use as the heating elements. 4987-S is recommended as an 850°C overglaze. These materials are also useful in other TFOS (Thick Film on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	27.5 ± 2.5 Pa.s
Colour:	Dark blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		165 S/S, 0 µm
Drying Time (at 125 °C): (dependent on substrate volume)		> 15 min
Firing Temperature Range:		850°C - 930 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Unabraded, unoxidised 430 S17
		122.5 mm diameter x 1.2 mm
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:
(of at least 3 layers between 9695 and 430 S17 stainless steel measured using an Elcometer 345 thickness gauge) > 80 µm

Approximate Coverage:
(80 µm thickness) 40 cm^2 / g

Breakdown Voltage:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric at 25°C in air using a standard Clare Flash Tester) 5/5 ≥ 1800 V AC

Insulation Resistance:
(measured on a 88 mm diameter 9695 print on a 108 mm diameter area of dielectric using 500 VDC at 25 °C in air)

After storage at 93 ± 2% RH, 25 ± 2°C for 48 hrs.	> 10^9 Ω
At 300°C	> 10^9 Ω

A wide range of ESL materials are compatible with 4987-S permitting the fabrication of other COS (Circuits on Steel)®.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PLATINUM CONDUCTOR 9501-CH

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

ESL 9501-CH is a low-cost, high-speed printing conductor material exhibiting high-conductivity and excellent adhesion. 9501-CH may be used contact pads for ESL 29XXX series resistors in HOS (Heaters on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	150 ± 20 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	10.5 ± 2.5 µm
Approximate Coverage:	60 - 70 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	2 - 4 mΩ/□ max
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	≥5 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	7 - 9 kg
Aged 48 hours at 150°C:	5 - 9 kg

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CERMET SILVER/PALLADIUM CONDUCTOR 9695

Cadmium Free

ESL 9695 is a low-cost, high-conductivity silver/palladium conductor for use on alumina. It is also used as a termination for 29XXX series resistors over 4924 dielectric in **Heaters on Steel® (HOS)**. It has a wide-firing temperature range and can also be used on Porcelain Enamelled Steel (PES). This conductor exhibits excellent solderability and adhesion and may be used as a termination for all ESL 850°C-firing resistor systems, as well as many other commercially available systems.

9695 is commonly used for ground plane and buried conductor layers in multilayer hybrid circuits as a substitute for higher palladium content conductors to improve conductivity and lower cost. A typical system consists of 9695, 4905-CH dielectric and 9633-B as the top conductor for excellent solder leach resistance. A potentiometer grade, 9695-P is also available.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum on PES:	625°C
	Optimum on alumina:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	3 - 6 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 62Sn/36Pb/2Ag at 220°C)	95 - 100%
Solderability after overglaze: (500°C, 5 min., 62Sn/36Pb/2Ag)	90 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag at 220°C)	≥ 3 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	≥ 6.4 kg
Aged 48 hours at 150°C:	≥ 4.0 kg

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CERMET RESISTOR SYSTEM PTC 2611-I Special

RoHS Compliant*

The PTC 2611-I Special is a thermistor paste designed for making positive temperature coefficient thermistor films. Applications where a thermistor is required to be intimately bonded to the substrate such as temperature compensation of hybrid circuits and fast response sensors may be achieved. When used as a temperature sensor, a linear response is obtained from ambient to temperatures in excess of 300°C with the advantage of reduced size and lower cost

The PTC 2611-I Special is designed to withstand high power dissipation and is ideally suited to the manufacturing of self-limiting thick film heater elements for a wide range of consumer and industrial applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 30 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 18 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		825 - 850 °C (in air)
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Recommended Termination:		9912-A
Thinner:		ESL 401

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TYPICAL PROPERTIES

Dried Print Thickness: (on 96% alumina)	15 ± 1.0 µm
Resistivity:	15Ω ± 20 %
TCR: (measured on a 2 x 20mm resistor at 25 & 125°C)	3000 ± 400 ppm / °C
Voltage Gradient:	> 25 V / mm

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Materials for Aluminium

4603
Data Sheet is currently unavailable

4604
Data Sheet is currently unavailable

4605
Data Sheet is currently unavailable

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DIELECTRIC COMPOSITION 4603

Dielectric Composition for Aluminium • RoHS Compliant *

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DIELECTRIC COMPOSITION 4604

Dielectric Composition for Aluminium • RoHS Compliant *

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Metallo-Organic Conductors

5051

Platinum metallo-organic conductor for glazed substrates. Sulphur, Cadmium and Lead free. Produces no noxious odour during firing.

8081-A

Thin printing metallo-organic gold that produces a conductive film thinner than 1 micrometer. Used for non-migrating terminations. High coverage.

8081-D

Thin printing metallo-organic gold that produces a conductive film thinner than 1 micrometer. High coverage. Lead, cadmium and nickel-free.

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METALLO-ORGANIC PLATINUM INK 5051

RoHS Compliant*

ESL 5051 is a sulphur-free, metallo-organic platinum, designed for screen-printing applications on glazed substrates. 5051 produces no noxious odour during firing and is Cd and Pb-free. The fired films of platinum of 5051 are suitable for resistance thermometers, heaters and terminations for chemical sensors. It is uniquely qualified in applications where the presence of sulphur containing platinum products would act as a poison for chemical gas sensors. A single layer will produce a 0.15 to 0.25 micron thick continuous bright film.

5051 is an alternative for expensive vacuum deposited platinum thin films.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 4 spindle, 25.5 ± 0.5 °C)	25 ± 5 Pa.s
Shelf Life (20 - 25°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 - 400 S/S, 0 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		5 - 20 min
Firing Temperature:	Optimum: Time at peak:	850°C 10 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		Glazed ceramic*
Thinner:		ESL 401

*Recommended underglaze is Code 129-C

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TYPICAL PROPERTIES

Dried Thickness: 5 - 8 µm

Fired Thickness: 0.15 - 0.25 µm

Approximate Coverage: 680 sq. cm/g

Resistivity: 3 - 4 mΩ/□

Typical Properties on Glazed Ceramic

Number of Layers	Resistivity	Fired Film Thickness	Hot TCR (+25°C to 125°C)	Cold TCR (-55°C to +25°C)
1	3.20 Ω/□	0.20 µm	+3277 ppm/°C	+3287 ppm/°C
2	1.06 Ω/□	0.35 µm	+3331 ppm/°C	+3322 ppm/°C
3	0.64 Ω/□	0.60 µm	+3352 ppm/°C	+3353 ppm/°C
4	0.47 Ω/□	0.75 µm	+3358 ppm/°C	+3321 ppm/°C
5	0.38 Ω/□	0.88 µm	+3418 ppm/°C	+3414 ppm/°C
6	0.31 Ω/□	1.08 µm	+3407 ppm/°C	+3408 ppm/°C

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GOLD METALLO- ORGANIC COMPOSITION 8081-A

ESL 8081-A is a thin printing metallo-organic gold that produces a fired conductive film of less than one-micrometer in thickness. It can be used for non-migrating terminations for thick film resistors and is economical because of its high coverage. It is not recommended for wire bonding or soldering because of its thinness. This conductor contains a precious metal composition that decomposes with heat at temperatures above 300°C. At temperatures near 600°C, a "thin" film with good adhesion to the substrate is formed. By printing this conductor to the exact pattern desired, it can be used for many conductive purposes in which direct wire bonding or soldering is not required.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 5 spindle, 25.5 ± 0.5 °C)		50 ± 10 Pa.s
Shelf Life (20°C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 mesh, 25-33 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		625 - 850°C
	Optimum:	850°C
Rate of Ascent/Descent:		60 - 100 °C min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: < 1 µm

Resistivity: < 400 mΩ/□

NOTES:

1. Adequate air flow and ventilation to remove the burn-off products is essential or unpleasant odors may accumulate.

2. Thinners are not normally required. ESL 413 may be used sparingly. For screen cleaning, ESL413, isopropyl alcohol or acetone may be used.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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GOLD METALLO- ORGANIC COMPOSITION 8081-D

RoHS Compliant*

ESL 8081-D is a thin printing metallo-organic gold that produces a fired conductive film of less than one-micrometer in thickness. It is economical because of its high coverage. This conductor contains a precious metal composition that decomposes with heat at temperatures above 300°C. Depending on the substrate material, at temperatures near 600°C, a "thin" film with good adhesion to the substrate is formed. The paste can be used on alumina, glazed alumina, borosilicate, and soda-lime substrates. By printing this conductor to the exact pattern desired, it can be used for many conductive purposes in which direct wire bonding or soldering is not required.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 5 spindle, 25.5 ± 0.5 °C)	50 ± 10 Pa.s
Shelf Life (20°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 - 400 mesh, 0-28 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		625 - 850°C
	Optimum:	850°C
Rate of Ascent/Descent:		60 - 100 °C min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: < 1 µm

Resistivity: < 800 mΩ/□

NOTES:

1. Adequate air flow and ventilation to remove the burn-off products is essential or unpleasant odors may accumulate.

2. Thinners are not normally required. ESL 413 may be used sparingly. For screen cleaning, ESL413, isopropyl alcohol or acetone may be used.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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Overglazes & Underglazes

4770-BCG
Low temperature, green overglaze for use with ESL resistor systems. Well suited to overglaze resistors before laser trimming.

4771-G
Low temperature, green overglaze with a matte finish for use with ESL resistor systems. Well suited to overglaze resistors before laser trimming.

4771-P
Low temperature, Cadmium and Lead free overglaze designed for screen printing over resistors in hybrid circuits.

4771-P1
Low firing temperature, semi-matte finish, high green-strength overglaze designed for screen-printing over resistors in hybrid circuits. Cadmium and lead-free.

4774-BCG
Low temperature, screen printable green resistor overglaze for use when laser trimming ESL resistor systems.

4909 MOD
Dielectric for printing over thick film thermal print head resistors. Excellent thermal conductivity and surface wear resistance.

4932
Dielectric paste with a green glossy finish and high green strength.

4932-A
Dielectric paste with a clear glossy finish and high green strength.

CODE 129C
Smooth dielectric for thermal printhead underglaze and other high temperature.

G481 & G482
Low temperature firing, semi-glossy, acid resistant, screen printable overglazes. For use with the R300-A/B Resistor Series. Cadmium free.

G485-1

Cadmium and lead-free, low firing temperature, glossy finish, high green strength overglaze. Green colour.

G486-1

Cadmium and lead-free, low firing temperature, glossy finish, high green strength overglaze. Black colour.

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416 EAST CHURCH ROAD
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T: 610-272-8000
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OVERGLAZE COMPOSITION 4770-BCG

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

ESL 4770-BCG overglaze composition is designed for use as a screen-printable protective and stabilizing coating over cermet conductors, resistors in thick film circuits and discrete resistors. Thin (approximately 12µm fired) coatings of 4770-BCG over resistors are preferred for good post laser trim stability.

When large numbers of large area overglaze prints are fired it is important that the furnace be supplied a sufficiency of clean and dry air. For further information please see the separate Air Supply data sheet.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	275 ± 30 Pa.s
Colour:	Translucent green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 12 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)		10 - 15 min
Firing Temperature Range:		500°C - 550°C in air
	Optimum:	525°C
	Time at peak:	5 - 10 min
Total Firing Cycle:		30 min
Thinner:		ESL 401

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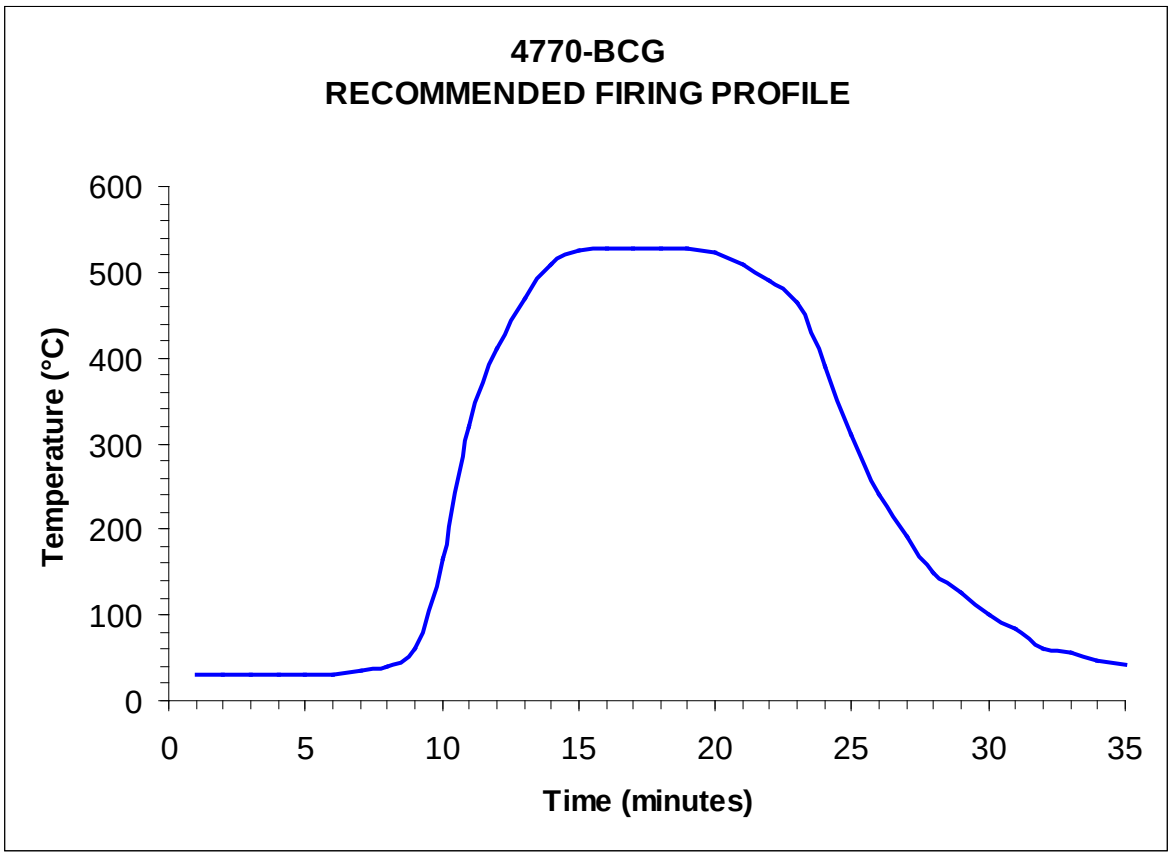
TYPICAL PROPERTIES

Fired Thickness: 10 - 14 µm



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OVERGLAZE COMPOSITION 4771-G

ESL 4771-G is a low-temperature, matte finish, green overglaze designed for screen-printing over resistors in hybrid circuits.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	160 ± 30 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 12µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		495 - 510°C (in air)
	Optimum:	500°C
	Time at peak:	1 min
Rate of Ascent/Descent:		90 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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OVERGLAZE COMPOSITION 4771-P

Acid Resistant, RoHS Compliant*

ESL 4771-P is a low firing temperature, semi-matte finish, green overglaze designed for screen-printing over resistors in hybrid circuits.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No.7 spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		525 - 625°C (in air)
	Optimum:	525°C
	Time at peak:	5 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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OVERGLAZE COMPOSITION 4771-P1

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4771-P1 is a low firing temperature, semi-matte finish, high green-strength overglaze designed for screen-printing over resistors in hybrid circuits.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		525 - 625 °C (in air)
	Optimum:	525 °C
	Time at peak:	5 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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OVERGLAZE COMPOSITION 4774-BCG

Low-Temperature-Firing Overglaze for Resistors

ESL 4774-BCG is a low temperature screen printable green resistor overglaze especially formulated for laser trimming when used with ESL Resistor Systems.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	275 ± 40 Pa.s
Colour:	Translucent green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 37.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C): (dependent on substrate volume)		10 - 15 min
Firing Temperature Range:		525°C - 565°C in air
	Optimum:	525°C
	Time at peak:	10 - 15 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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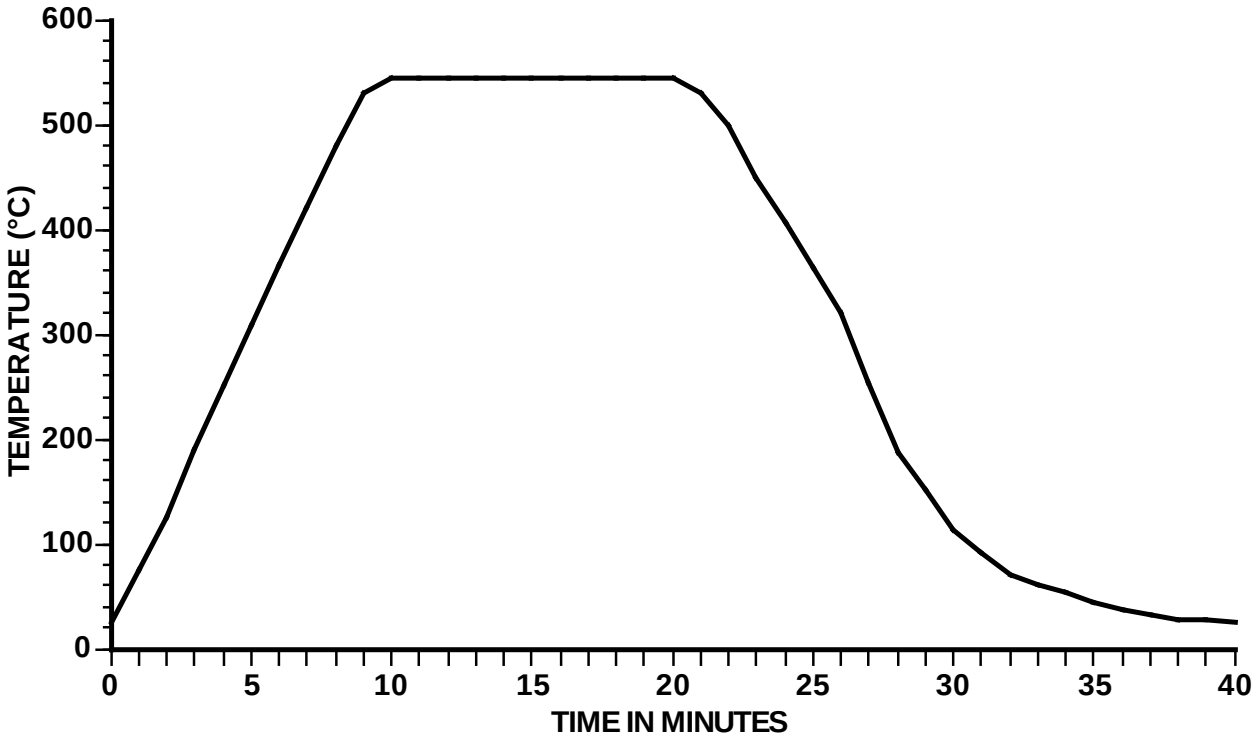
TYPICAL PROPERTIES

Fired Thickness: 12 - 18 µm

4774-BCG
RECOMMEND FIRING PROFILE



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DIELECTRIC COMPOSITION 4909-MOD

ESL 4909-MOD is designed for printing over fired thick film thermal printhead resistors. It provides excellent thermal conductivity as well as wear resistant surface.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	70 ± 15 Pa.s
Colour:	White - Transparent when fired
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		150 S/S, 25 - 40 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850°C
	Time at peak:	10 - 12 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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OVERGLAZE COMPOSITION 4932

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4932 is a cadmium and lead-free, glossy finish, high green strength overglaze.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		150 ± 25 Pa.s
Colour:		Green
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 °C
	Time at peak:	10 min
Total Firing Cycle:		60 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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www.electroscience.com

OVERGLAZE COMPOSITION 4932-A

High Green Strength, Acid Resistant, RoHS Compliant*

ESL 4932-A is a cadmium and lead-free, glossy finish, high green strength overglaze.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Clear
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 °C
	Time at peak:	10 min
Total Firing Cycle:		60 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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DIELECTRIC GLAZE PASTE CODE 129 C

ESL Code 129 C is a screen-printable, smooth surface dielectric designed for thermal printhead underglaze and other high temperature glaze applications

PASTE DATA

Rheology:	
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 50 Pa.s
Colour:	Off white
Solids Content:	72 - 75 %
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 37.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		1350°C
	Time at peak:	15 min
Firing Atmosphere:		air
Flow Rates:		10 - 60 litres / hour
Firing Profiles:		(See page 2)
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

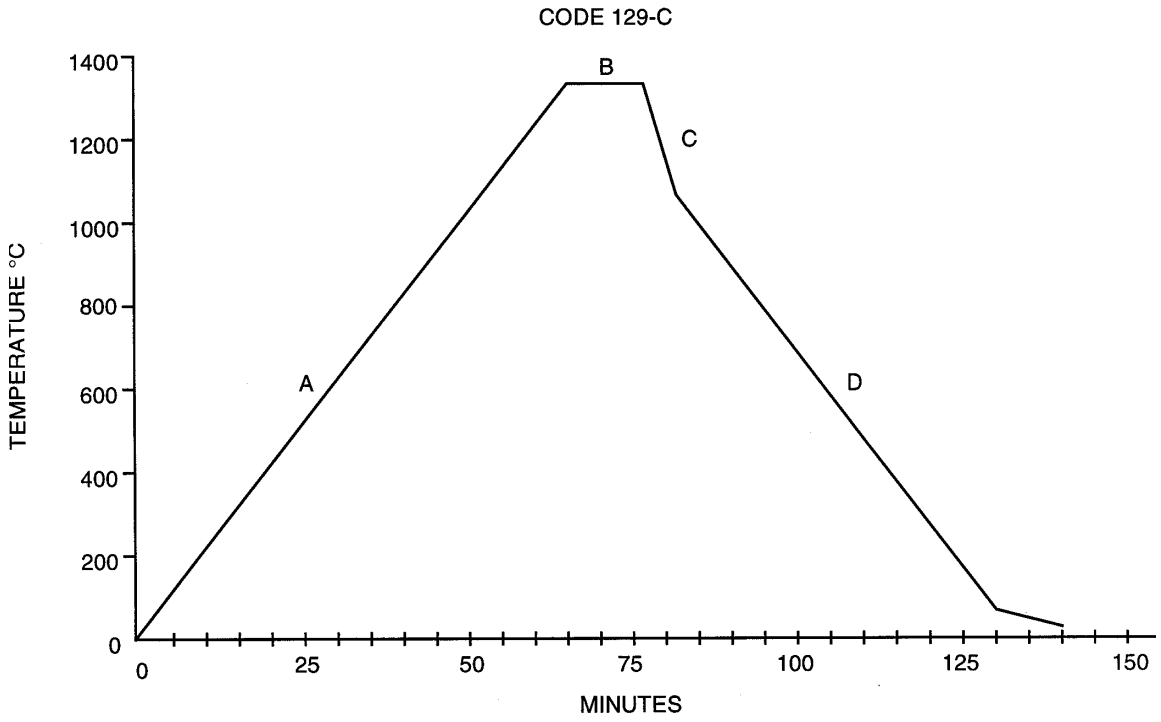
Fired Film Thickness:
(2 co-fired layers) — 50 µm total

TCE:
(25 - 400 °C) — 67 - 68 x 10^{-7} / °C

Glass Transition Point (Tg): — 703°C

Dilatometric Softening Point: — 761°C

Surface Smoothness: — Ra = 0.04 µm
(50 µm) — meniscus 5 µm



Segment	Mode	Rate (°C/min)	From (°C)	To (°C)	Time (min)
A	Heat	20	25	1350	66
B	Isothermal	0	1350	1350	15
C	Cool	50	1350	1100	5
D	Cool	20	1100	25	55

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OVERGLAZE COMPOSITION

G481
G482

Cadmium-Free

ESL G-481 and G-482 are low-temperature firing, semi-glossy, acid resistant, screen-printable overglazes. They are specially formulated for use with the ESL R-300-A/B Resistor Series. Due to their acid-resistant properties, they are particularly well suited for use with chip resistors. The G-481 is green in colour and is used for the first coating over the resistor prior to laser trim. The G-482 is designed for use as the final glass coating. Both may be used where resistance to acid plating baths is desired. Both materials are cadmium-free.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		225 ± 50 Pa.s
Colour:	G481:	Green
	G482:	Black
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		600 - 625°C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: 7 - 13 µm

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OVERGLAZE COMPOSITION G-485-1

High Green Strength, Acid Resistant, Cadmium and Lead-Free*

ESL G-485-1 is a cadmium and lead-free, low firing temperature, glossy finish, high green strength overglaze. It is designed for applications such as chip components that require electroplating.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 10 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		525 - 625 °C (in air)
	Optimum:	600 °C
	Time at peak:	5 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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OVERGLAZE COMPOSITION G-486-1

Acid Resistant, Cadmium and Lead-Free*

ESL G-486-1 is a cadmium and lead-free, low firing temperature, glossy finish, high green strength overglaze. It is designed for applications such as chip components that require electroplating.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 30 Pa.s
Colour:	Black
Shelf Life (20 - 25°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 12 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		525 - 625°C (in air)
	Optimum:	600°C
	Time at peak:	5 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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Palladium Conductors

6642

Fritless palladium conductor available in screen-printable or pourable versions designed for use on partially stabilized zirconia for oxygen sensors.

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CERMET PALLADIUM CONDUCTOR 6642

RoHS Compliant* Conductor for Oxygen Sensors

ESL 6642 is a fritless palladium conductor available in screen-printable or pourable versions. The material is designed for use on partially stabilized zirconia for oxygen sensors.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity:	
Printing Grade (Brookfield RVT ABZ spindle, 10 rpm, 25.5°C ± 0.5°C)	200 - 300 Pa.s
Pouring Grade (Brookfield RVT #3 spindle, 10 rpm, 25.5°C ± 0.5°C)	5 - 6 Pa.s
Bonding Mechanism:	MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion: (Printing grade)		325 S/S, 25 µm
Drying Time (at 70 - 125°C):		10 - 15 min
Firing Temperature Range:		1250 - 1450°C
	Time at peak:	15 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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Platinum Conductors

5051
Platinum metallo-organic conductor for glazed substrates. Sulphur, Cadmium and Lead free. Produces no noxious odour during firing.

5542
Fritless platinum conductor for partially stabilised zirconia. Resists oxidation.

5544
Fritted platinum conductor for use on 96% alumina substrate in resistance thermometer and heater applications. TCR > 3300 ppm / °C.

5545
Dense, fritted platinum coating for use on partially stabilised zirconia for oxygen sensors. Also for heating elements and tin oxide sensors.

5545-G
Screen-printable, dense, fritted platinum coating designed for use with partially stabilized zirconia for oxygen sensors and on alumina for semi-conducting tin oxide sensors for the detection of gases like CO or hydrocarbons.

5545-LS
Fritted platinum conductor for use as a heating element. Thin printing with TCR characteristics approaching that of bulk platinum.

5559-B
Platinum conductor designed to be co-fired with alumina tape at high temperatures.

5570
Platinum conductor designed to be co-fired with alumina tape or partially stabilised zirconia tape at high temperatures.

5571
Platinum conductor designed to be co-fired with alumina tape at high temperatures for use as a heater in planar sensors.

5572
Platinum conductor for use as an inner electrode material for partially stabilized zirconia conical oxygen sensors.

5573
Platinum conductor for use as an outer electrode material for partially stabilized zirconia conical oxygen sensors.

5574
Platinum conductor designed to be co-fired with alumina at high temperatures for conical oxygen sensors.

5575
Platinum via-fill conductor designed to be co-fired with alumina tape or partially stabilized zirconia tape at high temperatures.

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METALLO-ORGANIC PLATINUM INK 5051

RoHS Compliant*

ESL 5051 is a sulphur-free, metallo-organic platinum, designed for screen-printing applications on glazed substrates. 5051 produces no noxious odour during firing and is Cd and Pb-free. The fired films of platinum of 5051 are suitable for resistance thermometers, heaters and terminations for chemical sensors. It is uniquely qualified in applications where the presence of sulphur containing platinum products would act as a poison for chemical gas sensors. A single layer will produce a 0.15 to 0.25 micron thick continuous bright film.

5051 is an alternative for expensive vacuum deposited platinum thin films.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 4 spindle, 25.5 ± 0.5 °C)	25 ± 5 Pa.s
Shelf Life (20 - 25°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 - 400 S/S, 0 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		5 - 20 min
Firing Temperature:	Optimum: Time at peak:	850°C 10 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		Glazed ceramic*
Thinner:		ESL 401

*Recommended underglaze is Code 129-C

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TYPICAL PROPERTIES

Dried Thickness: 5 - 8 µm

Fired Thickness: 0.15 - 0.25 µm

Approximate Coverage: 680 sq. cm/g

Resistivity: 3 - 4 mΩ/□

Typical Properties on Glazed Ceramic

Number of Layers	Resistivity	Fired Film Thickness	Hot TCR (+25°C to 125°C)	Cold TCR (-55°C to +25°C)
1	3.20 Ω/□	0.20 µm	+3277 ppm/°C	+3287 ppm/°C
2	1.06 Ω/□	0.35 µm	+3331 ppm/°C	+3322 ppm/°C
3	0.64 Ω/□	0.60 µm	+3352 ppm/°C	+3353 ppm/°C
4	0.47 Ω/□	0.75 µm	+3358 ppm/°C	+3321 ppm/°C
5	0.38 Ω/□	0.88 µm	+3418 ppm/°C	+3414 ppm/°C
6	0.31 Ω/□	1.08 µm	+3407 ppm/°C	+3408 ppm/°C

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CERMET PLATINUM CONDUCTOR 5542 5542-DG

RoHS Compliant* Platinum Conductor for SOFC, Sensors, etc.

ESL 5542 is a fritless platinum paste that may be applied by screen-printing or dipping (5542-DG) to form electrodes on zirconia substrates for oxygen sensor and fuel cell applications.

5542 and 5542-DG are stable up to 800 - 900°C and resist oxidation.

PASTE DATA

Rheology:	5542: Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	5542: 85 ± 15 Pa.s
(Brookfield RVT, 10rpm, No. 3 spindle, 25.5 ± 0.5 °C)	5542-DG: 5.5 ± 0.5 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 100 °C):		10 -15 min
Firing Temperature Range:		980 - 1400°C in air
	Optimum:	980°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:	5542: 5.0 ± 1.0 µm
Resistivity:	5542: 65 - 85 mΩ/□

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET PLATINUM CONDUCTOR 5544

ESL 5544 is a screen printable, fritted Pt conductor for use on 96% alumina substrates in resistance-thermometer and heater applications. The TCR of the fired film is more than 3300 ppm/°C. The change of resistance is linear over the range of -50°C to +500°C.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	160±25 Pa•s
METALLIC PHASE:	platinum
BONDING MECHANISM:	Fritted
SHELF LIFE:	6 Months

PROCESSING

SCREEN/MESH/EMULSION:	325/37.5 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING RANGE:	980°C-1300°C
OPTIMUM:	1200°C
CALIBRATION TEMPERATURE:	980°C
TIME AT PEAK:	10 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER:	ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

FIRED FILM THICKNESS:	6-9 µm
RESISTIVITY:	≤ 70 mΩ/square
HOT TCR: (25°C to +125°C)	≥ 3300 ppm/°C
COLD TCR: (25°C to -55°C)	≥ 3300 ppm/°C
PRINTING RESOLUTION: (Line/Space)	125 µm x 125 µm

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET PLATINUM CONDUCTOR 5545

For Heating Elements and Sensors

ESL 5545 is a screen-printable, dense, fritted platinum coating designed for use with partially stabilized zirconia for oxygen sensors. It can also be used on alumina for semi-conducting tin oxide sensors for the detection of gases like CO or hydrocarbons. As a sensor, it's change in resistance is linear over the temperature range -50 to 500°C. ESL 5545 is suitable for use as a heating element and is stable at 600°C in H_2 containing atmospheres without significant degradation of adhesion (when fired at 1300°C). Excellent performance, on pre-fired ceramics, is obtained when fired at temperatures of 850°C - 1300°C.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Platinum Content:	64 - 67% by weight
Solids Content:	77 - 79% by weight
Bonding Mechanism:	Fritted
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1300°C in air
	Optimum:	980°C
	Time at peak:	15 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
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TYPICAL PROPERTIES

Resistivity (8 - 14 µm):	45 - 110 mΩ/□
Approximate Coverage:	80 - 100 cm^2/g
Adhesion: (90° pull, 2.5 mm x 2.5 mm pads, 62Sn/36Pb/2Ag solder on zirconia	>5.0 kg

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET PLATINUM CONDUCTOR 5545-G

RoHS Compliant*

ESL 5545-G is a screen-printable, dense, fritted platinum coating designed for use with partially stabilized zirconia for oxygen sensors. It can also be used on alumina for semi-conducting tin oxide sensors for the detection of gases like CO or hydrocarbons. As a sensor, its change in resistance is linear over the temperature range -50 to 500°C. ESL 5545-G is suitable for use as a heating element and is stable at 600°C in H_2 containing atmospheres without significant degradation of adhesion (when fired at 1300°C). Excellent performance, on pre-fired ceramics, is obtained when fired at temperatures of 850°C - 1300°C.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Solids Content:	77 - 79% by weight
Bonding Mechanism:	Fritted
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1300°C in air
	Optimum:	980°C
	Time at peak:	15 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina

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TYPICAL PROPERTIES

Resistivity (9 - 11 µm):	70 - 80 mΩ/□
Approximate Coverage:	80 - 100 cm^2/g
Adhesion: (90° pull, 2.5 mm x 2.5 mm pads, 62Sn/36Pb/2Ag solder on zirconia)	>5.0 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERAMIC TAPES & THICK-FILM MATERIALS
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T: 610-272-8000
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CERMET PLATINUM CONDUCTOR 5545-LS

For Heating Elements

ESL 5545-LS is a screen printable, fritted platinum conductor designed for use as a heating element. This material is thin printing and has TCR characteristics approaching that of bulk platinum. The TCR is the most positive when the material is fired at 1300°C. Customers who fire in the range of 850°C to 1300°C obtain excellent performance on pre-fired ceramics.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield HBT Cone/Plate Viscometer, at 38.4 sec^{-1}, 23°C±0.2°C)	60-90 Pa·s
BONDING MECHANISM:	Fritted
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME:	5-10 minutes
DRYING:	10-15 minutes, 90°C-125°C
DRIED THICKNESS:	9±3 µm
FIRING RANGE:	850°C-1300°C
CALIBRATION:	850°C
TIME AT PEAK:	10-12 minutes
SUBSTRATE OF CALIBRATION:	96% alumina

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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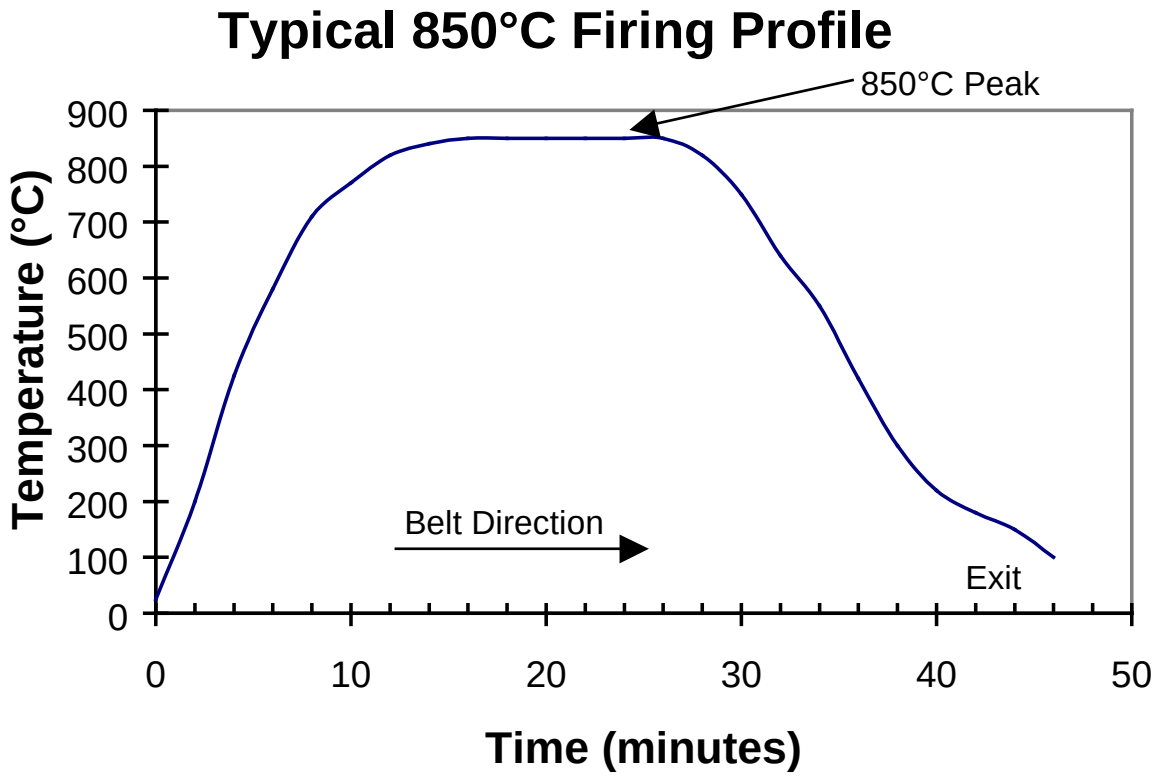
TYPICAL PROPERTIES

RESISTIVITY: (Normalized at 8 µm dried thickness)	300-400 mΩ/square
FIRED THICKNESS:	3.5-4.5 µm
SOLDERED ADHESION: (2.5 mm x 2.5 mm pads, 62 Sn/36 Pb/2 Ag solder, on zirconia)	> 50 N
TCR:	3500±200 ppm/°C



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CO-FIRING PLATINUM CONDUCTOR 5559-B

RoHS compliant* co-firable conductor designed for use as a heater in planar sensors

ESL 5559-B is a platinum conductor designed to be co-fired with alumina tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	75 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	90 ± 10 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SUBSTRATE OF CALIBRATION:	alumina tape

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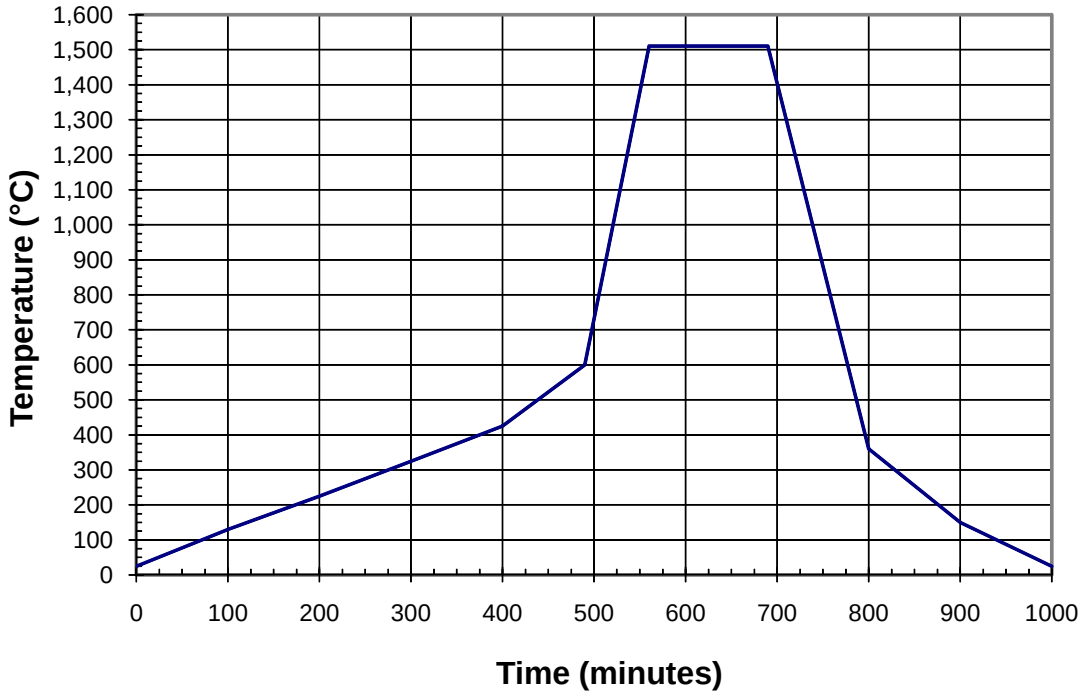
Typical Firing Profile for 5559-B



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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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CO-FIRING POROUS PLATINUM CONDUCTOR 5570

RoHS compliant* conductor designed for use as an electrode in planar sensors

ESL 5570 is designed to be co-fired with partially stabilized zirconia tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 20.0°C ± 0.5°C)	70 ± 20 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	30 ± 10 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SODIUM CONCENTRATION:	≤ 50 ppm
SUBSTRATE OF CALIBRATION:	partially stabilized zirconia tape

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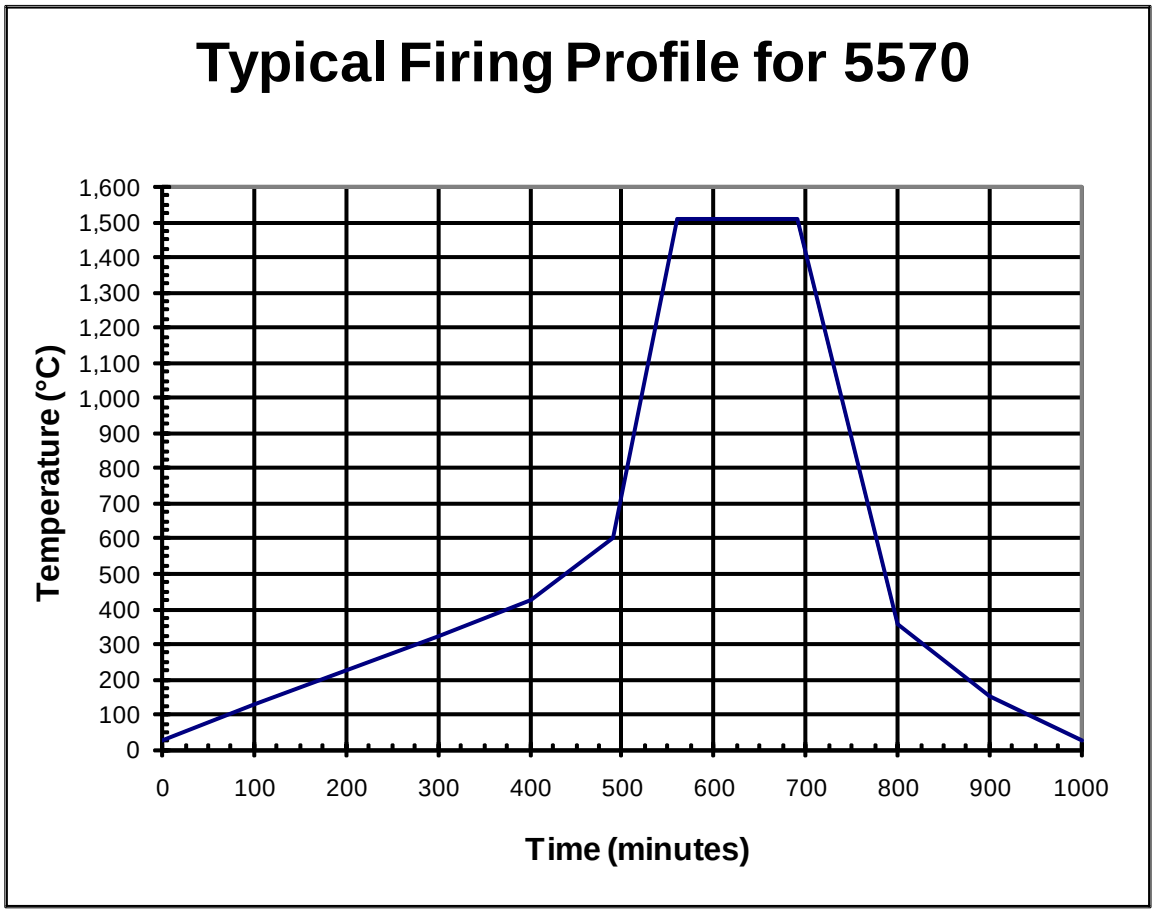

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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CO-FIRING PLATINUM CONDUCTOR 5571

RoHS compliant* co-fireable conductor designed for use as a heater in planar sensors

ESL 5571 is a platinum conductor designed to be co-fired with alumina tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable pastes
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	75 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	40 ± 5 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SODIUM CONCENTRATION:	≤ 50 ppm
SUBSTRATE OF CALIBRATION:	alumina tape

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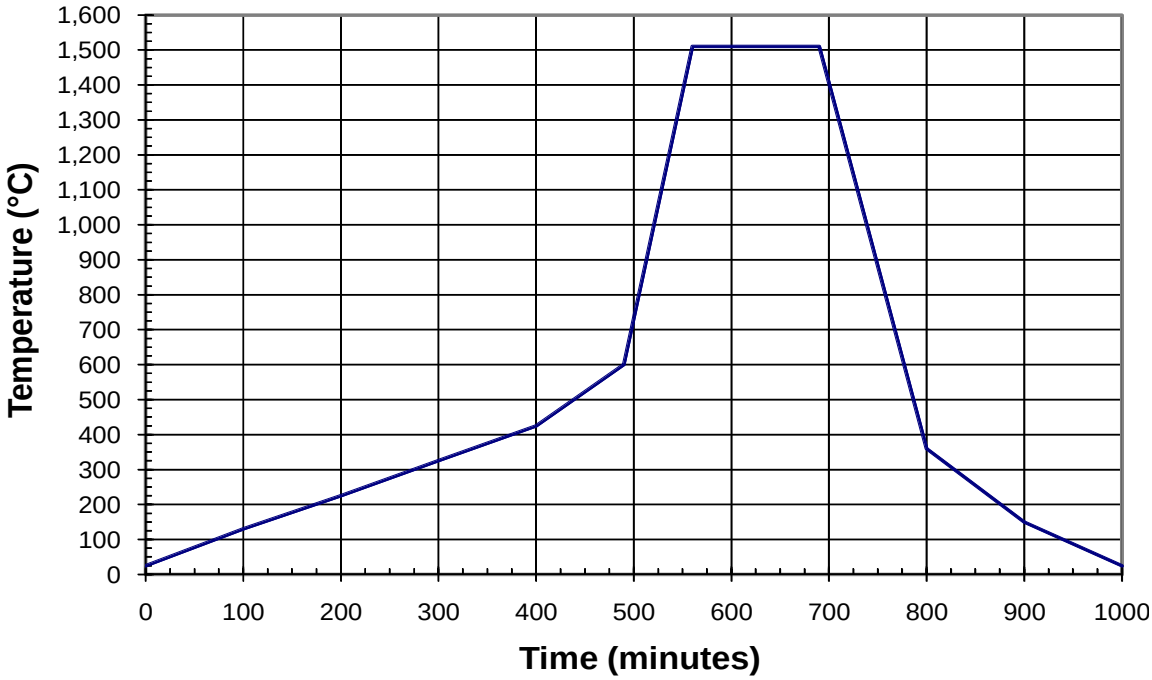
Typical Firing Profile for 5571



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CERMET PLATINUM CONDUCTOR 5572

RoHS Compliant* Conductor for Conical Oxygen Sensors

ESL 5572 is a platinum conductor for use as an inner electrode material for partially stabilized zirconia conical oxygen sensors. A pouring grade is available upon request.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY:	
(Brookfield HBT, cone/plate, 38.4 sec^{-1} at 20°C±0.5°C)	50-100 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION: (Printing Grade)	325/25 μm
DRYING:	10-15 minutes,125°C
FIRING RANGE:	1250°C-1510°C
TIME AT PEAK:	120 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER	ESL 437

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CERMET PLATINUM CONDUCTOR 5573

RoHS Compliant* Conductor for Conical Oxygen Sensors

ESL 5573 is a platinum conductor for use as an outer electrode material for partially stabilized zirconia conical oxygen sensors. This material performs well when fired on partially fired ceramic bodies. It is pad-printable.

PASTE DATA

RHEOLOGY:	Pad-printable paste
VISCOSITY:	
(Brookfield HBT, SC4-14/6R, 10 RPM at 25°C±0.5°C)	22-32 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION: (Printing Grade)	325/25 µm
DRYING:	10-15 minutes, 125°C
FIRING RANGE:	1250°C-1510°C
TIME AT PEAK:	120 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER	ESL 437

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CO-FIRING PLATINUM CONDUCTOR

5574
5574-A

RoHS compliant* co-fireable conductor designed for use as lead or contact pads in planar sensors

ESL 5574 is a platinum conductor designed to be co-fired with alumina at high temperatures. A lower resistivity version is also available (5574-A).

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable pastes
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	70 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:		325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	5574:	≤ 20 mΩ/square
	5574-A:	≤ 12 mΩ/square
FIRING RANGE:		1500°C ± 10°C
		see profile on back
TIME AT PEAK TEMPERATURE:		120 min.
SODIUM CONCENTRATION:		≤ 50 ppm
SUBSTRATE OF CALIBRATION:		alumina tape

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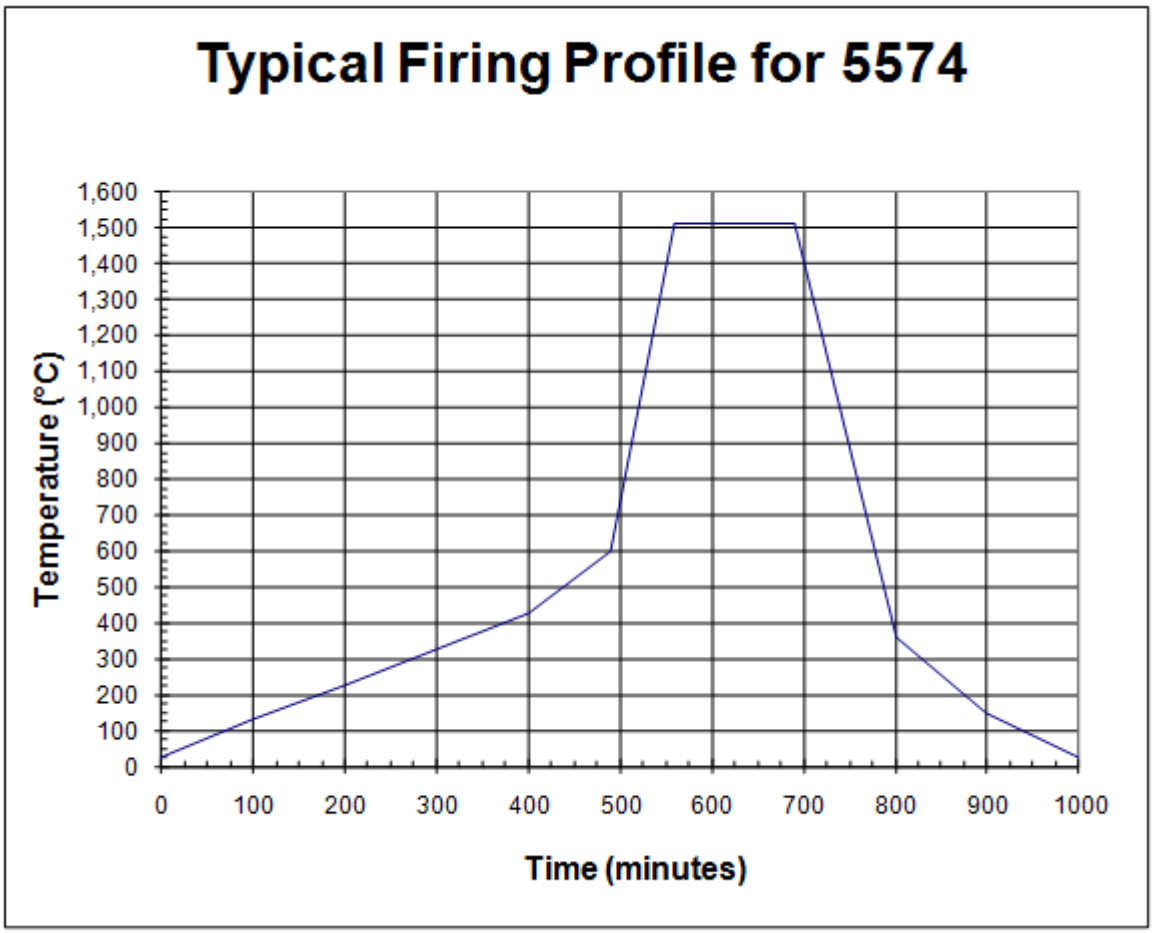

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CO-FIRING PLATINUM VIA-FILL CONDUCTOR 5575

RoHS compliant* co-firable conductor designed for use as a via-fill in planar sensors

ESL 5575 is a platinum via-fill conductor designed to be co-fired with alumina tape or partially stabilized zirconia tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, SC4-14 spindle, 1 RPM at 25.0°C ± 0.5°C)	1300 ± 200 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm in application, use a stencil
RESISTIVITY: (25 µm fired thickness)	50 ± 15 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SUBSTRATE OF CALIBRATION:	alumina tape

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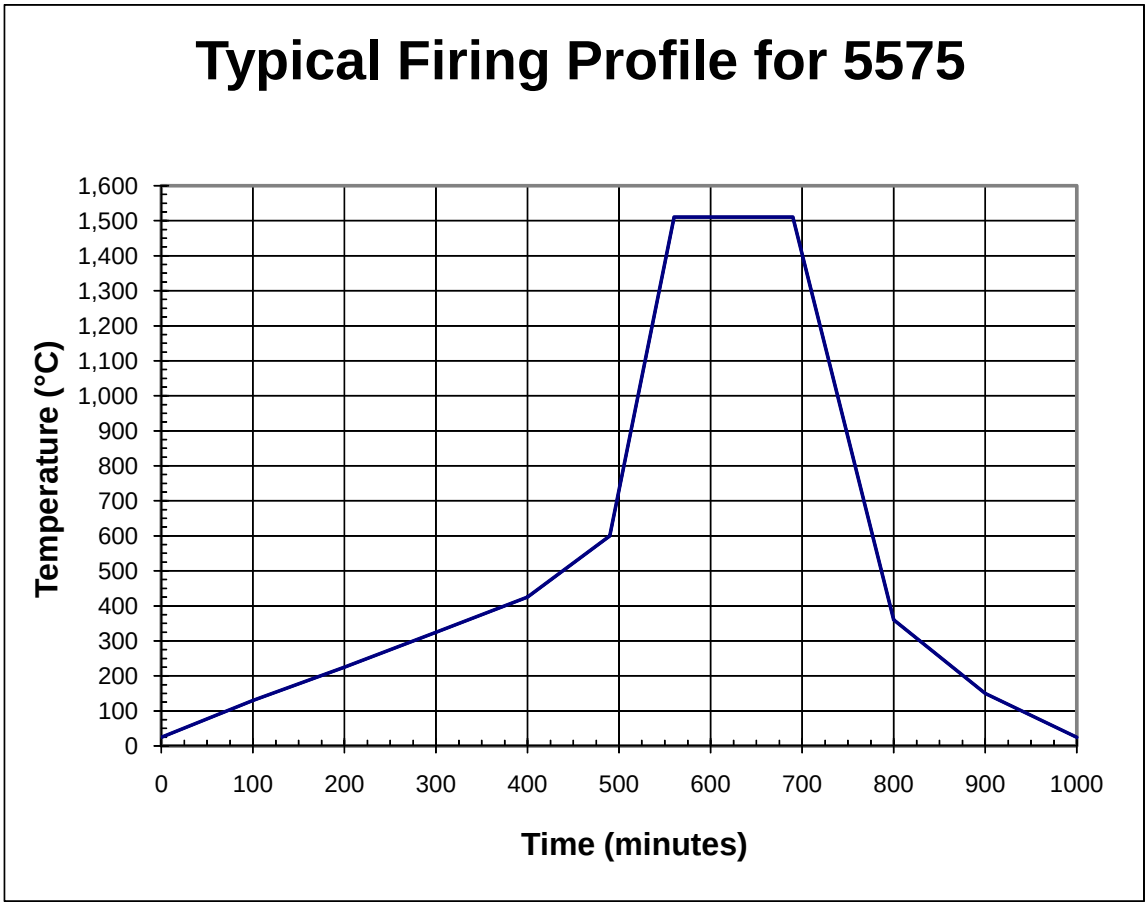

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Platinum / Gold Conductors

5800-B (850°C)
General-purpose platinum/gold conductor exhibiting good solderability and adhesion on alumina. Excellent solder leach resistance.

5837
Platinum gold conductor well suited for resistor terminations in hybrid circuits. Intend for use on bare alumina.

5837-A
Platinum gold conductor for top of 4905-C multilayer dielectric. Excellent solder leach resistance.

5837-G
Lead, Cadmium and Nickel-free platinum/gold conductor for printing on alumina and 4905-CH dielectric. Also suitable for beryllia.

5837-THP
Platinum gold conductor specially formulated for through hole printing and applications requiring low viscosity.

5867
Platinum/palladium/gold conductor designed for excellent bond strength, good solderability and solder leach resistance on both alumina and dielectric.

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CERMET PLATINUM/GOLD CONDUCTOR

5800-B (850)

Cadmium-Free

ESL 5800-B (850) is a cadmium-free, platinum / gold conductor designed for 850°C firing. This conductor exhibits excellent wear characteristics, solderability as well as adhesion and may be used in potentiometer applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	375 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000 °C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	11.0 ± 2.0 µm
Approximate Coverage:	75 - 100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 10.0 µm fired thickness)	< 75 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag,220 °C)	95% -100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220 °C)	> 5 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	> 7 kg
Aged 48 hours at 150°C:	> 5 kg

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CERMET PLATINUM/GOLD CONDUCTOR 5837

ESL 5837 is a platinum gold conductor solderable both on alumina and when printed and separately fired over 4905-CH dielectric. It is used in high reliability multilayer circuits where chip carriers are soldered to the top layer. Re-fire capability on alumina is also high. A typical system that is used is 8836/4905-CH/5837. 5837 can also be used on beryllia substrates with good initial adhesion. However, the aged adhesion is lower than that obtained on 96% alumina substrates. This may be improved by firing at 980°C.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)			12.0 ± 2.0 µm
Approximate Coverage:			55 - 70 cm^2/g
Resistivity:			40 - 65 mΩ/□
Printing Resolution: (line/space)			0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip)			
62Sn/36Pb/2Ag	(220°C)		95 - 100 %
62Sn/36Pb/2Ag	(250°C, over 4905-CH)		90 - 95 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)			10 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)			
	Initial pull strength:		5.5 - 8.0 kg
	Aged 48 hours at 150°C:		3.2 - 6.5 kg
	Initial pull strength:	on 4905-CH	4.0 - 8.0 kg
	Aged 48 hours at 150°C:	on 4905-CH	3.2 - 5.0 kg

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CERMET PLATINUM GOLD CONDUCTOR 5837-A

ESL 5837-A is designed for use on top of 4905-C multilayer dielectric. It is solderable with Sn60 solder and exhibits good solderability and excellent solder leach resistance. This material is ideally suited for high reliability hybrid circuits and for resistor terminations. This material should not be used directly on alumina substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	300±25 Pa·s
BONDING MECHANISM:	Mixed
SHELF LIFE: (25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING RANGE:	
OPTIMUM:	850°C
TIME AT PEAK:	10-12 minutes
RATE OF ASCENT/DESCENT:	60°C-100°C/minute
SUBSTRATE OF CALIBRATION:	4905-C on 96% alumina
THINNER:	ESL 413

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TYPICAL PROPERTIES

FIRED THICKNESS:	10-15 µm
APPROXIMATE COVERAGE:	55-70 cm^2/gram
RESISTIVITY: (Normalized to 12.5 µm)	≤ 70 mΩ/sq.
PRINTING RESOLUTION: (Line/Space)	125 µm x 125 µm
SOLDER WETTABILITY: (RMA flux, 5 sec, dip)	
62 Sn/36 Pb/2 Ag, 220°C±5°C	Excellent
63 Sn/37 Pb, 250°C±5°C	Excellent
SOLDER LEACH: (No. of 10 sec. dip to double resistance of 0.25 mm wide x 100 mm long conductor)	
62 Sn/36 Pb/2 Ag, 220°C±5°C	5-10 dips
ADHESION: (90° pull, 2.0 x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220°C±5°C)	
Initial pull strength:	50-60 N
Aged 48 hours at 150°C:	30-50 N
ULTRASONIC WIRE BOND: (25 µm Al wire)	5-8 grams
THERMOSONIC WIRE BOND: (25 µm Au wire)	3-5 grams
COMPATIBILITY:	R-300-A/B Resistor Series

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CERMET PLATINUM / GOLD CONDUCTOR 5837-G

RoHS Compliant*

ESL 5837-G is a platinum / gold conductor that is solderable both on 96% alumina substrates and when fired over 4913 and 4920 dielectrics. The 5837-G can be used in high reliability multilayer circuits where chip carriers are soldered to the top layer. The re-fire capability on alumina is also high. A typical lead and cadmium-free system consists of 8844-G gold conductor, 4913 dielectric and 5837-G. The 5837-G can also be used on beryllia substrates with excellent initial adhesion. However, the aged adhesion is lower than that obtained on 96% alumina substrates. This may be improved by firing at 980°C.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 12.0 ± 2.0 µm

Approximate Coverage: 55 - 70 cm^2/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 85 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:
(RMA flux, 5 sec. dip,
95.5Sn/3.8Ag/0.7Cu, 250°C)

on 96% alumina	95 - 100 %
over 4913	90 - 95 %
over 4920	90 - 95 %

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu, 250°C) > 6 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)

Initial pull strength:	on 96% alumina	> 7.0 kg
Aged 48 hours at 150°C:	on 96% alumina	> 4.0 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
www.electroscience.com

CERMET PLATINUM GOLD CONDUCTOR 5837-THP

A platinum gold conductor specially formulated for through-hole printing applications and other applications requiring low viscosity.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
METALLIC PHASE:	platinum gold
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	70-100 Pa·s
BONDING MECHANISM:	Mixed
SHELF LIFE:	6 months

PROCESSING

SCREEN/EMULSION:	200-325/25 µm
LEVELING TIME: (at 25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING:	800°C-1000°C
OPTIMUM:	850°C
TIME AT PEAK:	10-12 minutes
SUBSTRATE:	96% alumina
THINNER:	ESL 413

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TYPICAL PROPERTIES

RESISTIVITY: (Normalized 12.0 µm)	≤ 125 mΩ/sq
ADHESION: (90° pull, 2.0 x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220°C±5°C)	≥ 5.6 kg
COMPATIBILITY:	4608 & 4905-C

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CERMET PLATINUM PALLADIUM GOLD CONDUCTOR 5867

ESL 5867 is a platinum palladium gold conductor designed for excellent bond strength, good solderability and solder leach resistance on both alumina and dielectric. This material can be fired in the range of 850°C to 930°C, and is wirebondable with both ultrasonic aluminium wire and thermosonic gold wire. If used as the top conductor layer on dielectric, firing in the range of 700°C to 750°C will improve the solderability.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	350±25 Pa·s
BONDING MECHANISM:	Mixed
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING RANGE:	700°C-930°C
OPTIMUM:	850°C
TIME AT PEAK:	10-12 minutes
RATE OF ASCENT/DESCENT:	60°C-100°C/minute
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER:	ESL 413

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

FIRED THICKNESS:		10-15 µm
APPROXIMATE COVERAGE:		55-65 cm^2/g
RESISTIVITY: (Normalized 12.0 µm)		≤ 125 mΩ/sq.
PRINTING RESOLUTION: (Line/Space)		250 µm x 250 µm
SOLDER WETTABILITY:		
(RMA Flux, 5 sec. dip)	**62 Sn/36 Pb/2 Ag, 220°C±5°C**	Excellent
	63 Sn/37 Pb, 250°C±5°C	Excellent
SOLDER LEACH: (No. of 10 sec. dips to double resistance of 0.25 mm wide x 100 mm long conductor)		
	62 Sn/36 Pb/2 Ag, 220°C±5°C	5-9 dips
	63 Sn/37 Pb, 250°C±5°C	≥ 6 dips
ADHESION: (90° pull, 2.0 x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220°C±5°C)		
	Initial pull test:	4 - 5 kg
	Aged for 48 hours at 150°C:	3 - 4 kg
ULTRASONIC WIRE BOND: (25 µm Al wire)		5-7 g
THERMOSONIC WIRE BOND: (25 µm Au wire)		3-4 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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Polymers: Conductor

1107-S
Phenolic based, silver filled, thermosetting conductive polymer. Exhibits a very smooth surface.

1109-S
Silver filled, thermosetting phenolic resin material for use as a conductive coating, electrical contact, termination or adhesive.

1112-S
Silver filled, thermoplastic acrylic compound. Can be used on plastic substrates such as PC boards, polyester film as well as glass and ceramic.

1120
Silver filled resin material for use as a conductor on low temperature substrates. May be applied on flexible substrates.

1901-E
An economic silver-filled resin material designed for use as a conductor on glass substrates.

1901-H
Slow-drying, silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates.

1901-H1
A silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates.

1901-S
Silver filled, flexible resin material for use as a conductor on low temperature substrates. May be used as an antenna on smart cards. Resistivity <20 mΩ/□ at 25 - 35 µm cured thickness.

1901-S (LV)
A low viscosity, silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates.

1901-SB
An economical silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates.

1901-SD

Slow drying, silver filled, flexible resin material for use as a conductor on low temperature substrates. May be used as an antenna on smart cards. Resistivity <20 mΩ/☐ at 25 - 35 µm cured thickness.

1902

Silver/silver chloride filled, flexible resin material for use as a sensor compound. May be used on most plastic/flexible or regular rigid substrates.

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T: 610-272-8000
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POLYMER SILVER CONDUCTOR 1107-S

RoHS Compliant*

ESL 1107-S is a phenolic based, silver filled, thermosetting conductive polymer that exhibits a very smooth surface. It can be nickel plated by electroless techniques to enhance solder leach resistance and solderability.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm ABZ Spindle, 25.5 ± 0.5 °C)	80 ± 20 Pa.s
Shelf Life: (Material will dry when in contact with air. Refrigerated storage is recommended)	6 months

PROCESSING

Screen Mesh, Emulsion:	200-325 S/S, 25 µm
Levelling Time (20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Curing Schedules:	Ventilated Box Oven: 150°C / 2hrs IR Furnace: 220°C peak / 3 - 4 min
Substrate for Calibration:	96% alumina
Thinner:	ESL 402

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

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TYPICAL PROPERTIES

Cured Thickness:	25 ± 7 µm
Approximate Coverage:	150 cm^2 / g
Resistivity:	<40 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 2 sec. dip, 62Sn/36Pb/2Ag, 220°C)	Very good to excellent
Compatibility:	240-SB Polymer

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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POLYMER SILVER CONDUCTOR 1109-S

RoHS Compliant*

ESL 1109-S is a silver-filled, thermosetting phenolic resin material designed for use as a conductive coating, electrical contact, termination or adhesive. It exhibits excellent adhesion to metal, glass, ceramic and most plastic surfaces. ESL 1109-S is used for screening conductive paths on printed circuit board materials and can be used as terminations for polymer resistors. It can be used for mounting silicon chips, monolithic capacitors and chip resistors onto circuits, and is non-corrosive to aluminium wire bonds. ESL 1109-S can be electroless nickel plated for solderability.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Shelf Life (at 5°C): (Material will harden when in contact with air. Refrigeration storage is recommended)	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25 µm
Levelling Time at 25°C:	5 - 10 min
Drying at 125°C:	10 - 15 min
Curing Schedule:	150 - 220 °C
Optimum:	150°C
Curing Time:	2 hours
Substrate for Calibration:	alumina
Thinner:	ESL 402

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 75 µm
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 50 mΩ/□
Solder Wettability: (RMA Flux, 2 sec. dip, 62Sn/36Pb/2Ag, 220°C)	Good

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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POLYMER SILVER CONDUCTOR 1112-S

RoHS Compliant*

ESL 1112-S is a silver-filled, thermoplastic acrylic resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used on flexible substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	60 ± 5 Pa.s
Shelf Life: (at 5°C refrigeration recommended)	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Levelling Time (20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Curing Schedule:	80°C / 1 hour or 125°C / 30 min Optimum: 125°C / 30 min
Substrate for Calibration:	96% alumina
Thinner:	ESL 419

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	23 ± 5 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 10 mm conductor track)	15 - 40 mΩ/□
Printing Resolution: (line /space)	0.250 mm / 0.250 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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POLYMER SILVER CONDUCTOR 1120

Low Temperature Curing • RoHS Compliant*

ESL 1120 is a silver-filled resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used on flexible substrates using roller applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 4 spindle, 25.5 ± 0.5 °C)	4.5 ± 1 Pa.s
Shelf Life: (at 0 - 5 °C refrigeration recommended)	6 months

PROCESSING

Drying Time (at 125°C):	1 - 2 min
Curing Schedule:	150°C / 30 min
Substrate for Calibration:	Mylar™
Thinner:	ESL 1120 Thinner

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 10 mm conductor track)	35 ± 5 µm
Approximate Coverage: (at 35 µm cured thickness)	35 cm^2/g
Resistivity: (measured on a 100 mm x 10 mm conductor track)	<20 mΩ/□
Resistance to Acetone:	Good
Flexibility: (to BS EN ISO 1519:1995)	Good, no cracking with 4mm cylindrical mandrel
Adhesion: (to DIN 53151)	Grade 0

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
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POLYMER SILVER CONDUCTOR 1901-E

RoHS Compliant*

Polymer Silver for Application on Glass Substrates

ESL 1901-E is an economic silver-filled resin material designed for use as a conductor on glass substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 1 rpm, No. 6 spindle, 25.5 ± 0.5 °C)	120 ± 20 Pa.s
Shelf Life (at 5°C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	Glass
Thinner:	ESL 110

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 30 mΩ/□
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

POLYMER SILVER CONDUCTOR 1901-H

RoHS Compliant*

Polymer Silver for Low Temperature Substrates

ESL 1901-H is a slow-drying, silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible, resistant to corrosion and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 1 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	30 ± 10 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 30 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 402

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	8 - 20 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 100mΩ/□
Storage at 60 °C / 85% relative humidity for 24 hours	No change in resistivity
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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POLYMER SILVER CONDUCTOR 1901-H1

RoHS Compliant*

ESL 1901-H1 is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used on most plastic / flexible substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	50 ± 10 Pa.s
Shelf Life: (at 5°C refrigeration recommended)	6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 25 µm
Levelling Time (20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Curing Schedule:		60°C / 10 min
	Optimum:	125°C / 30 min
Substrate for Calibration:		96% alumina
Thinner and Screen Clean Up:		ESL 419

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	18 - 28 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	15 - 25 mΩ/□
Printing Resolution: (line/space)	0.250 mm / 0.250 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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POLYMER SILVER CONDUCTOR 1901-S

RoHS Compliant*

Polymer Silver For Low Temperature Substrates

ESL 1901-S is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 1 rpm, No. 6 spindle, 25.5 ± 0.5 °C)	170 ± 10 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 20 mΩ/□
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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T: 610-272-8000
F: 610-272-6759
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POLYMER SILVER CONDUCTOR 1901-S (LV)

RoHS Compliant*

Polymer Silver For Low Temperature Substrates

ESL 1901-S (LV) is a low viscosity, silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 5 spindle, 25.5 ± 0.5 °C)	15 ± 3 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 35 mΩ/□

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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POLYMER SILVER CONDUCTOR 1901-SB

RoHS Compliant*

Polymer Silver For Low Temperature Substrates

ESL 1901-SB is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible, resistant to corrosion and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 1 rpm, No. 6 spindle, 25.5 ± 0.5 °C)	30 ± 10 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 20 mΩ/□
Storage at 60 °C / 85% relative humidity for 24 hours	No change in resistivity
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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POLYMER SILVER CONDUCTOR 1901-SD

RoHS Compliant*

Slow-Drying Polymer Silver for RFID Antennas

ESL 1901-SD is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates and may be used as an antenna in RFID applications. A slow-drying material to give excellent screen-life, the cured silver film remains reasonably flexible and the resistance of the antenna track remains constant over time. After fitting an appropriate chip, the RFID device can store information. The 1901-SD can also be used as an antenna in contactless smart cards. The paper, foil or plastic sheet bearing the printed antenna is laminated within a number of plastic layers and the individual cards are punched out. Many antenna patterns can be printed in a single operation.

This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	60 ± 10 Pa.s
Shelf Life (at 5°C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 20 mΩ/□
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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T: 610-272-8000
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POLYMER SILVER / SILVER CHLORIDE CONDUCTOR

1902

RoHS Compliant*

ESL 1902 is a 65:35 silver / silver chloride-filled, flexible resin material designed for use as an electrode in electrochemical sensors in various biomedical applications. This composition is a high solids screen printable silver conductor that may be used on various plastic/flexible or regular rigid substrates such as polyester, paper, ABS, FR4 or alumina.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 6 spindle, 25.5 ± 0.5 °C)	35 ± 15 Pa.s
Solids:	84 - 86 %
Storage & Shelf Life: In tightly sealed black jars in a stable environment at < 25°C	6 months

PROCESSING

Mix thoroughly with a plastic spatula before use.

Screen Mesh, Emulsion:	200 or 325 polyester, 25 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Curing Schedule:	125°C / 3 - 5 min
Substrate for Calibration:	Flexible PVC Card
Thinner:	ESL 117

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	30 ± 5 µm
Approximate Coverage:	60 cm^2 / g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 100 mΩ / □

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Polymers: Polyimide

14401
High temperature dielectric providing very good adhesion, thermal stability and electrical insulation when used on metal substrates.

15501
High temperature resistor for use on glass, ceramic, flexible polyimide insulated Aluminium and other metal substrates.

19101
High temperature, low resistivity Silver conductor that provides good adhesion and thermal stability. Designed for use as a heating element on a wide variety of substrates.

19102-A
Solderable high-temperature, low-resistivity silver conductor that provides good adhesion and thermal stability. Designed for use as a heating element on ceramic and polyimide film.

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POLYMER DIELECTRIC 14401

High Temperature Insulating Coating • RoHS Compliant*

ESL 14401 is a high temperature dielectric that provides very good adhesion, thermal stability, and electrical insulation when used over metal substrates such as aluminium or steel. It is designed for use with 19101 polymer silver conductor for heater applications requiring high temperature stability.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	60±10 Pa·s
COLOR:	Brown
SHELF LIFE: (at 5°C)	3 months

PROCESSING

SCREEN MESH/EMULSION:	165-200/0-30 µm
LEVELING TIME:	5-10 minutes
DRYING AT 125°C:	10-15 minutes
CURING CYCLE:	320°C/150 minutes
	(10°C-15°C/min. rise)
SUBSTRATE FOR CALIBRATION:	alumina
THINNER:	ESL 455

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TYPICAL PROPERTIES (five print, dry, co-cured layers, 320°C/150 minutes, ≥50 µm)

CURED THICKNESS:	≥50 µm
DIELECTRIC CONSTANT (K) AT 1 MHz: (25°C)	3.8-4.8
DISSIPATION FACTOR AT 1 MHz: (25°C)	< 0.2%
INSULATION RESISTANCE: (at 100 VDC)	> 10^{12} Ω•cm
BREAKDOWN VOLTAGE: (at 25°C in air)	≥ 1500VDC/25µm
FLASH BREAKDOWN VOLTAGE: (at 250°C, one minute, 5mA leakage current trip using a standard Clare Flash Tester, aluminium substrate)	≥ 1250VAC
STABILITY: (16 hrs. at 250°C)	No measurable change of electrical properties
COMPATIBLE MATERIALS:	ESL 19101 Silver Conductor
	ESL 15501 Resistor

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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POLYMER RESISTOR 15501

For High Temperature Applications • RoHS Compliant*

ESL 15501 is a high temperature resistor designed for use on glass, ceramic, flexible polyimide film, insulated aluminium and other metal substrates. When blended with ESL 19101 silver conductor, it provides resistivities in the range of 15 milliohms per square to 35 milliohms per square. It can be used with ESL 14401 polymer dielectric when co-cured with the dielectric.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	130±10 Pa·s
SHELF LIFE: (at 5°C)	3 months
(at -18°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	200-325/20-30 µm
LEVELING TIME:	5-10 minutes
DRYING AT 125°C:	10-15 minutes
CURING CYCLE:	320°C/150 minutes
	(10°C-15°C/min. rise)
SUBSTRATE FOR CALIBRATION:	glass
THINNER:	ESL 455

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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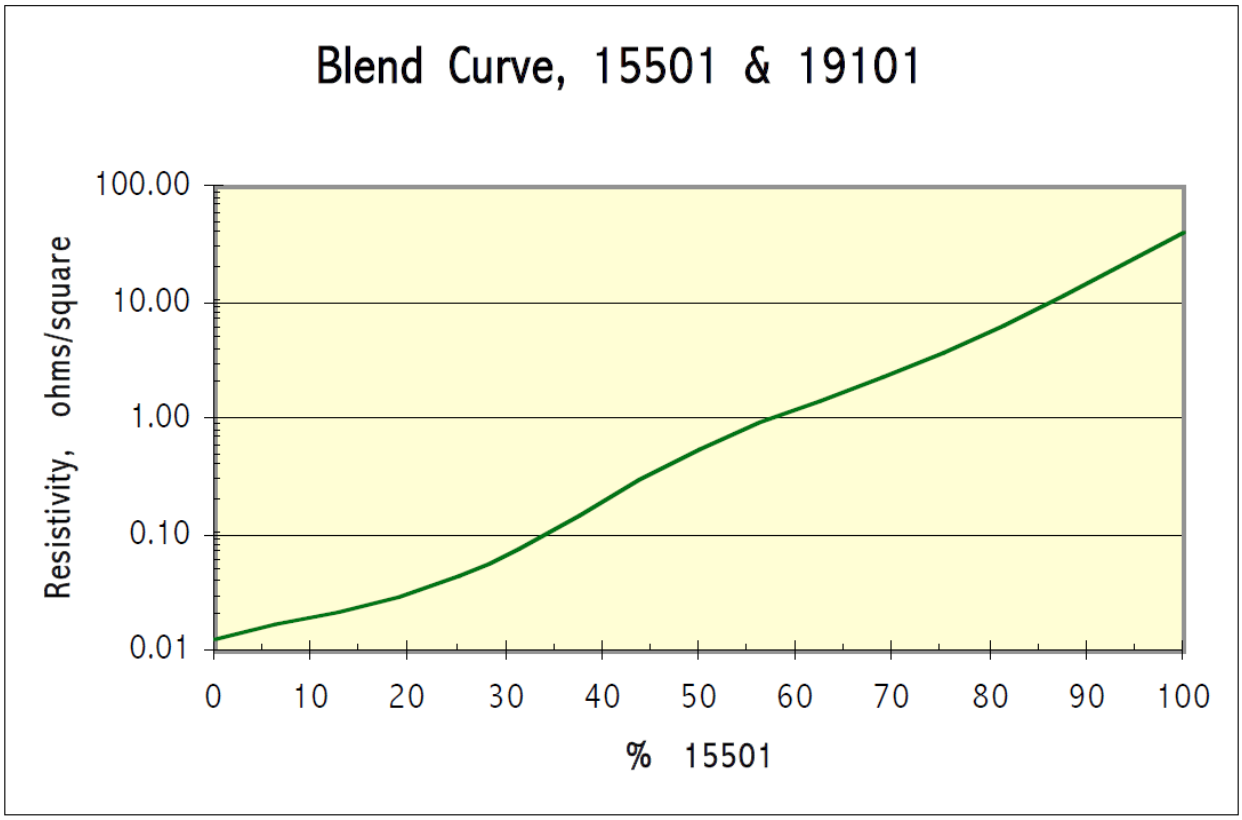
TYPICAL PROPERTIES

CURED THICKNESS:	10 - 15 µm
RESISTIVITY: (at 12.5 µm cured thickness)	35 - 45 Ω/square
TCR: (25-250°C)	3100±150 ppm/°C
RESISTIVITY STABILITY: (16 hrs. at 250°C)	≤10%
COMPATIBLE MATERIALS:	ESL 14101 Dielectric, ESL 19101 Conductor



***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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POLYMER CONDUCTOR 19101

For High Temperature Applications • RoHS Compliant*

ESL 19101 is a high temperature, low resistivity, silver conductor, which provides very good adhesion and thermal stability. It is designed for use as a heating element on glass, ceramic and polyimide film. The ESL 19101 can also be used on ESL 14401 polymer dielectric on metal substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	100±10 Pa·s
SHELF LIFE: (at 5°C)	3 months

PROCESSING

SCREEN MESH/EMULSION:	200/20-30 µm
LEVELING TIME:	5-10 minutes
DRYING AT 125°C:	10-15 minutes
CURING CYCLE:	320°C/150 minutes (10°C-15°C/min. rise)
SUBSTRATE FOR CALIBRATION:	glass
THINNER:	ESL 455

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

CURED THICKNESS:	8 - 14 µm
RESISTIVITY: (at 12 µm cured thickness)	8 - 16 mΩ/square
TCR: (25-250°C)	3100±150 ppm/°C
RESISTIVITY STABILITY: (16 hrs. at 250°C)	≤5%
COMPATIBLE MATERIALS:	ESL 14101 Dielectric

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T: 610-272-8000
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POLYMER SILVER CONDUCTOR 19102-A

RoHS Compliant* High Temperature Conductor

ESL 19102-A is a solderable high-temperature, low-resistivity silver conductor that provides good adhesion and thermal stability. It is designed for use as a heating element on ceramic and polyimide film. The ESL 19102-A can also be used on ESL 14401 and 14402 polymer dielectric on metal substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield RVT, ABZ spindle, 10 rpm, 25.5°C ± 0.5°C)	225 ± 50 Pa·s
COLOR:	Brown
SHELF LIFE: (at 5°C)	3 months

PROCESSING

SCREEN MESH / EMULSION:	200 / 20-30 µm
LEVELING TIME:	5-10 minutes
DRYING at 125°C:	10-15 minutes
CURING CYCLE:	320°C / 150 minutes (10-15°C/min. rise)
SUBSTRATE OF CALIBRATION:	aluminium
THINNER	ESL 455

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

CURED THICKNESS:	10-15 µm
RESISTIVITY: (12 µm cured thickness)	< 12 mΩ/sq.
COMPATIBLE MATERIALS:	ESL 14401 and 14402 dielectric

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Polymers: Protective

240-SB
Mineral filled, thermosetting modified silicone coating forming a protective coating for thick film materials. Blue in colour.

240-SB Colours
White, Grey, Red, Orange Yellow ,Green and Black versions of 240-SB. Commonly used as marking inks on standard 240-SB blue background.

240-SB FL
Fine line version of 240-SB for intricate solder dams. Also available in black.

241-S
Translucent version of 240-SB. May be used to protect resistors.

242-SB
Thermosetting, mineral filled epoxy coating resistant to solvent attack when fully cured. May be used on alumina or porcelain enamelled steel.

243-S
A screen-printable, thermo-setting, epoxy coating that is resistant to solvent attack when fully cured.

244-T
A screen-printable resin coating that may be used to protect silver polymer on glass substrates.

245 Black
A filled, thermosetting modified silicone coating for thick film conductors, resistors and capacitors on ceramic, porcelain enamelled steel and printed circuit boards.

245 White
A filled, thermosetting modified silicone coating for thick film conductors, resistors and capacitors on ceramic, porcelain enamelled steel and printed circuit boards.

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PROTECTIVE POLYMER COATING

240-SB
240-SB Fine Line
240-SB Colours
240-SB Dipping Grade

RoHS Compliant*

ESL 240-SB is a mineral-filled, thermosetting modified silicone coating. It has been specifically formulated as a screen-printable protective coating for thick film conductors, resistors and capacitors on ceramic, porcelain enamelled steel and printed circuit boards. Only one layer (~25µm) is required when used as a protective coating. The fine-line version of the product is designed for intricate solder dams as well as a marking ink. Both rheologies are available in standard blue or black.

ESL 240-SB Colours are also available in white, grey, red, yellow and green and these are commonly used as marking inks, often on a standard 240-SB Blue background. Separate drying followed by co-curing of the two polymer inks is essential for reliable adhesion.

The 240-SB Dipping Grade version of the polymer coating is low viscosity which is used as an encapsulant for hybrid circuits. Long drying schedules on thick coatings are recommended for this product.

Infrared curing can be used provided that there is adequate ventilation in the oven. However this is not recommended for thick coatings. The best results, easily tested by a solvent resistance check, are obtained by using a box oven and ensuring that the printed substrates are maintained at 200°C for one hour. At temperatures above 250°C all colours will darken. The hardest coatings are obtained with the highest temperature cures.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity:		
(Brookfield RVT,	240-SB, 240-SB Colours	150 ± 25 Pa.s (ABZ Spindle)
10 rpm, 25.5 ± 0.5 °C)	240-SB Fine Line	225 ± 25 Pa.s (ABZ Spindle)
	240-SB Grey	95 ± 10 Pa.s (No. 7 Spindle)
	240-SB Dipping Grade	13 ± 1 Pa.s (No. 4 Spindle)
Shelf Life (20 - 25 °C):		6 months

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PROCESSING

Screen Mesh, Emulsion:	240-SB	200 S/S, 25 µm
	240-SB Fine Line	325 S/S, 25 µm
Levelling Time (20°C):		5 - 10 min
Drying Time (at 125°C):	240-SB, Fine Line, Colours	10 - 15 min
(at 70 - 90 °C):	240-SB Dipping Grade	8 - 16 hours
Curing Schedules:	240-SB, Fine Line, Colours	150°C / 2hrs or 200°C / 1hr
	240-SB Dipping Grade	150°C / 1hr
Optimum:	240-SB, Fine Line, Colours	200°C / 1hr
Substrate for Calibration:		96% alumina
Thinner:		ESL 402

TYPICAL PROPERTIES

Cured Thickness: (measured on 96% alumina) (50 µm for the following data)		20 - 50 µm
Approximate Coverage:		120 cm^2 / g
Volume Resistivity:		$>10^{10}$ Ω.cm
Printing Resolution: (line/space)	240-SB Fine Line	0.150 mm / 0.150 mm
Service Temperature:		-100 to +150°C
Dielectric Constant (K) at 1 kHz: (at 25°C)		6 - 8
Dissipation Factor at 1 kHz: (at 25°C, depending upon conductor)		<0.1%
Insulation Resistance: (at 100V DC)		$>10^{10}$ Ω
Breakdown Voltage: (at 25°C in air)		> 500 V / 50µm
Solvent Resistance:		Good resistance to acetone when fully cured

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T: 610-272-8000
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POLYMER PROTECTIVE COATING 241-S

RoHS Compliant*

ESL 241-S is the translucent version of 240-SB and may be used to protect resistors. Overcoated resistors are visible to assist trimming.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Translucent blue
Shelf Life (at 20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Curing Schedule:		150°C / 2 hours or 200°C / 1 hour
	Optimum:	200°C / 1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 402

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on 96% alumina)	20 - 50 µm
Approximate Coverage:	120 cm^2/g
Volume Resistivity:	$>10^{10}\Omega.cm$
Service Temperature:	-100 to +150°C
Insulation Resistance:	$>10^{10}\ \Omega$
Solvent Resistance:	Good resistance to Acetone when fully cured

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PROTECTIVE POLYMER COATING 242-SB

RoHS Compliant*

ESL 242-SB is a screen-printable, thermo-setting, mineral-filled epoxy coating that is resistant to solvent attack when fully cured. This coating may be used to protect thick film circuits on alumina or porcelain enamelled steel. A typical polymer thick film multilayer build on printed circuit board (FR4) material consists of 1109-S / 242-SB / 1109-S electro-less nickel-plated. Only one layer (~25µm) is required when used as a protection; two layers are required for multilayer work.

Due to its mineral-filler, the 242-SB Series polymer coatings are not recommended for repeated flexing actions on plastic film substrates.
After printing, screen cleaning should be carried out using hydrocarbon solvent of low flash-point (as used in the PCB industry).

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm ABZ Spindle, 25.5 ± 0.5 °C)	80 ± 20 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 25 µm
Levelling Time (20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Curing Schedules:		150°C / 2hrs
	Optimum:	200°C / 1hr
Substrate for Calibration:		96% alumina
Thinner:		ESL 402

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TYPICAL PROPERTIES

Cured Thickness: (2 layers measured on 96% alumina)	45 ± 10 µm
Approximate Coverage:	120 cm^2 / g
Volume Resistivity:	$>10^{10}$ mΩ.cm
Service Temperature:	-100 to +150 °C
Dielectric Constant (K) at 1 kHz: (at 25°C)	5 - 10
Dissipation Factor at 1 kHz: (at 25°C, depending upon conductor)	<0.75%
Insulation Resistance: (at 100V DC)	$>10^{10}$ Ω
Breakdown Voltage: (at 25°C in air)	> 500 V / 50µm
Solvent Resistance:	Good resistance to acetone when fully cured

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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F: 610-272-6759
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PROTECTIVE POLYMER COATING 243-S

RoHS Compliant*

ESL 243-S is a screen-printable, thermo-setting, epoxy coating that is resistant to solvent attack when fully cured. This coating may be used to protect thick film circuits on alumina or porcelain enamelled steel.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm No. 7 spindle, 25.5 ± 0.5 °C)	80 ± 20 Pa.s
Shelf Life (20 - 25 °C):	6 months
Colour:	Translucent blue

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25 µm
Levelling Time (20 °C):	5 - 10 min
Drying Time (at 125 °C):	10 - 15 min
Curing Schedule:	150°C / 5 - 15 min
Substrate for Calibration:	96% alumina
Thinner:	ESL 402

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TYPICAL PROPERTIES

Cured Thickness: (1 layer measured on 96% alumina)	10 - 15 µm
Approximate Coverage:	120 cm^2 / g
Service Temperature:	-100 to +150 °C
Solvent Resistance:	Good resistance to acetone when fully cured
Acid Resistance:	<1% weight loss in 5% H_2SO_4 at room temperature

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CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
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F: 610-272-6759
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PROTECTIVE POLYMER COATING

244-T

RoHS Compliant*

ESL 244-T is a screen-printable resin coating. This coating may be used to protect silver polymer on glass substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm No. 7 spindle, 25.5 ± 0.5 °C)	100 ± 20 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 38 µm
Curing Schedules:	125°C / 5 - 15 min
Substrate for Calibration:	Glass
Thinner:	ESL 110

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness:
(1 layer measured on glass) 10 - 15 µm

Approximate Coverage: 120 cm^2 / g

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PROTECTIVE POLYMER COATING 245- Black

RoHS Compliant*

ESL 245-Black is a filled, thermosetting modified silicone coating. It has been specifically formulated as a screen-printable protective coating for thick film conductors, resistors and capacitors on ceramic, porcelain enamelled steel and printed circuit boards. Only one layer (~25µm) is required when used as a protective coating.

This product can be used as a G2 coating.

Touch dry after 10 minutes drying at 125°C.

It provides a hard solvent resistant finish that can be overprinted with conventional marking inks.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, 25.5 ± 0.5 °C)	170 ± 25 Pa.s (ABZ Spindle)
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 10 µm
Levelling Time (20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Curing Schedules:	150°C / 2hrs or 200°C / 1hr
Substrate for Calibration:	96% alumina
Thinner:	ESL 402

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on 96% alumina) (50 µm for the following data)	15 - 50 µm
Approximate Coverage:	120 cm^2 / g
Volume Resistivity:	$>10^{10}$ Ω.cm
Service Temperature:	-100 to +150°C
Dielectric Constant (K) at 1 kHz: (at 25°C)	6 - 8
Dissipation Factor at 1 kHz: (at 25°C, depending upon conductor)	<0.1%
Insulation Resistance: (at 100V DC)	$>10^{10}$ Ω
Breakdown Voltage: (at 25°C in air)	> 500 V / 50µm
Solvent Resistance:	Good resistance to acetone when fully cured

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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PROTECTIVE POLYMER COATING 245-White

RoHS Compliant*

ESL 245-White is a filled, thermosetting modified silicone coating. It has been specifically formulated as a screen-printable protective coating for thick film conductors, resistors and capacitors on ceramic, porcelain enamelled steel and printed circuit boards. Only one layer (~25µm) is required when used as a protective coating.

This product can be used as a G2 coating.

Touch dry after 10 minutes drying at 110°C.

It provides a hard solvent resistant finish that can be overprinted with conventional marking inks.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, 25.5 ± 0.5 °C)	70 ± 25 Pa.s (ABZ Spindle)
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 25 µm
Levelling Time (20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Curing Schedules:	150°C -200°C 30 minutes
Substrate for Calibration:	96% alumina
Thinner:	ESL 402

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TYPICAL PROPERTIES

Cured Thickness: (measured on 96% alumina) (50 µm for the following data)	15 - 50 µm
Approximate Coverage:	120 cm^2 / g
Volume Resistivity:	$>10^{10}$ Ω.cm
Service Temperature:	-100 to +150°C
Dielectric Constant (K) at 1 kHz: (at 25°C)	6 - 8
Dissipation Factor at 1 kHz: (at 25°C, depending upon conductor)	<0.1%
Insulation Resistance: (at 100V DC)	$>10^{10}$ Ω
Breakdown Voltage: (at 25°C in air)	> 500 V / 50µm
Solvent Resistance:	Good resistance to acetone when fully cured

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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Polymers: Resistor

RS12100 Series

Economical carbon composition resistive coatings. For producing stable resistors on FR-4, Kapton, ceramic or other suitable substrates.

RS15100 & RS15100-P

Carbon based thermosetting resin producing stable and tolerant resistors for use on many different types of substrate including PC boards. P version is Potentiometer grade.

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POLYMER RESISTOR SERIES RS12100

Economical Resistors for Electronic Applications • RoHS Compliant*

ESL RS12100 Series polymer resistors are screen-printable, carbon composition, resistive coatings that offer an economical approach for the production of stable resistors in consumer electronic applications. They are designed for use on FR-4, Kapton®, ceramic or other suitable substrates and can be cured in a well-ventilated box oven.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 7 Spindle, 25.5 ± 0.5 °C)	80 ± 20 Pa.s
Colour:	Black
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12 µm
Drying Time (at 125°C):		10 - 15 min
Curing Conditions:	Box Oven:	150°C in a well-ventilated oven for 2 hours
Cured Film Thickness:		18 ± 2 µm
Substrate for Calibration:		FR-4
Termination Conductor:		ESL 1109-S
Thinner:		ESL 402

NOTE: Depending on the substrate used, RS 12100 Series materials may be cured at higher temperatures or longer times such as 200°C for two hours. This will improve rotational life in potentiometer applications and stability at elevated temperatures or on exposure to humidity. In order to achieve the best stability, the curing temperature should be approximately 100°C higher than the operational temperature.

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TYPICAL RESISTOR PROPERTIES					
	RS 12112	**RS 12113**	**RS 12114**	**RS 12115**	**RS 12116**
Resistance	100 Ω/sq	1 kΩ/sq	10 kΩ/sq	100 kΩ/sq	1 MΩ/sq
Resistance Tolerance	± 25%	± 25%	± 25%	± 25%	± 25%

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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POLYMER RESISTOR SERIES

RS15100
RS15100-P

RoHS Compliant*

GENERAL

The ESL RS15100 and RS15100-P resistor systems are thermosetting resin compounds that are applied by screen-printing. Curing produces carbon-based resistors with stability and tolerances suitable for many electronic applications. A variety of substrates may be used including phenolic, glass-epoxy, and other pc-board materials, ceramic, glass, and high temperature polyimide materials.

PRINTING

The RS15100 Series and RS15100-P Series are designed to be screen-printed using stainless steel screens. Typically 150 - 200 mesh screens with 25 micrometer emulsion are used to give a cured thickness of 16 to 20 micrometers. For viscosity adjustment for screen-printing, use ESL 402 thinner.

CURING

Curing of these materials may be done in a well-ventilated box oven or conveyor furnace. The standard box oven calibration cure is indicated in the table.

STABILITY CONSIDERATIONS

There is a wide range of time-temperature combinations, which can be used to cure the resistor paste. Each set of curing conditions employed has a somewhat different target of ultimate sheet resistivity. The users must choose for themselves the optimum heat treatment required for their particular application.

To obtain maximum stability for cured resistors, it is important to advance the degree of cure as far as possible along the curing curves, prior to using or testing the resistors. Thus, if only short times are available for curing, one should use the highest consistent with the stability of the other elements present (e.g., substrates, termination, materials, etc.).

The choice of calibration, time and temperature is arbitrary and simply allows for the reproduction of manufacturing and testing conditions. They are not chosen for the purpose of obtaining the best performance and indeed they are not recommendations for the customer's actual choice.

The customer should choose the conditions that give the lowest possible sheet resistivity for any polymer paste series if maximizing thermal and power stability are the primary objectives.

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

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APPLICATIONS

The RS15100 Series is used primarily to produce resistors on polyester (Mylar®) or polyimide (Kapton®) flexible films that can withstand cure cycles in the 135 - 200 °C range.

The RS15100-P Series is a version of the RS15100 Series designed for the manufacture of potentiometers. It may be used on the same films as the RS15100 Series or on printed circuit board materials, glass, or ceramic.

RS15100 / RS15100-P CHARACTERISTICS

TYPICAL PROPERTIES	RS15100	RS15100-P
Viscosity, Pa·s	80 ± 20	80 ± 20
Shelf Life, 5°C	6 months	6 months
Resistivity Ranges		
Ohms/square		
10	RS15111	RS15111-P
100	RS15112	RS15112-P
1 K	RS15113	RS15113-P
10 K	RS15114	RS15114-P
100 K	RS15115	RS15115-P
1 M	RS15116	RS15116-P
Resistivity Tolerance, % with calibration cure	± 25%	± 25%
Thinner	402	402
Drying	100 - 125 °C, 10 - 15 min.	100 - 125 °C, 10 - 15 min.
Calibration Cure	150 °C, 2 hours	150 °C, 2 hours
Cured Thickness	18 ± 2 µm	18 ± 2 µm
Cure Temperature, Range	135 - 200 °C	135 - 200 °C
Standard Terminations	1109-S	1109-S

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“Smart” Polymers

1901-I

Flexible resin material designed for use as an insulator on low temperature substrates. Suitable as a dielectric layer between the conductive tracks on smart cards.

1901-S

Silver filled, flexible resin material for use as a conductor on low temperature substrates. May be used as an antenna on smart cards. Resistivity <20 mΩ/☐ at 25 - 35 µm cured thickness.

1901-S (LV)

A low viscosity, silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates.

1901-SB

An economical silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates.

1901-SD

Slow drying, silver filled, flexible resin material for use as a conductor on low temperature substrates. May be used as an antenna on smart cards. Resistivity <20 mΩ/☐ at 25 - 35 µm cured thickness.

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POLYMER INSULATOR 1901-I

Polymer Insulator for RFID Antennas • RoHS Compliant*

ESL 1901-I is a flexible resin material designed for use as an insulator on low-temperature substrates. This insulator may be used as a buffer layer between the conductive tracks on RFID antennas. After screen-printing and curing, the insulating film remains reasonably flexible and the resistance of the antenna track made from 1901-S / 1901-SD remains constant over time. The paper or plastic sheet bearing the printed antenna is laminated within a number of plastic layers and the individual cards are punched out. Many antenna pattern layers can be insulated in a single print operation.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	50 ± 10 Pa.s
Shelf Life (at 5°C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 2 mm x 2 mm pad)	25 - 30 µm
Approximate Coverage:	100 cm^2/g
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

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POLYMER SILVER CONDUCTOR 1901-S

RoHS Compliant*

Polymer Silver For Low Temperature Substrates

ESL 1901-S is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 1 rpm, No. 6 spindle, 25.5 ± 0.5 °C)	170 ± 10 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 20 mΩ/□
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

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T: 610-272-8000
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POLYMER SILVER CONDUCTOR 1901-S (LV)

RoHS Compliant*

Polymer Silver For Low Temperature Substrates

ESL 1901-S (LV) is a low viscosity, silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 5 spindle, 25.5 ± 0.5 °C)	15 ± 3 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 35 mΩ/□

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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POLYMER SILVER CONDUCTOR 1901-SB

RoHS Compliant*

Polymer Silver For Low Temperature Substrates

ESL 1901-SB is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates. This silver conductor may be used in the manufacture of four and five wire analogue resistive touch panels, for printed antennas in RFID applications and as conductors in flexible solar cells. After screen-printing and curing the silver film remains reasonably flexible, resistant to corrosion and the resistance of the conductor remains constant over time. This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 1 rpm, No. 6 spindle, 25.5 ± 0.5 °C)	30 ± 10 Pa.s
Shelf Life (at 5 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 20 mΩ/□
Storage at 60 °C / 85% relative humidity for 24 hours	No change in resistivity
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

POLYMER SILVER CONDUCTOR 1901-SD

RoHS Compliant*

Slow-Drying Polymer Silver for RFID Antennas

ESL 1901-SD is a silver-filled, flexible resin material designed for use as a conductor on low-temperature substrates and may be used as an antenna in RFID applications. A slow-drying material to give excellent screen-life, the cured silver film remains reasonably flexible and the resistance of the antenna track remains constant over time. After fitting an appropriate chip, the RFID device can store information. The 1901-SD can also be used as an antenna in contactless smart cards. The paper, foil or plastic sheet bearing the printed antenna is laminated within a number of plastic layers and the individual cards are punched out. Many antenna patterns can be printed in a single operation.

This versatile polymer has also been successfully used on other substrates such as cloth.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No. 7 spindle, 25.5 ± 0.5 °C)	60 ± 10 Pa.s
Shelf Life (at 5°C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 or 325 S/S, 25 µm
Curing Schedule:	125°C / 10 min
Substrate for Calibration:	PVC plastic card
Thinner:	ESL 659

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Cured Thickness: (measured on a 100 mm x 0.25 mm conductor track)	25 - 35 µm
Approximate Coverage:	100 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 20 mΩ/□
Printing Resolution: (line/space)	0.25 mm / 0.25 mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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Resistors

2700 Series
Family of low cost ruthenium based materials providing stable performance under high voltage stress.

2700-G Series
Cadmium-free family of ruthenium based materials providing stable performance under high voltage stress.

29xxx Series
Series of low value resistor materials for heating elements on stainless steel substrates insulated with 4924 dielectric.

29xxx-A Series
Series of low value resistor materials for heating elements on austenitic steel substrates insulated with 4916 dielectric.

29xxx-B Series
Series of low value resistor materials for heating elements on stainless steel substrates insulated with 4986 dielectric.

29xxx-C Series
Series of low value resistor materials for heating elements on ferric steel substrates insulated with 4987 dielectric.

3100 Series
Ruthenium based resistor paste system for use on Elpor II or similar insulated steel substrates.

33000-G Series
Resistor series for surge arrestor applications. These resistors are very stable against high voltage pulses.

3414 Series
High gauge factor resistor pastes for piezo-resistive applications on alumina or other ceramic substrates.

3424
High gauge factor, low noise, resistor paste for piezo-resistive applications on alumina or other ceramic membranes or substrates.

3900 Series
Ruthenium based resistor system for use in hybrid micro-electronic circuits and discrete components.

3900-J Series
Ruthenium based resistor pastes designed for use in thick film hybrid microelectronic circuits and discrete components.

NTC-2100 Series
Series of thermistor pastes for making negative temperature coefficient thermistor films.

PTC-2600 Series
Series of thermistor pastes for making positive temperature coefficient thermistor films.

PTC-2600-I Series
Series of thermistor pastes for making positive temperature coefficient thermistor films. Withstands high power dissipation.

PTC-2611-I Special
Thermistor paste designed for making positive temperature coefficient thermistor films.

R-300-P Series
Series of economical resistor pastes for applications in high performance cermet trimmers and potentiometers.

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CERMET RESISTOR SYSTEM 2700 Series

For Hybrid Circuits & Discrete Components • Outstanding Voltage Stability

ESL 2700 Series is a family of low cost ruthenium based materials providing stable performance under high voltage stresses. The 2700 Series are suitable for TV focus controls, lightning surge arrestors, and high voltage applications. Resistivities are available in seven contiguous ranges for 10 Ω/sq. to 10 MΩ/sq. Adjacent resistivities are blendable.

The 2700 Series exhibits tight resistance distributions, low surface contact resistance for high resistivities, and small shifts in resistance after the application of very high voltages. These low cost compositions have found use in TV focus controls, high voltage dividers, and bleeder resistors. They are easy to process, are stable, laser trimable, and find use in many industrial and commercial applications.

Extremely high short-time power levels may be used for special pulsing or high voltage surge applications. ESL 2714 is suggested for use in lightning arrestor circuits, and in some instances, 2-3 mm long resistors have been subjected to many thousands of 1 kV capacitor discharges with good performance. High voltage stress changes are about twice as good for the gold terminated resistors, as compared to palladium silver terminations.

Characteristics of the 2700 Series are:

- Low cost
- Wide range of resistivities: 10 Ω/sq. to 10 MΩ/sq.
- Tight resistance distribution
- High Voltage insensitivity
- TCR's of ±100 ppm
- Good Heat Stability: < 0.3% DR in the mid-ranges, 150°C for 1000 hours, no load
- Low contact resistance in the high ranges

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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See Caution and Disclaimer on other side.

PASTE DATA

Blending:		Adjacent decade values of the seven contiguous ranges are blendable with each other.
Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)		225 ± 25 Pa.s
Shelf Life (20 - 25 °C):		6 Months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min [a]
Firing Temperature:	Optimum:	850 °C
	Time at peak:	10 - 12 min
Total Firing Cycle:		45 min [b]
Substrate for Calibration:		96% alumina [c]
Thinner:		ESL 401
Terminations of Calibration:		ESL 9635-B [d]

TYPICAL PROPERTIES

Dried Thickness:	22.5 ± 2.5 µm

Stabilisation:

Overglazes or post-fire stabilizations are not normally required for resistors 1kΩ/sq. or higher. If desired, however, ESL 4770-BCG (500 - 540°C) or ESL 4775 (500°C) may be used. ESL 242-SB Yellow may be used with curing at 150°C. Thermal stabilizations for high power applications may typically be performed between 300°C for 50 hours to 450°C for 2 hours (before final laser trimming). Voltage short time overloads of about twice rated voltage for 5 to 10 seconds may additionally be used for stabilization. Heat stabilization conditions should take into consideration any possible effects on the solderability or wire bondability of the conductor used.

Overglaze protection is required for 2711 and 2712 due to their higher concentrations of the conductive phase, which results in a porous film structure.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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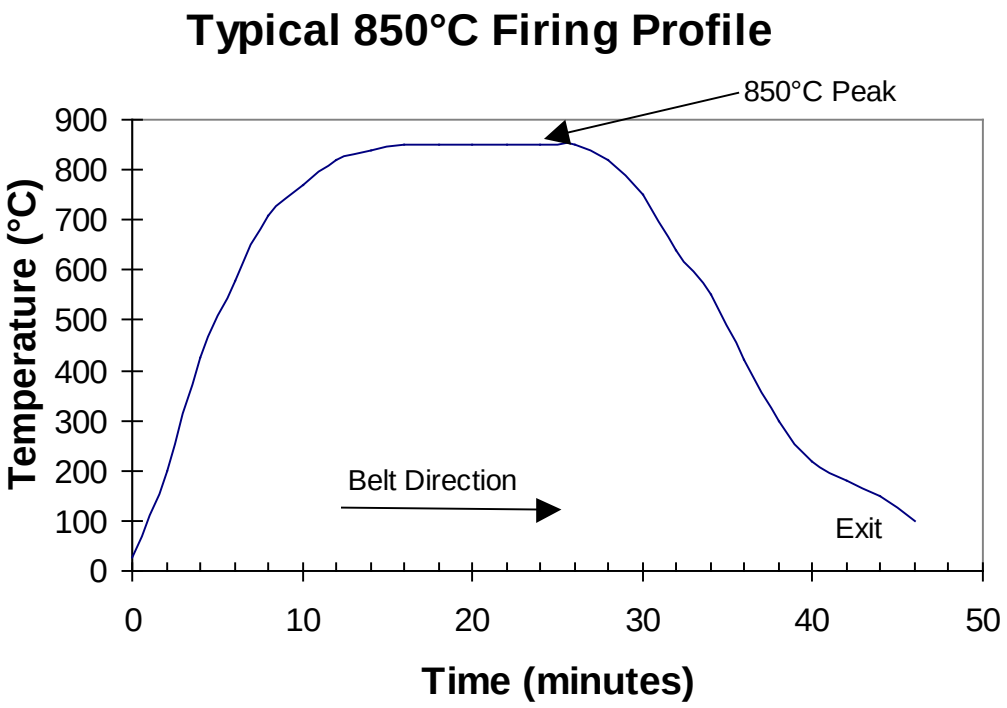
Power Rating:

The 2700 Series resistors are rated for power at a level of 0.16 Watts/mm^2 (100 W/sq. inch). A hot spot maximum of 150°C is recommended.

Notes:

a - Drying in an inadequately air vented furnace is not recommended and can shift resistivities.
b - The 2700 Series has low sensitivity to firing times. Changes in resistivity of ±20% may be expected by varying the firing cycle time by ±15 minutes. For mid-range and high resistivities, lowering peak firing temperatures will raise resistivity. Increasing peak temperatures will have very little effect on resistivity over a 10°C range.
c - Small shifts in resistivity may occur with 99% alumina substrates or substrates containing substantial amounts of calcium or barium silicates.
d - The 2700 Series resistors are calibrated to give as-fired resistivities of ±10% in the mid-rangers and ±20% in the end ranges, measured on 1.25 mm x 1.25 mm resistors. Most other ESL silver, palladium silver, platinum silver or gold terminations may be used. Higher silver content terminations other than 9635-B give slightly lower resistivities, more positive TCR's, and somewhat larger geometry effects for small sized resistors. Gold terminations usually give higher resistivities, more negative TCR's and smaller geometry effects. Upon refiring, the resistivities of the high values of the 2700 Series will drop by 10 - 20% using gold terminations, and by 30 - 50% with silver bearing terminations.



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COMPOSITION	2711	2712	2713	2714	2715	2716	2717
VISCOSITY (Pa·s)	225 ± 25						
DRIED THICKNESS (µm)	22.5 ± 2.5						
FIRED THICKNESS (µm)	12.5 ± 2.5						
RESISTIVITY (Ω/sq.)	10	100	1 k	10 k	100 k	1 M	10 M
TOLERANCE (%)	±20	±10	±10	±10	±10	±20	±20
TCR (-55°C to +125°C)	250 ± 100	50 ± 100	50 ± 100	±100	±250	-200 ± 100	-250 ± 100
Noise (dB) (Quan Tech)	N/A	≤ -20	≤ -5	≤ 0	≤ +5	≤ +20	≤ +35
VCR (ppm/V/cm)	N/A	N/A	N/A	≥ -15	-20	≤ -30	≤ -50
HEAT STABILITY (%) (%ΔR, 150°C, 1000 hours)	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0
EFFECT OF OVERGLAZE (%) (530°C, 10-12 min. @ PEAK)	±2.5	±2.5	±2.5	±2.5	±2.5	±2.5	±2.5
REFIRE (%) (at 850°C)	±20	±20	≥ -40	±40	-40	≥ -40	-50
STOL (%) (2.5 x Rated Voltage, 5 sec.)	0.25	0.25	0.25	0.25	-	-	-
LASER TRIM (%) (125°C, 24 hours)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
PULSING (%) (20 Pulses @ 1250 V)	±5	±5	±5	±5	±5	±5	±6
FIRING SENSITIVITY (%) (Fire at 825°C or 875°C)	N/A	±30	±30	±30	±30	±30	±30
SOLDER DIP (220°C, 5 sec.)							
BARE RESISTORS (%)	3.00	0.30	0.20	0.20	0.20	0.50	0.50
OVERGLAZED (%)	0.30	0.10	0.10	0.10	0.10	0.20	0.30

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET RESISTOR SYSTEM 2700-G Series

Ruthenium Resistor • Cadmium-free

ESL 2700-G Series is a cadmium-free family of ruthenium based materials providing stable performance under high voltage stresses. The 2700-G Series are suitable for TV focus controls, lightning surge arrestors, and high voltage applications. Resistivities are available in seven contiguous ranges for 10 Ω/sq. to 10 MΩ/sq. Adjacent resistivities are blendable. ESL 2700-GD Series is available for use over 4913-G.

The 2700-G Series exhibits tight resistance distributions, low surface contact resistance for high resistivities, and small shifts in resistance after the application of very high voltages. These low cost compositions have found use in TV focus controls, high voltage dividers, and bleeder resistors. They are easy to process, are stable, laser trimable, and find use in many industrial and commercial applications.

Extremely high short-time power levels may be used for special pulsing or high voltage surge applications. ESL 2714-G is suggested for use in lightning arrestor circuits, and in some instances, 2-3 mm long resistors have been subjected to many thousands of 1 kV capacitor discharges with good performance. High voltage stress changes are about twice as good for the gold terminated resistors, as compared to palladium silver terminations.

Characteristics of the 2700-G Series are:

- Wide range of resistivities: 10 Ω/sq. to 10 MΩ/sq.
- Tight resistance distribution
- High Voltage insensitivity
- TCR's of ±100 ppm
- Good Heat Stability: < 0.3% DR in the mid-ranges, 150°C for 1000 hours, no load
- Low contact resistance in the high ranges

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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PASTE DATA

Blending:		Adjacent decade values of the seven contiguous ranges are blendable with each other
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		225 ± 25 Pa.s
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850°C
	Time at peak:	10 min
Total Cycle Time:		45 min
Substrate for Calibration:		96% alumina
Recommended Termination:		9695
Thinner:		ESL 401

TYPICAL PROPERTIES

Dried Print Thickness: (on 96% alumina)	22.5 ± 2.5 µm

Stabilization:

Overglazes or post-fire stabilizations are not normally required for resistors 1 kΩ/sq. or higher. If desired, however, ESL 4771-P (500°C-540°C) may be used. ESL 242-SB Yellow may be used with curing at 150°C. Thermal stabilizations for high power applications may typically be performed between 300°C for 50 hours to 450°C for 2 hours (before final laser trimming). Voltage short time overloads of about twice rated voltage for 5 to 10 seconds may additionally be used for stabilization. Heat stabilization conditions should take into consideration any possible effects on the solderability or wire bondability of the conductor used.

Overglaze protection is required for 2711-G and 2712-G due to their higher concentrations of the conductive phase, which results in a porous film structure**.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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Power Rating:

The 2700-G Series resistors are rated for power at a level of 0.16 Watts/mm2 (100 Ω/sq. inch). A hot spot maximum of 150°C is recommended.

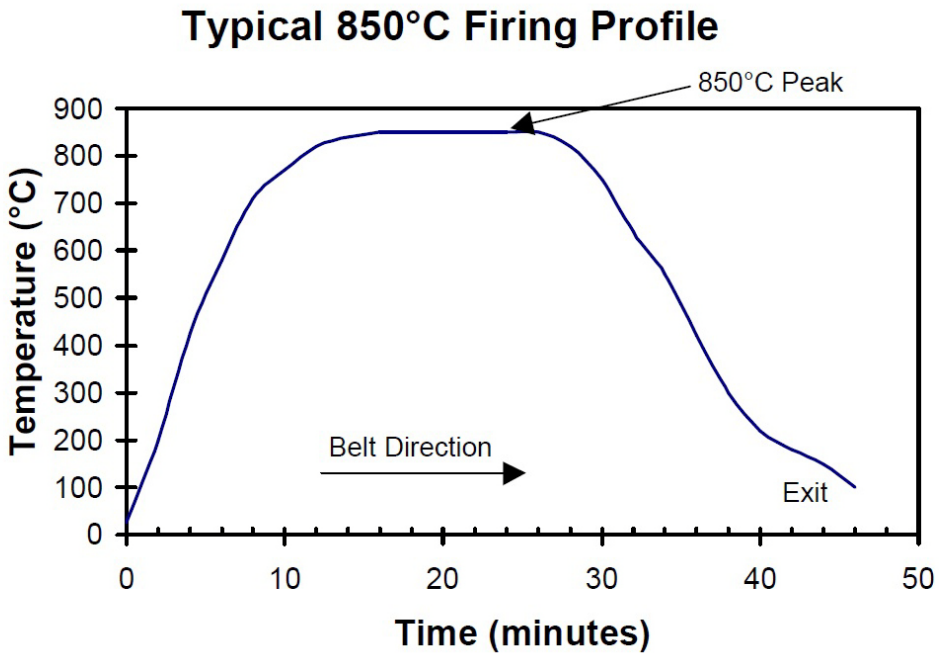
Notes:

a - Drying in an inadequately air vented furnace is not recommended and can shift resistivities.

b - The 2700-G Series has low sensitivity to firing times. Changes in resistivity of ±20% may be expected by varying the firing cycle time by ±15 minutes. For mid-range and high resistivities, lowering peak firing temperatures will raise resistivity. Increasing peak temperatures will have very little effect on resistivity over a 10°C range.

c - Small shifts in resistivity may occur with 99% alumina substrates or substrates containing substantial amounts of calcium or barium silicates.

d - The 2700-G Series resistors are calibrated to give as-fired resistivities of ±10% in the mid-rangers and ±20% in the end ranges, measured on 1.25 mm x 1.25 mm resistors. Most other ESL silver, palladium silver, platinum-silver, or gold terminations may be used. Higher silver content terminations other than 9635-B give slightly lower resistivities, more positive TCR's, and somewhat larger geometry effects for small sized resistors. Gold terminations usually give higher resistivities, more negative TCR's and smaller geometry effects. Upon refiring, the resistivities of the high values of the 2700-G Series will drop by 10%-20% using gold terminations and by 30%-50% with silver bearing terminations.



CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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COMPOSITION	2711-G	2712-G	2713-G	2714-G	2715-G	2716-G	2717-G
VISCOSITY Pa·s	225±25	225±25	225±25	225±25	225±25	225±25	225±25
DRIED THICKNESS (µm)	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5	22.5±2.5
FIRED THICKNESS (µm)	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5	12.5±2.5
RESISTIVITY (Ω/sq.)	10	100	1 k	10 k	100 k	1 M	10 M
TOLERANCE (%)	±20	±10	±10	±10	±10	±20	±20
TCR (-55°C to +125°C)	±100	±100	±100	±100	±100	-100±100	-250±100
Noise (Quan Tech) (dB)	N/A	≤ -20	≤ -5	≤ 0	≤ +5	≤ +20	≤ +35
VCR (ppm/V/cm)	N/A	N/A	N/A	≥ -15	-20	≤ -30	≤ -50
HEAT STABILITY (%ΔR, 150°C, 1000 hours)	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0
EFFECT OF OVERGLAZE (%) (530°C, 10-12 min. @ PEAK)	±2.5	±2.5	±2.5	±2.5	±2.5	±2.5	±2.5
REFIRE (at 850°C) (%)	±20	±20	≥ -40	±40	-40	≥ -40	-50
STOL (2.5 x Rated Voltage, 5 sec.)(%)	0.25	0.25	0.25	0.25	-	-	-
LASER TRIM (125°C, 24 hours) (%)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PULSING (20 Pulses @ 1250 V) (%)	±5	±5	±5	±5	±5	±5	±5
FIRING SENSITIVITY (Fire at 825°C or 875°C) (%)	N/A	±30	±30	±30	±30	±30	±30
SOLDER DIP (220°C, 5 sec.)							
BARE RESISTORS (%)	3.00	0.30	0.20	0.20	0.20	0.50	0.50
OVERGLAZED (%)	0.30	0.10	0.10	0.10	0.10	0.20	0.30

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ESL ELECTROSCIENCE
CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET RESISTOR 29XXX Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-free*

ESL 29XXX Series are low value resistors designed for use as heating elements on stainless steel substrates in combination with ESL's insulating dielectrics. They are available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		ESL 4924 on 96% alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Dried Thickness:
(427 mm x 2.4 mm resistor track with 9695 terminations over 4924 dielectric) 21 ± 1 µm

Approximate Coverage: 80 cm^2 / g

Resistivity & TCR:

Table 1: Resistor Properties								
Product Number	29106	29206	29109	29115	29215	29130	29230	29515
Resistivity (mΩ/sq) ± 10%	100	200	100	100	200	100	200	500
Average TCR (ppm/°C) ± 50	600	600	900	1500	1500	3320	3320	1500

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ESL ELECTROSCIENCE
CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET RESISTOR 29XXX-A Series

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ESL 29XXX-A Series are low value resistors designed for use as heating elements on austenitic stainless steel substrates insulated with ESL 4916 insulating dielectric. 29XXX-A is available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		ESL 4916 on 96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Dried Thickness:
(427.2 mm x 2.4 mm resistor track with 9695 terminations over 4916 Glaze) 21 ± 1 µm

Approximate Coverage: 80 cm^2 / g

Resistivity & TCR:

Table 1: Resistor Properties

Product Number	29103-A	29106-A	29206-A	29109-A	29209-A	29115-A	29215-A	29130-A	29230-A	29515-A
Resistivity (mΩ/sq) ± 10%	100	100	200	100	200	100	200	100	200	500
TCR (ppm/°C)	350	600	600	900	900	1500	1500	3250	3250	1500
TCR Tolerance (ppm/°C)	50	50	50	50	50	50	50	250	250	50

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET RESISTOR 29XXX-B Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-free*

ESL 29XXX-B Series are low value resistors designed for use as heating elements on stainless steel substrates insulated with ESL's 4986 insulating dielectrics. 29XXX-B is available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		4986 on 96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Dried Thickness:
(427.2 mm x 2.4 mm resistor track with 9695 terminations over 4986 dielectric) 21 ± 1 µm

Approximate Coverage: 80 cm^2/g

Resistivity & TCR:

Table 1: Resistor Properties

Product Number	29103-B	29106-B	29206-B	29109-B	29209-B	29115-B	29215-B	29130-B	29230-B	29515-B
Resistivity (mΩ/sq) ± 10%	100	100	200	100	200	100	200	100	200	500
TCR (ppm/°C)	350	600	600	900	900	1500	1500	3250	3250	1500
TCR Tolerance (ppm/°C)	50	50	50	50	50	50	50	250	250	50

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
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CERMET RESISTOR 29XXX-C Series

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

Cadmium, Lead and Nickel-Free*

ESL 29XXX-C Series are low value resistors designed for use as heating elements on ferritic stainless steel substrates insulated with ESL 4987 insulating dielectric. 29XXX-C is available in a range of resistivities and temperature coefficients of resistance (TCR) - see Table 1. Intermediate resistivities may be obtained by blending the two members of a TCR group.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)		225 ± 25 Pa.s
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		250 S/S, 5 µm
Levelling Time (at 20°C):		10 - 15 min
Drying Time (at 125°C):		15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		4987 on 96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Dried Thickness:
(427.2 mm x 2.4 mm resistor track with 9695 terminations over 4987 Glaze) 21 ± 1 µm

Approximate Coverage: 80 cm^2/g

Resistivity & TCR:

Table 1: Resistor Properties

Product Number	29103-C	29106-C	29206-C	29109-C	29209-C	29115-C	29215-C	29130-C	29230-C	29515-C
Resistivity (mΩ/sq) ± 10%	100	100	200	100	200	100	200	100	200	500
TCR (ppm/°C)	350	600	600	900	900	1500	1500	3250	3250	1500
TCR Tolerance (ppm/°C)	50	50	50	50	50	50	50	250	250	50

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
www.electroscience.com

CERMET RESISTOR SYSTEM 3100 Series

The ESL 3100 Series is a ruthenium based, thick film resistor paste system designed for use on Elpor II or similar insulated steel substrates. It is intended to be fired in the range of 600°C to 650°C. These materials are aimed at low cost; broader tolerance, commercial markets, and are ideal replacements for PC boards with 5 - 10% tolerance chip resistors. These materials should not be considered as direct replacements for higher precision thick film cermet circuits on high alumina substrates. Typical material characteristics are shown below.

	3100 - 0.65	**3110**	**3111**	**3112**	**3113**	**3114**	**3115**	**3116**
Nominal Resistivity (Ω/square) (1.25 x 1.25 mm resistor)	0.65*	1	10	100	1k	10k	100k	1M
Tolerance (%)	±5	±30	±30	±25	±25	±25	±25	±30
Average TCR (ppm/°C) (25°C to +125°C) and (25°C to -55°C)	≤1000	±250	±250	±200	±200	-50 ± 200	-50 ± 200	100 ± 200
Heat Stability (%ΔR) (200°C, 24 hours)	N/A	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0

* Tested using a nine square pattern

PROCESSING NOTES

Blending: Most of the ESL 3100 Series pastes are blendable. ESL 3110 and 3111 may be blended with one another but not with other members of the series. (Stir well before using)

Viscosity:
(Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C) 225 ± 25 Pa.s

Resistivity: ESL 9595-A platinum silver is used for terminations. Other ESL conductors such as 9996-B (Ag) or 593 (Ag) for low temperature firing may be used with slight resistance and TCR effects.

Substrates: Elpor II substrates are used for calibration. Other insulated steel substrates may be used although differences in fired properties may be observed.

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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PRINTING AND DRYING

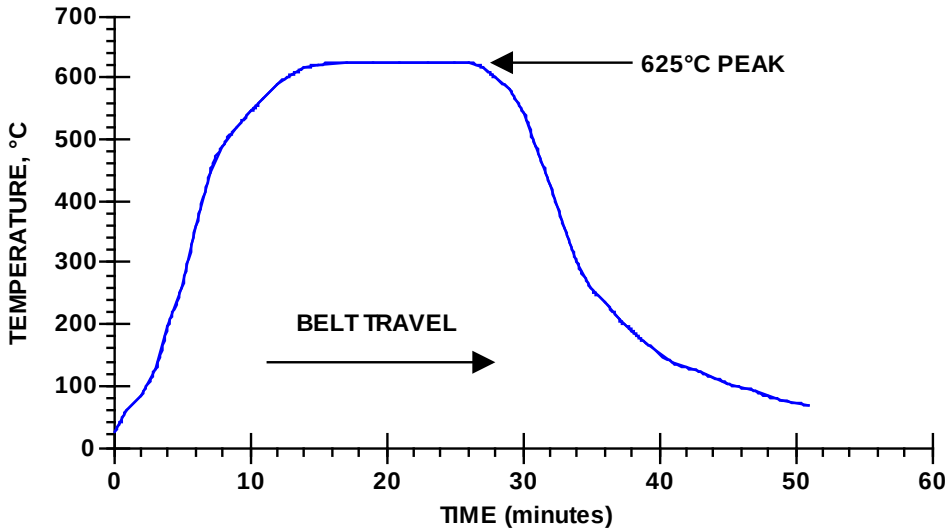
Screen Mesh, Emulsion:	200 S/S, 20 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 -15 min
Dried Thickness:	25 ± 3 µm

Note: The use of a 325 mesh screen will give a thinner dried thickness. A fired thickness range of 8 to 12 µm will trim more rapidly that thicker films, and will resist thermal expansion-contraction mismatch (strains between the steel, enamel and resistors during laser trimming) more readily than resistor films which are 13 to 18 µm thick. Thinner resistor films can be volatilized by a YAG laser at lower power and thus with less danger of cutting through the 125 to 150 µm thick enamel coating on the steel substrates. However, users should expect increases in sheet resistivity with thinner films.

Firing Temperature / Time:	625 °C / 10 - 12 min
Clean Air Exchange:	(minimum) 1-2 times / min
Total Firing Cycle:	45 min

Stabilisation:
For tolerances tighter than 5%, heat stabilization at 200°C to 450°C, prior to laser trimming has proven advantageous. Overglazing with ESL 4775 may stabilize, although firing temperature and time are critical. Expect changes of 5% to 10% due to overglazing or heat stabilization. Refiring resistors (normal profile) will cause changes (increasing with resistivity) of -5% to -30%. Use ESL 242-SB (epoxy overcoat) for post trim protection.

TYPICAL 625°C FIRING PROFILE



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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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CERMET RESISTOR SYSTEM 33000-G Series

Resistor Series Designed For Surge Arrestor Applications
SVHC-free • RoHS Compliant*

The ESL 33000-G Resistor Series is specially designed for applications requiring a surge arrestor. The resistors are very stable against high voltage pulses. This resistor series is intended for use on 96% alumina substrate. It can be deposited on the substrate by normal screen-printing techniques then fired in a conveyor belt furnace. These resistors are normally used in a serpentine pattern. Adjacent resistance values of the series are blendable. These materials may also be used in power chip resistor applications using compatible ESL materials shown below.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	350 ± 50 Pa.s
Shelf Life (20 - 25°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		ESL C-964-A terminations on 96% alumina
Thinner:		ESL 413
Compatible Materials:	Overglaze:	ESL G-471 (500°C), G-481 (600°C), 4612-D (850°C)
	Conductor:	ESL 9912-F (Ag), 9512 (Ag/Pt)

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
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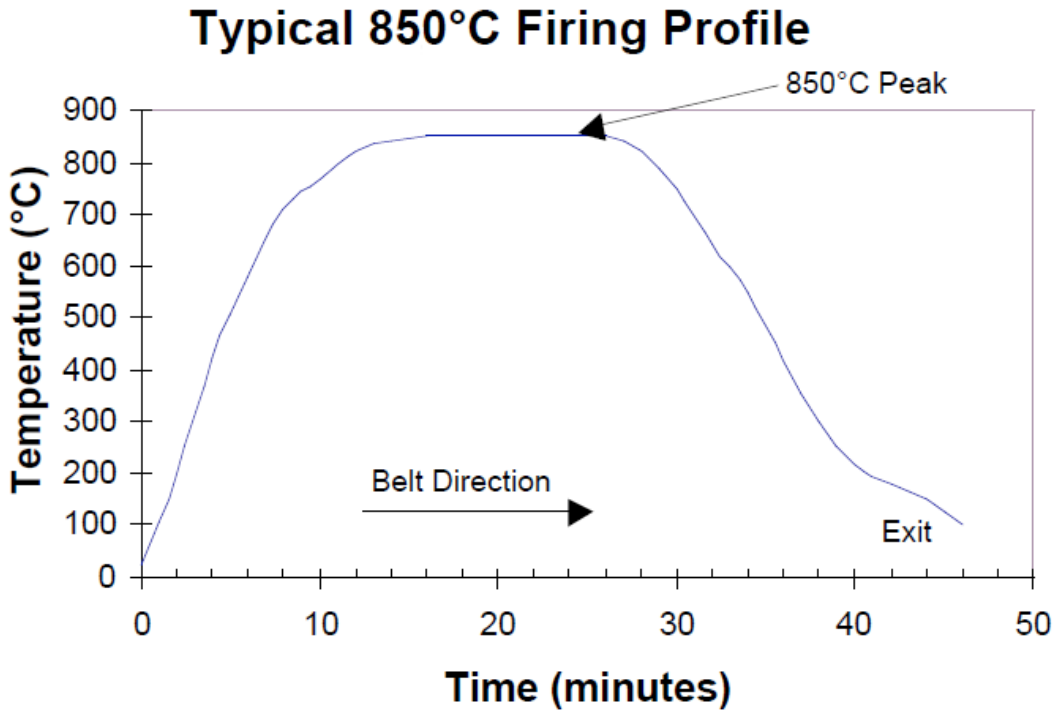
See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

	33002-G	33005-G	33010-G	33020-G	33050-G	33100-G	33101-G
Resistivity, Ω/sq.	0.020	0.050	0.10	0.20	0.50	1.0	10
Tolerance, %	±30	±20	±10	±10	±10	±10	±10
Dried Thickness, µm	22 -27	22 - 27	18 - 23	18 - 23	18 - 23	18 - 23	18 - 23
HTCR, ppm/°C	+400	+200	±50	±50	±50	±50	±50
CTCR, ppm/°C	+500	+200	±100	±100	±100	±100	±100
Pulse Test, ΔR*,%	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1

* Wave shape:

1. 10 µsec. x 1,000 µsec. / 1,000 VDC / 100 A
2. 2 µsec. x 10 µsec. / 2,500 VDC / 500 A
3. Resistors (200 square serpentine pattern, 1 mm wide) overglazed with 4612-D, fired at 850°C.



***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERMET RESISTOR 3414 Series

High Gauge Factor

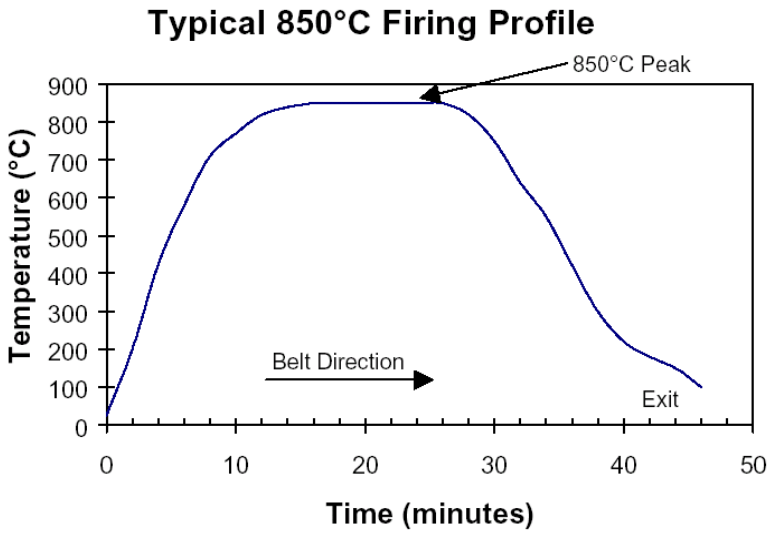
ESL 3414 Series high gauge factor resistor pastes are specifically designed for piezo-resistive applications on alumina or other ceramic membranes or substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 12 min
Firing Temperature:		850°C (in air)
	Time at peak:	10- 12 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		9635-A on 96% alumina
Thinner:		ESL 401



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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES:

Fired Resistor Thickness: 11±1 µm

Resistor Terminations: (Pre-fired) ESL 8836

	3414-B-LBM	3414-B-HBM	3414-A	3414-B
Sheet Resistivity:[1] (kΩ/sq.)	1.0 - 1.5	2.5 - 3.0	7.2 - 8.8	3.6 - 4.4
TCR: (in ppm/°C)	±150	±150	±100	±100
Noise Index:[1]	0 dB	3 dB	1 dB	6 dB
Typical Gauge Factor:[2]				
Longitudinal:	15 - 16	17 - 18	14 - 15	18 - 19
Transverse:	8 - 9	10 - 11	8 - 10	10 - 12
Nonlinearity:	1%	1%	1%	3%
Hysteresis:	1%	1%	1%	3%

NOTES:

1. 1.25 mm x 1.25 mm geometry
2. 1.00 mm x 1.00 mm geometry
3. Designing resistors with an active length greater than 1.25 mm may minimize the ESD sensitivity.

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CERMET HIGH GAUGE FACTOR RESISTOR SYSTEM

3424

ESL 3424 is a high gauge factor, low noise, resistor paste specifically designed for piezo-resistive applications on alumina or other ceramic membranes or substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 1000°C (in air)
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		9635-A on 96% alumina
Thinner:		ESL 401

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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Dried Print Thickness: (measured on a 1.25 mm x 1.25 mm resistor on 96% alumina)	22.5 ± 2.5 µm
Approximate Coverage:	120 cm^2 / g
Resistivity: (measured on a 1.25 mm x 1.25 mm resistor)	9 - 10 K Ω/□
TCR: (measured on a 1.25 mm x 1.25 mm resistor)	± 100 ppm / °C
Noise Index: (measured on a 1.0 mm x 1.0 mm resistor terminated on 8836)	< - 10 dB

Guage Factor:
(measured on a 1.0 mm x 1.0 mm resistor terminated on 8836)

Longitudinal:	8 - 10
Transverse:	5 - 7
Nonlinearity:	≤ 1%
Hysteresis:	≤ 1%

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET RESISTOR SYSTEM 3900 Series

The 3900 Series is a ruthenium-based resistor system for use in hybrid micro-electronic circuits and discrete components. It is used for the most demanding telecommunications, aerospace and medical applications and combines high performance, low cost, and ease of processing. The resistors exhibit good voltage and thermal stability.

The 3900 Series has the following characteristics:

- Wide range of resistivities: 0.1Ω/sq. to 1 MΩ/sq.
- Temperature Coefficient of Resistance (TCR): less than 50 ppm/°C for the 100 Ω, 1 kΩ, and 10 kΩ resistivity ranges.
- TCR tracking within 10 ppm/°C when the same size and termination are used with an individual resistivity.
- Low sensitivity of TCR and resistivity to printing and firing cycles.
- Good power load stability, up to 1000 mW/mm^2 (650 W/in^2) - with or without overglaze as long as hot spot temperatures are limited to 150°C. Heat stabilization may be used to permit stable operation at significantly higher power loading.
- Excellent stability after laser trimming.
- Specially blended intermediate resistor values are available on request.
- All members of the 3900 Series are co-fireable.

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See Caution and Disclaimer on page 2.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste

PROCESSING

Screen Mesh, Emulsion:		200 / 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina*

*** - NOTE:** Beryllia substrates may also be used but resistivity and TCR changes will occur. Similarly, small shifts in resistivity and TCR may occur with 99% alumina substrates or substrates containing substantial amounts of calcium and barium silicates.

Stabilization:

If required, post-fire stabilization, such as overglazing with 4770-BCG (fired at 500°C - 525°C) and/or 240-SB (modified silicone resin, cured at 200°C - 250°C), may be used. For high precision applications, or tight tolerance resistors the following procedure may be used: overglaze with 4770-BCG, trim to 1% of nominal value, anneal at 200°C for 24 hours before fine trimming to the desired tolerance. Laser cuts may be protected with a low temperature polymer coating such as 240-SB.

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PROPERTIES	3900-0.1OHM	3910	3911	3912	3913	3914	3915	3916
Resistivity (Ω/square)[1]	0.1	1	10	100	1 k	10 k	100 k	1 M
Tolerance (%)	±50	±30	±10	±10	±10	±10	±10	±10
Viscosity (Pa·s)[2]	300±25	225 ± 25						
Dried Thickness (µm)	22.5 ± 2.5							
Thinner	ESL 401							
Average TCR (ppm/°C)[3]	75 ± 75	50 ± 100	0 ± 100	0 ± 50	0 ± 50	0 ± 50	0 ± 100	-100 ± 100
STOL (V/mm)[4]	-	-	8.07	24.6	70.9	64.0	128	-
Std. Working Voltage (V/mm)[5]	-	-	3.22	9.84	28.3	25.6	51.2	-
Max Rated Power (mW/mm^2)[6]	-	-	974	970	1001	60.6	27.0	-
Quan-Tech Noise (dB)	N/A	N/A	N/A	≤-10	≤-10	≤+10	≤+25	≤+35
Average VCR (ppm/V/cm)	-	-	-	-	-	≤-100	≤100	≤-450
Laser Trim Stability (%ΔR) (1,000 hours at 150°C)	-	-	±0.3%	±0.3%	±0.3%	±0.3%	±0.3%	±0.3%
Termination Conductor	8835-1B	9635-B						
Shelf Life (25°C)	6 months							

[1] CALIBRATION: Resistor size: 1.25 mm x 1.25 mm.
[2] VISCOSITY: Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C.
[3] CTCR: -55°C to +25°C. HTCR: +25°C to +125°C. Resistor size measured for TCR: 3900-0.1 OHM & 3910 - 20 mm x 2 mm; all others - 1.25 mm x 1.25 mm.
[4] STOL: Voltage required, 5 second duration, to induce a resistance change of ±0.1% at 25°C.
[5] STANDARD WORKING VOLTAGE: 0.4 x STOL Voltage.
[6] MAXIMUM RATED POWER: (Standard Working Voltage)^2/Resistance.

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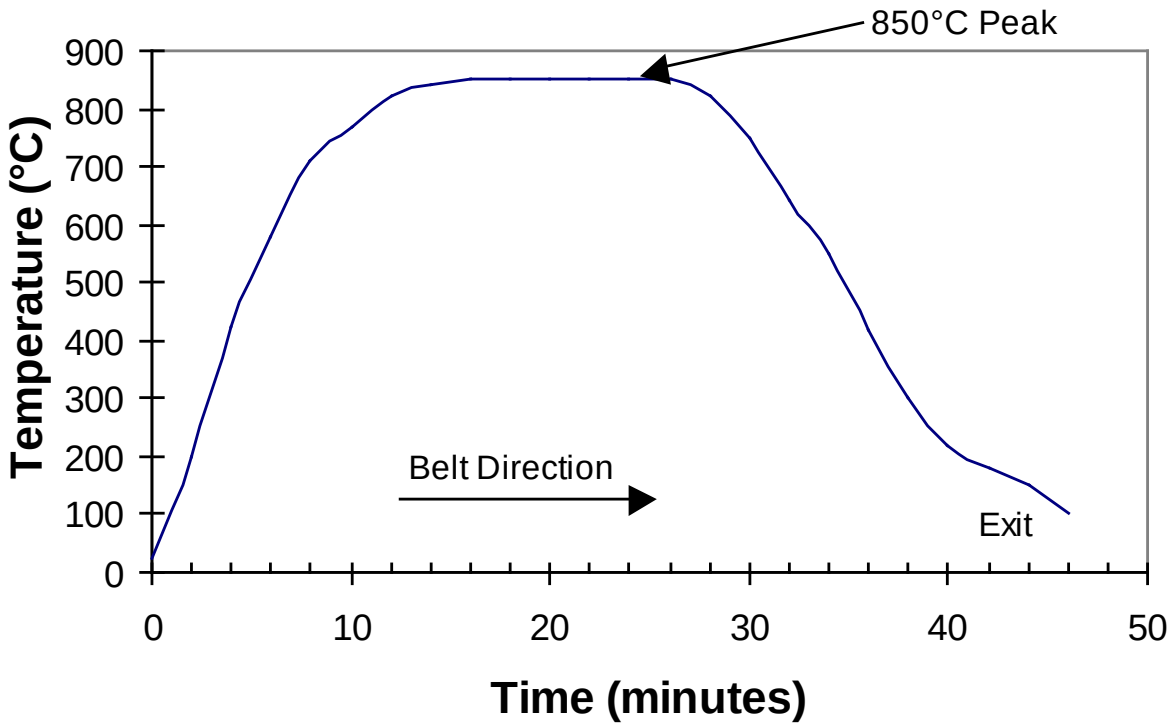
Typical 850°C Firing Profile



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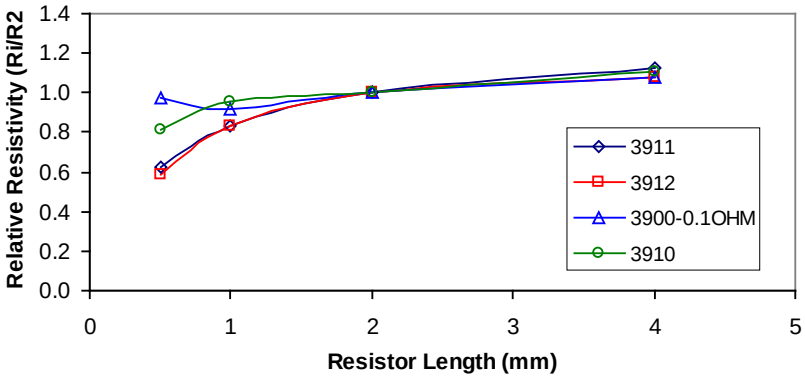
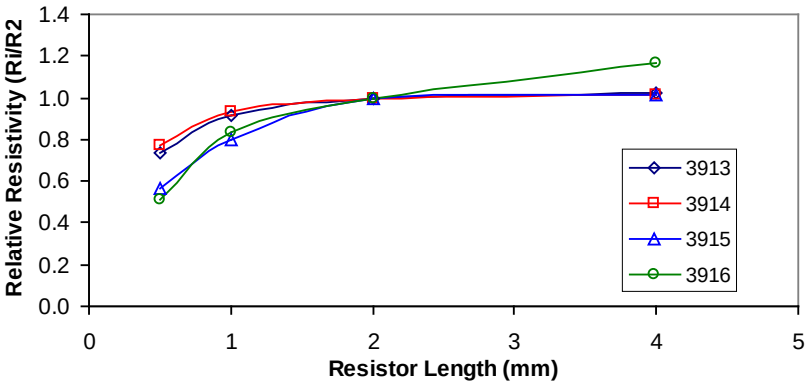
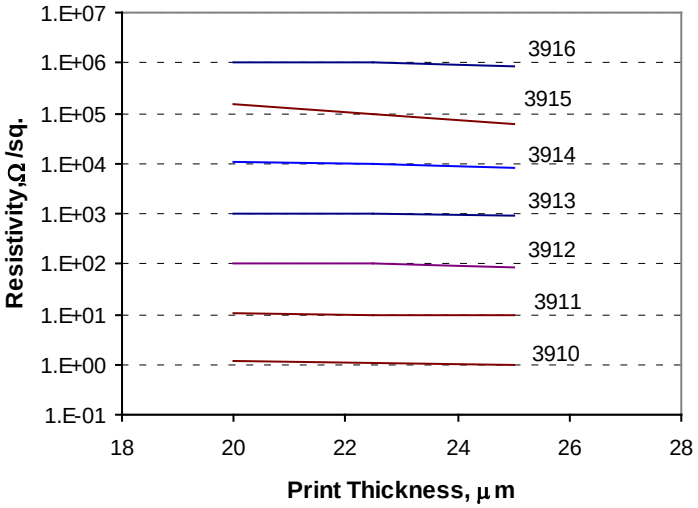
3900-Series Resistivity vs Resistor Length



3900-Series Resistivity vs Resistor Length



3900 Series Resistivity vs. Print Thickness



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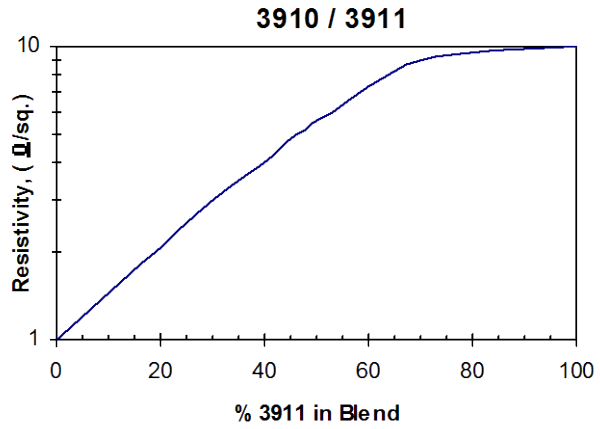
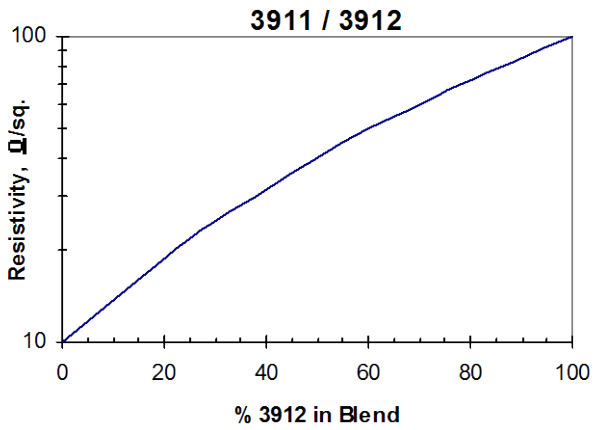
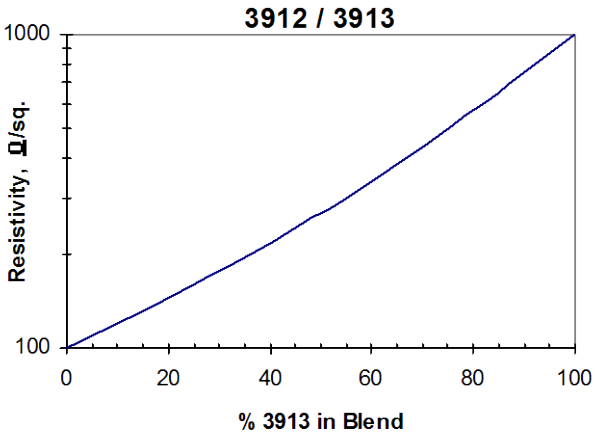
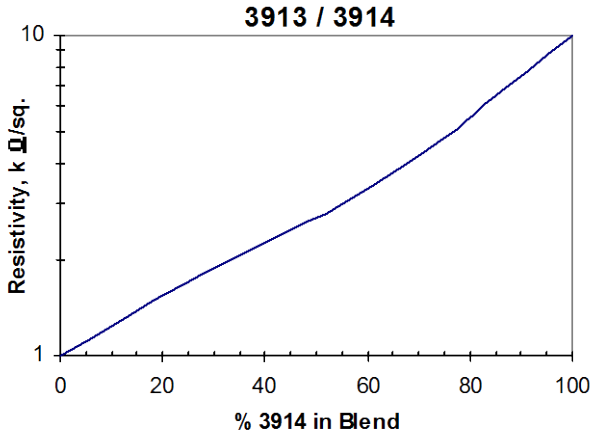
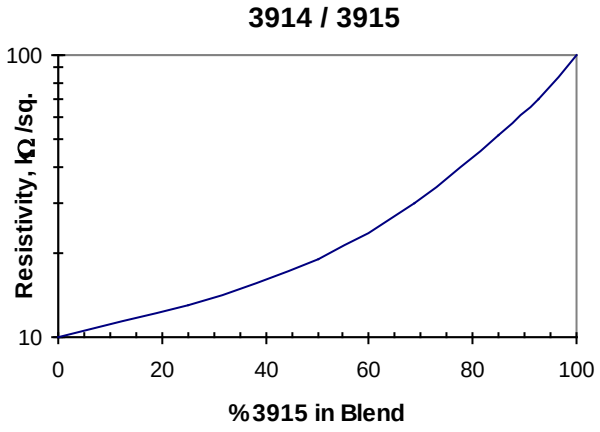
Blending Curves for Adjacent Members of the 3900 Series Resistors











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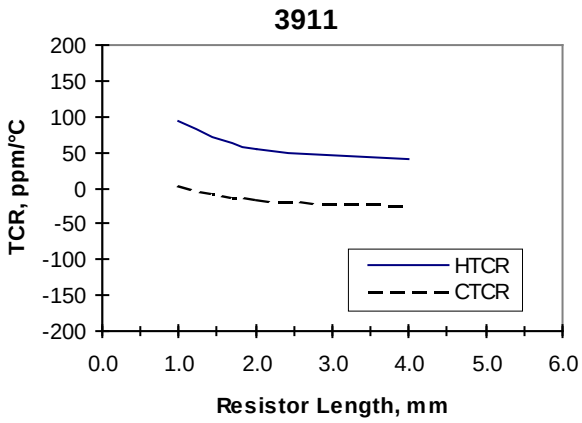
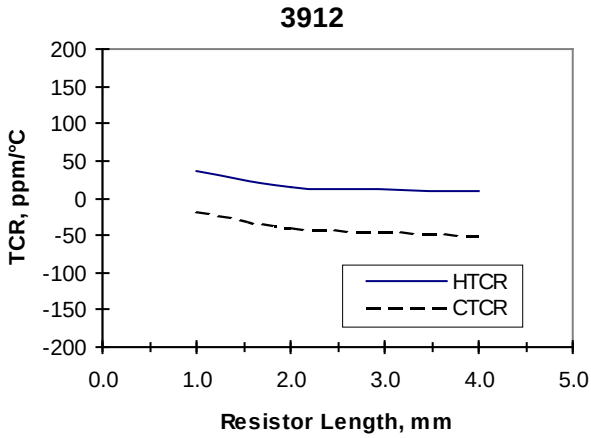
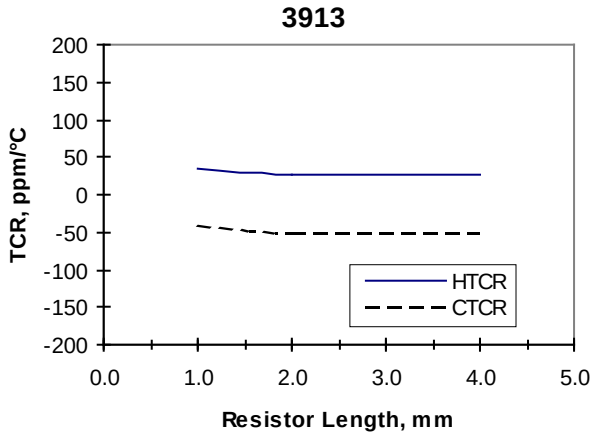
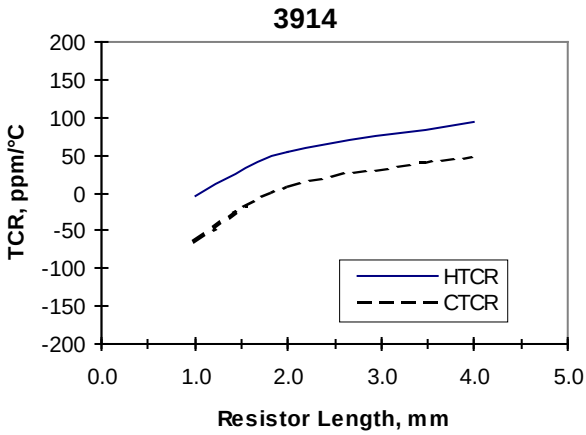
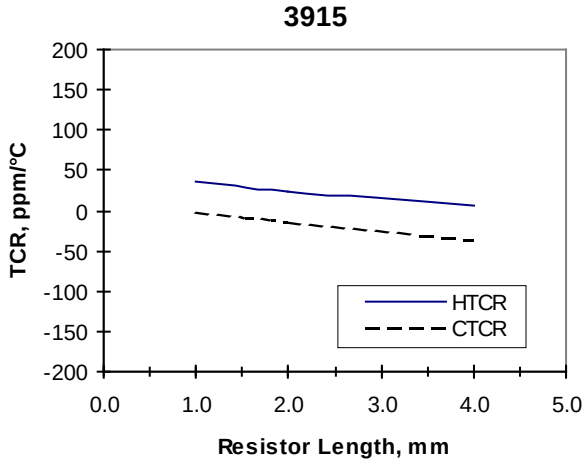
TCR (ppm/°C) vs. Resistor Length (mm) for the 3900 Series Resistors

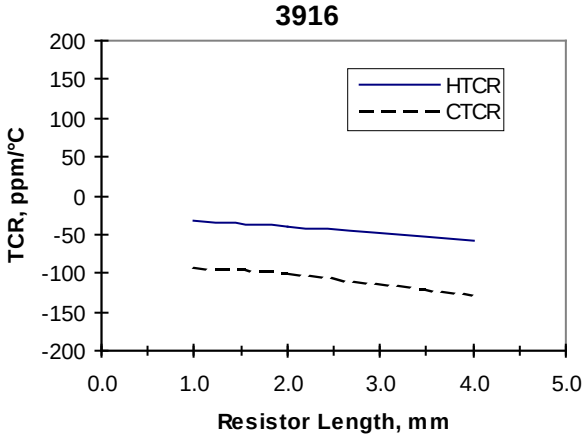












NOTE: HTCR: +25°C to +125°C
CTCR: -55°C to +25°C

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T: 610-272-8000
F: 610-272-6759
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CERMET RESISTOR SYSTEM 3900-J SERIES

Cadmium-Free Resistor Material

The 3900-J Resistor Series are ruthenium based resistor pastes designed for use in thick film hybrid microelectronic circuits and discrete components. They combine high performance, low cost, with ease of processing.

PASTE DATA

RHEOLOGY:	Thixotropic screen printable paste
VISCOSITY: (Brookfield RVT, ABZ spindle, 10 RPM, 25.5°C±0.5°C)	225±25 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/12.5 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING TIME: (125°C)	10-15 minutes
FIRING TEMPERATURE:	850°C
TIME AT PEAK:	10-12 minutes
TOTAL CYCLE:	45 minutes
TERMINATIONS:	9635-B
THINNER:	ESL 401
SUBSTRATE OF CALIBRATION:	96% alumina

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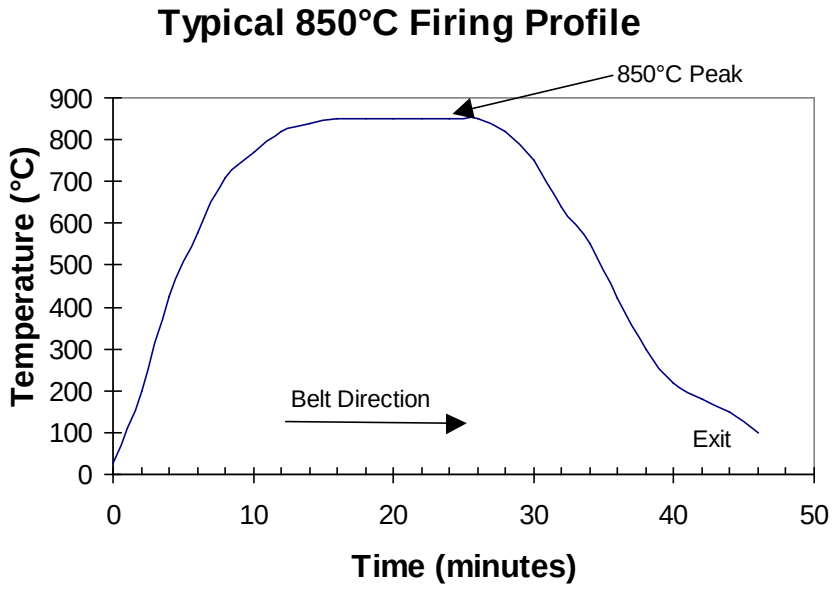
3900-J RESISTOR SERIES – TYPICAL PROPERTIES

PROPERTIES	3910-J	3911-J	3912-J
Viscosity (Pa·s)	225±25		
Resistivity (Ω/sq.)	1	10	100
Tolerance(%)	±30%	±10%	±10%
Coefficient of Variation (%)	≤8	≤8	≤8
Dried Thickness	22.5±2.5µm		
Average TCR (ppm/°C)	0±100	0±100	0±50
CRV, % (Max)	±1.0%	±1.0%	±1.0%
Wear, % (Max)	±1.0%	±1.0%	±1.0%

a. CRV per ESL standard test procedure TM3-18. Resistor size = 1.25mm square.
b. Wear per ESL standard test procedure TM3-18. Resistor size = 2mm x 20mm.



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F: 610-272-6759
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THERMISTOR COMPOSITION NTC-2100 SERIES

FEATURE DESIGN FLEXIBILITY, SMALLER SIZE, AND ECONOMIC ADVANTAGES COMPARED TO DISCRETE THERMISTORS

The NTC-2100 Series of thermistor pastes are designed for making negative temperature coefficient thermistor films. They are printed and fired on ceramic substrates using typical thick film processing. These materials are used in applications where the thermistor is to be intimately bonded to the substrate, such as temperature compensation of hybrid circuits. This design flexibility, decreased size and lower cost are advantageous when compared to discrete thermistor components.

Designation	Average Beta (ß) -55°C to 125°C	Nominal Sheet Resistivity*	Resistance Range (Ω)**
NTC-2131	300	30	3 to 300
NTC-2112	725	100	10 to 1 k
NTC-2113	1700	1 k	100 to 10 k
NTC-2114	2125	10 k	1 k to 100 k
NTC-2115	2500	100 k	10 k to1 M
NTC-2116	3100	1,000 k	100 k to 10 M

Notes: * 0.040 x 0.040 Resistor, Ω/square at a dry print thickness of 22.5 µm.

** Resistive Element Geometry ranging from 1/10 of a square to 10 squares

Beta Tolerance of ±20%

Resistivity Tolerance of ±20%; except NTC-2115 and NTC-2116, ±30%

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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Resistive Element Geometry / Sheet Resistivity

Consider the resistive element (resistor material) between the termination materials as a rectangular solid. It has thickness t, length l, (distance between terminations) and width w, (distance perpendicular to terminations). The ratio of the resistive element length to width (l:w) is called the number of squares. Resistive element geometry is an important consideration when designing a thick film circuit.

A resistance value can be targeted by multiplying the Nominal Sheet Resistivity by the resistive element geometry. ESL NTC-2100 Series materials retain their sheet resistivity over resistive element geometry ranging from 1/10 of a square to 10 squares.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5°C±0.5°C)	250±50 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/10-25 µm
LEVELING TIME:	5-10 minutes
DRYING TIME AT 125°C:	10-15 minutes
FIRING TEMPERATURE:	850°C (in air)
SUBSTRATE FOR CALIBRATION:	96% alumina
RECOMMENDED TERMINATIONS:	5837 (PtAu), 9635-A (AgPd)
OVERGLAZE: (1-2 minutes at a peak temperature of 490°C)	4782
STABILIZATION: (After overglaze)	150°C for 16 hours
THINNER:	ESL 437

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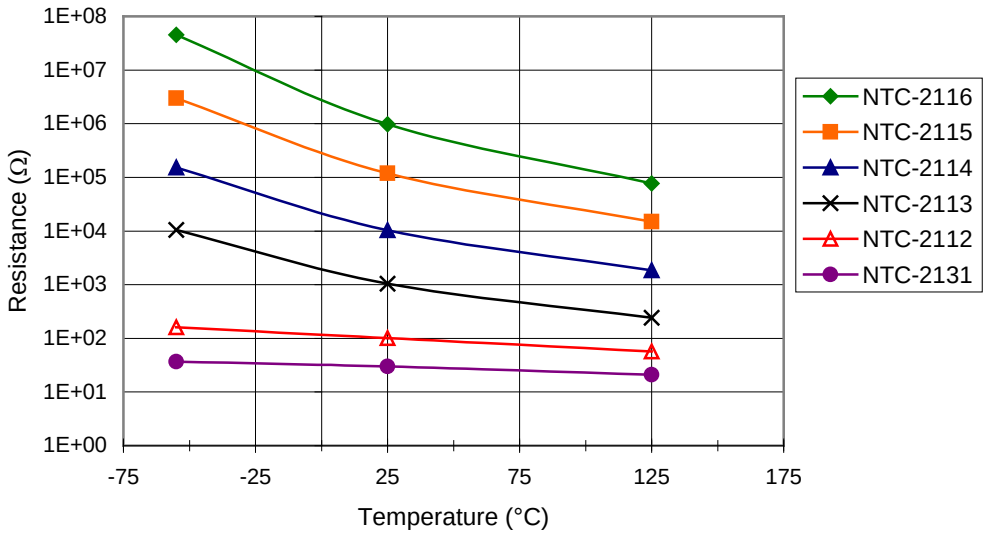
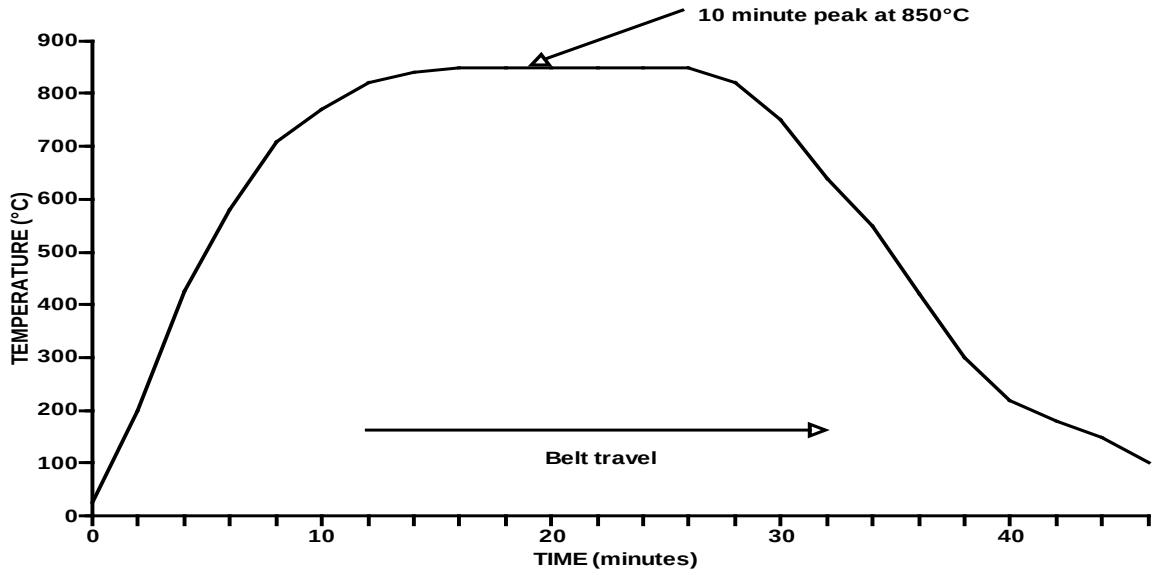
TYPICAL PROPERTIES

DRY PRINT THICKNESS: 20-25 µm

NTC-2100 Series Resistance vs. Temperature



RECOMMENDED PROFILE FOR THE NTC-2100 SERIES THERMISTORS



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CERMET THERMISTOR SYSTEM PTC-2600 SERIES

The PTC-2600 Series of thermistor pastes are designed for making positive temperature coefficient thermistor films. The materials are designed for applications for which thermistors are required to be intimately bonded to the substrate. The materials are useful in applications where temperature compensation of hybrid circuits and fast response sensors is required. When used as temperature sensors, a linear response is obtained from ambient to temperatures in excess of 300°C. The PTC-2600 Series may be used to replace discrete thermistor components with the advantage of reduced size and lower cost.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5°C±0.5°C)	200±30 Pa·s
SHELF LIFE: (20°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/18.0 µm
LEVELING TIME: (20°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING TEMPERATURE: (in air)	850°C
TIME AT PEAK TEMPERATURE:	10 minutes
RATE OF ASCENT/DESCENT:	50°C-60°C/minute
SUBSTRATE FOR CALIBRATION:	96% alumina
RECOMMENDED TERMINATION:	9912-A (Ag)
THINNER:	ESL 401

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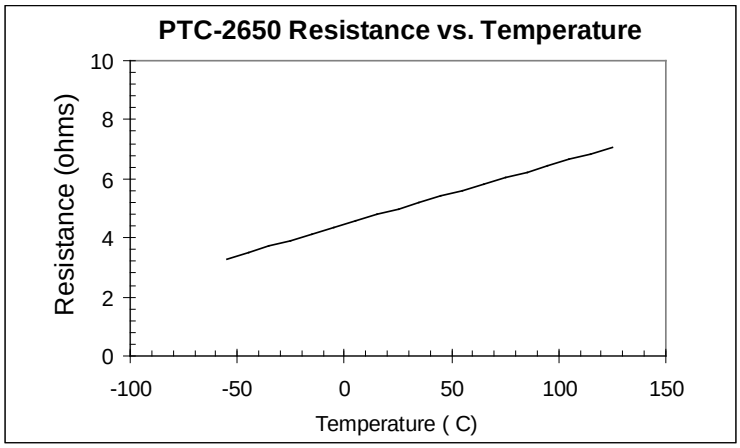
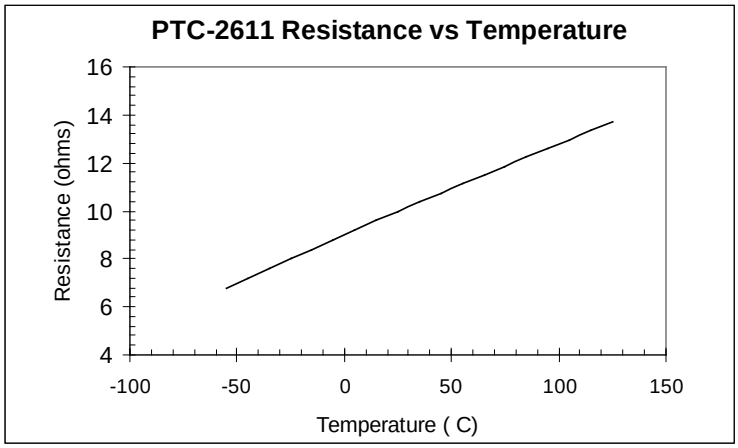
TYPICAL PROPERTIES

DRIED PRINT THICKNESS: (on 96% alumina) 22.5 ± 2.5 µm

	RESISTIVITY	HOT TCR, ppm/°C (+25°C to +125°C)	COLD TCR, ppm/°C (-55°C to +25°C)
PTC-2650	5 Ω/sq.±10%	+4000 ± 500	+4000 ± 500
PTC-2611	10 Ω/sq.±10%	+4100 ± 500	+4100 ± 500





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F: 610-272-6759
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CERMET RESISTOR SYSTEM PTC 2600-I SERIES

The PTC 2600-I Series of thermistor pastes is designed for making positive temperature coefficient thermistor films. Application where thermistors are required to be intimately bonded to the substrate such as temperature compensation of hybrid circuits and fast response sensors may be achieved with the PTC 2600-I Series. When used as temperature sensors, a linear response is obtained from ambient to temperatures in excess of 300°C with the advantage of reduced size and lower cost. Four values of sheet resistivity are available: 5 Ω/sq., 10 Ω/sq., 100 Ω/sq., and 1 kΩ/sq.

The 2600-I Series is designed to withstand high power dissipation and is ideally suited to the manufacturing of self limiting thick film heater elements for a wide range of consumer and industrial applications.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5°C±0.5°C)	200±30 Pa•s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/18 microns
LEVELING TIME: (20°C-25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING TEMPERATURE RANGE:	825°C-850°C (in air)
OPTIMUM (CALIBRATION):	850°C
TIME AT PEAK TEMPERATURE:	10 minutes

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RATE OF ASCENT / DESCENT:	50°C-60°C/minute
SUBSTRATE FOR CALIBRATION:	96% alumina
RECOMMENDED TERMINATION:	9912-A
THINNER:	ESL 401

TYPICAL PROPERTIES

DRIED PRINT THICKNESS: (on 96% alumina)			22.5 ± 2.5 µm
RESISTIVITY:	2650-I		5 Ω ±30%
	2611-I		10 Ω ±20%
	2612-I		100 Ω ±20%
	2613-I		1 kΩ ±10%
TCR: (Measured on a 2 mm x 20 mm resistor)	2650-I	Hot and Cold sides	3400 ± 400 ppm/°C
	2611-I	Hot and Cold sides	3000 ± 400 ppm/°C
	2612-I	Hot and Cold sides	2200 ± 400 ppm/°C
	2613-I	Hot and Cold sides	1600 ± 400 ppm/°C
VOLTAGE GRADIENT:			> 25V/mm

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CERMET RESISTOR SYSTEM PTC 2611-I Special

RoHS Compliant*

The PTC 2611-I Special is a thermistor paste designed for making positive temperature coefficient thermistor films. Applications where a thermistor is required to be intimately bonded to the substrate such as temperature compensation of hybrid circuits and fast response sensors may be achieved. When used as a temperature sensor, a linear response is obtained from ambient to temperatures in excess of 300°C with the advantage of reduced size and lower cost

The PTC 2611-I Special is designed to withstand high power dissipation and is ideally suited to the manufacturing of self-limiting thick film heater elements for a wide range of consumer and industrial applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 30 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 18 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		825 - 850 °C (in air)
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Recommended Termination:		9912-A
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Dried Print Thickness: (on 96% alumina)	15 ± 1.0 µm
Resistivity:	15Ω ± 20 %
TCR: (measured on a 2 x 20mm resistor at 25 & 125°C)	3000 ± 400 ppm / °C
Voltage Gradient:	> 25 V / mm

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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ESL ELECTROSCIENCE
CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET RESISTOR SYSTEM R-300-P SERIES

Cadmium Free

The R-300-P Resistor Series is an economical resistor paste designed for applications in high performance cermet trimmers and potentiometers.

The unique chemistry of the R-300-P Series provides excellent printing characteristics, nearly linear blending of adjacent members and minimal sensitivity towards wide variations in firing conditions. These advantageous features together with excellent fired resistor surface characteristics and low TCR's make this series a logical choice for exacting potentiometer requirements.

PASTE DATA

VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	**R-310-P & R-311-P**	300±50 Pa·s
	R-312-P to R-316-P	225±50 Pa·s
THINNER:		ESL 435

PROCESSING STIR WELL BEFORE USE

PRINT THICKNESS: A dry resistor film thickness range of 20 to 25 microns is recommended for optimum performance of the R-300-P series. With respect to ESL calibrations, use of different wiper metallurgies and/or higher wiper pressures may require a different dry film thickness to obtain optimum performance with this resistor series.

PRINTING AND DRYING: A 200 mesh stainless steel screen with 12±3 microns emulsion thickness is recommended. Allow wet prints to level at room temperature for 5 to 15 minutes. Then dry at 125° C for 10 to 15 minutes.

SUBSTRATES: The typical resistor performance data is based on tests using 96% alumina substrates (Kyocera A476). Substrates of other compositions may result in variations in resistor performance.

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See Caution and Disclaimer on other side.

FIRING:

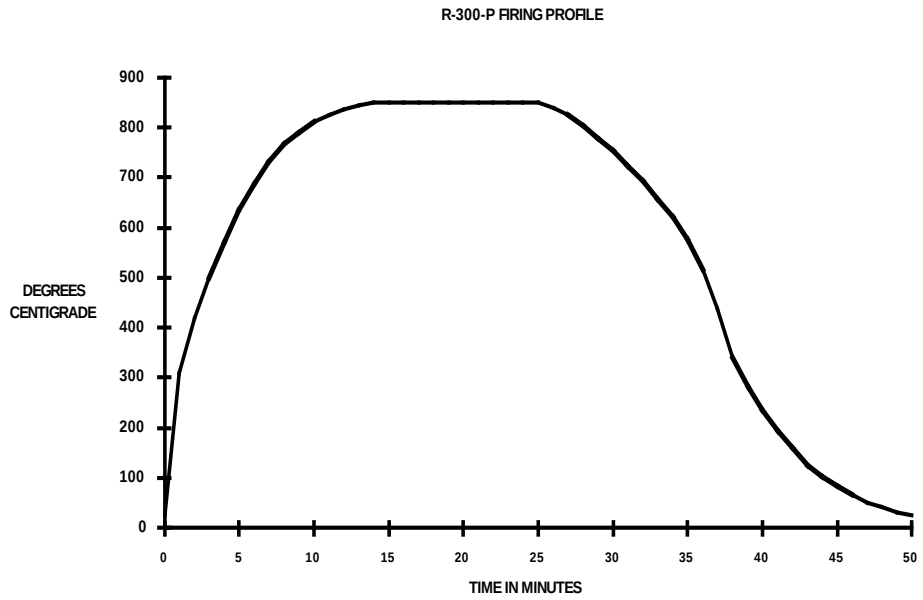
A continuous belt furnace with a total cycle time of 50 minutes and 11 minutes at a peak temperature of 850°C is recommended. See Figure 1. A dry, clean air atmosphere is required with a constant airflow of 20 liters per minute (for 10 cm wide belts) counter current to the substrate movement. The volume of air exchanged each minute should be approximately equal to the total volume of the furnace muffle. High production rates require increased airflows to keep vehicle burn-out products out of the peak firing zones. Avoid contamination of the air with vapors of halogenated solvents, residual compressor oil vapors and soldering flux fumes.

R-300-P SERIES

TERMINATIONS:

Reported resistor properties are with ESL C-951 PtAg conductor composition prefired at 850°C using a resistor geometry 1 mm wide x 4 mm long. Potentiometer properties are reported on a 2 mm wide x 20 mm long resistor. This resistor series is compatible with other ESL conductive compositions such as silver, palladium-silver, platinum-gold, and gold. However, some shifts in resistivity and TCR may result with their usage.

Figure 1



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R-300-P SERIES

TYPICAL RESISTOR PROPERTIES[a]

	R-310-P	R-311-P	R-312-P	R-313-P	R-314-P	R-315-P	R-316-P
RESISTIVITY (Ω/sq.):	1.5	10	100	1 k	10 k	100 k	1 M
SHIPPING TOLERANCE (%):	±20	±10	±10	±10	±10	±10	±10
TCR (ppm/°C):	±150	±100	±50	±50	±50	±50	±50
SHORT TIME OVERLOAD[b] (V/mm^2):	0.4	3	10	28	77	100	141

TYPICAL POTENTIOMETER PROPERTIES[c]

CRV:							
	< 1.0%	< 0.5%	< 0.3%	< 0.3%	< 0.3%	< 0.3%	< 0.3%
	< 1.0%	< 0.5%	< 0.3%	< 0.3%	< 0.3%	< 0.3%	< 0.3%
CONTACT NOISE:							
	< 1.0%	< 0.5%	< 0.3%	< 0.3%	< 0.3%	< 0.3%	< 0.3%
	< 1.0%	< 0.5%	< 0.3%	< 0.3%	< 0.3%	< 0.3%	< 0.3%
ROTATIONAL LIFE:							
	< 2.0%	< 1.0%	< 0.5%	< 0.2%	< 0.2%	< 0.2%	< 0.2%

a. Resistor Geometry: 1 mm width x 4 mm length. ESL C-951 PtAg terminations prefired at 850°C, 96% alumina substrate.

b. STOL: Voltage required, 5 seconds duration, to induce a resistance change of 0.5% at 25°C.

c. Ten finger Palliney 8 wiper, 10 grams/finger weight, 2 mm wide x 20 mm long resistor.

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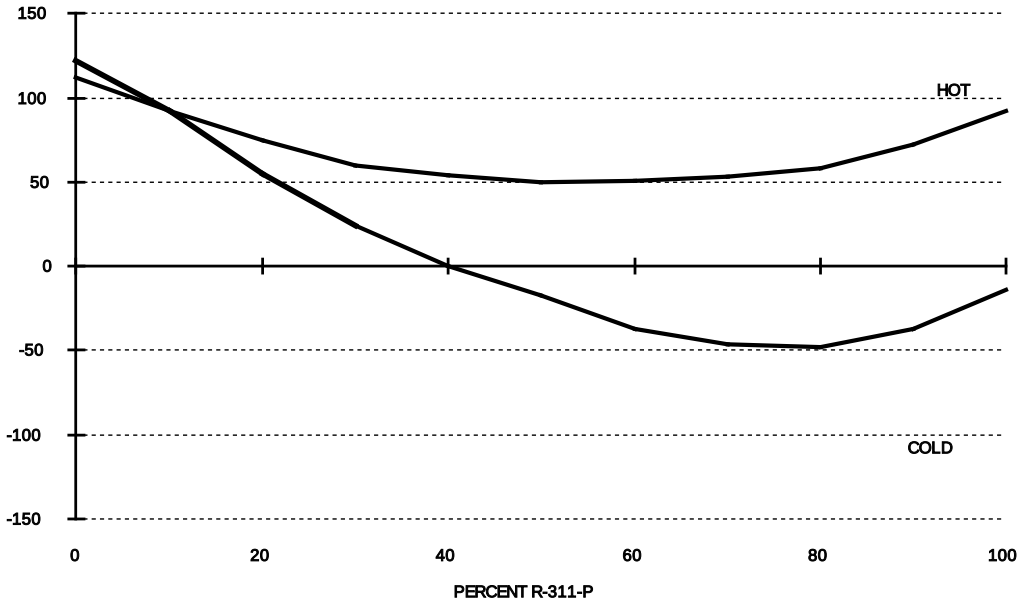
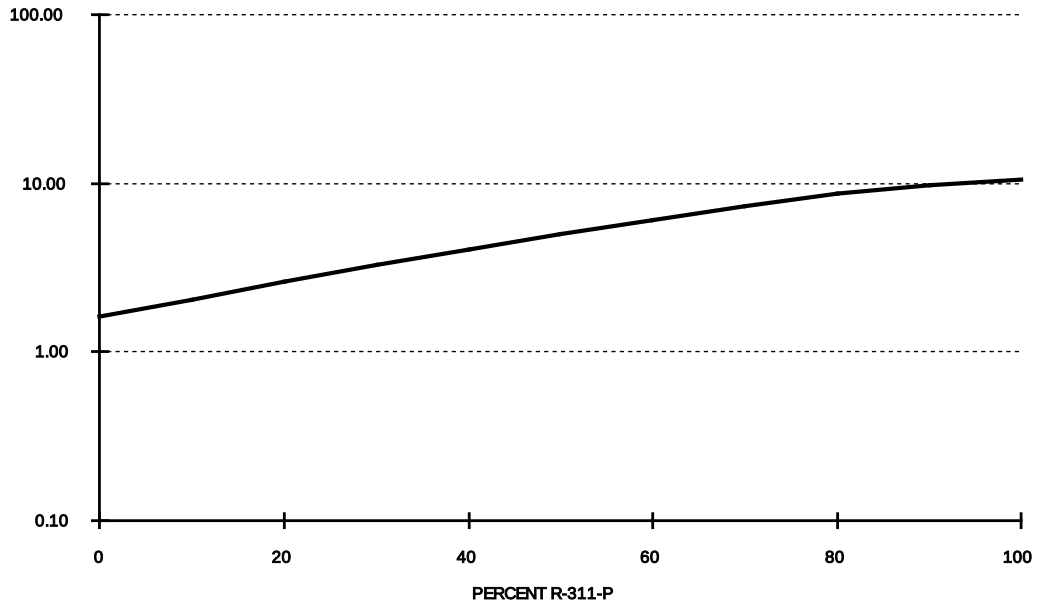
R-300-P SERIES

BLENDING CURVES FOR R-310-P / R-311-P

RESISTANCE VERSUS PERCENT BLEND



TCR VERSUS PERCENT BLEND



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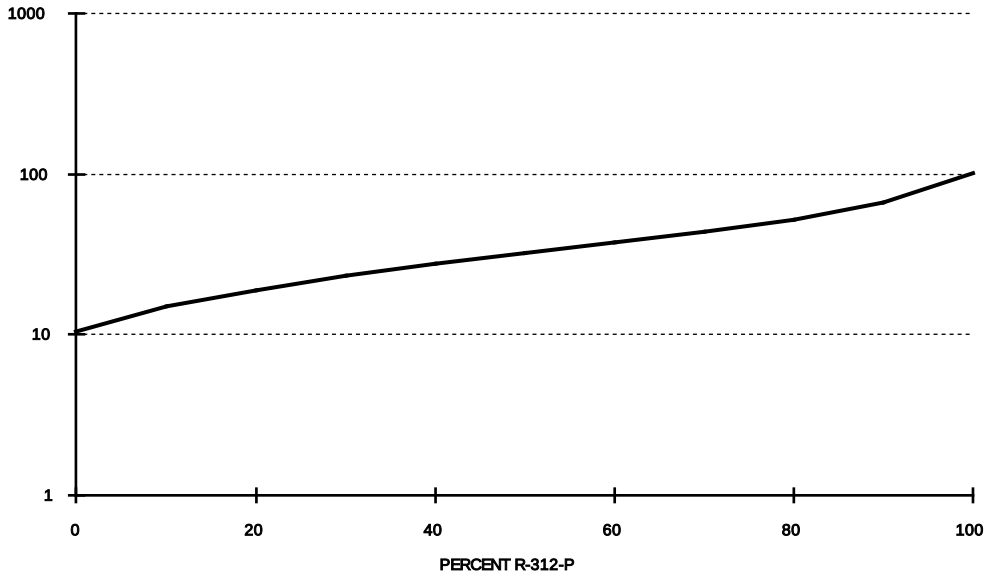
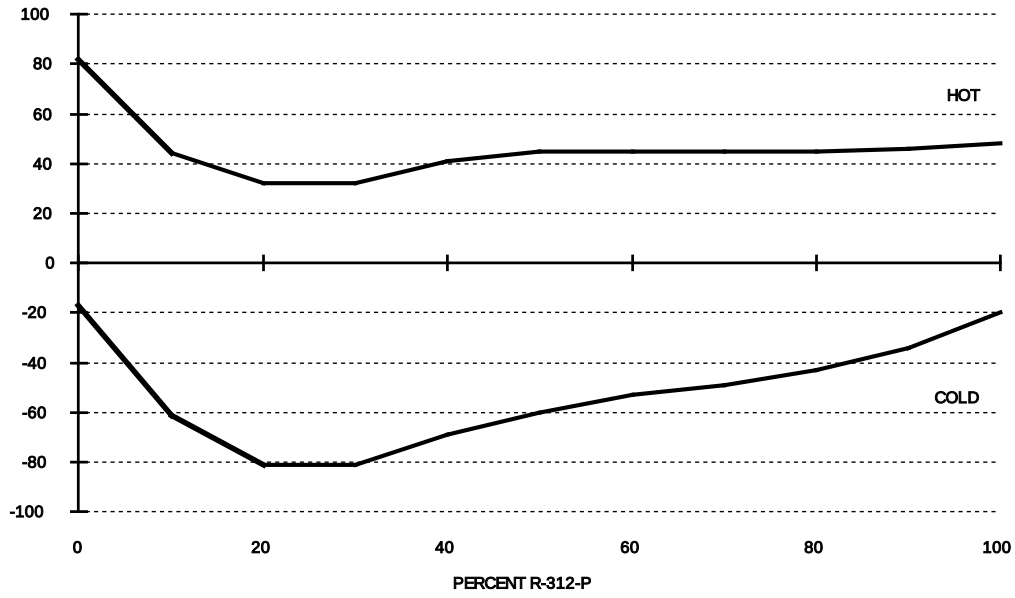
R-300-P SERIES

BLENDING CURVES FOR R-311-P / R-312-P

RESISTANCE VERSUS PERCENT BLEND



TCR VERSUS PERCENT BLEND



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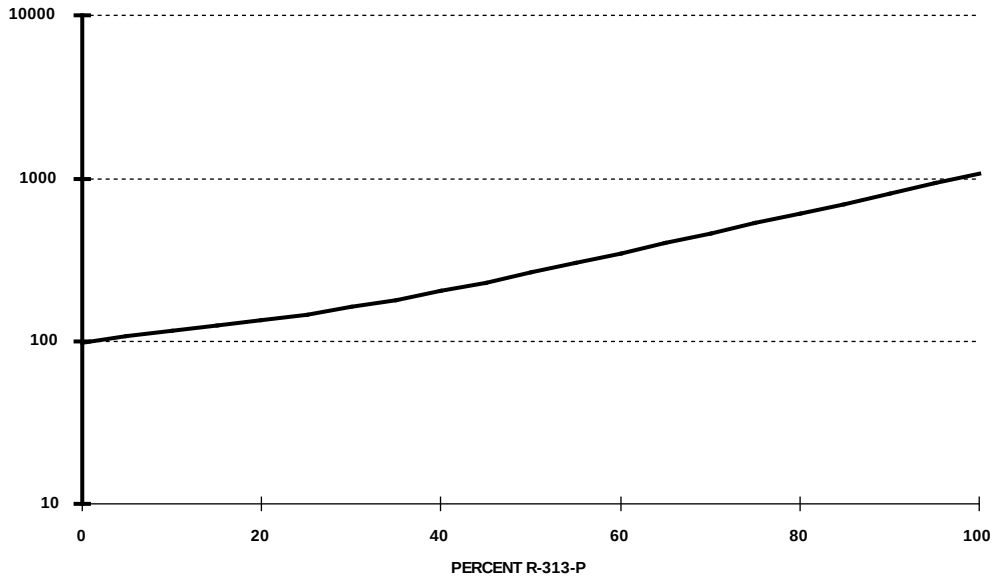
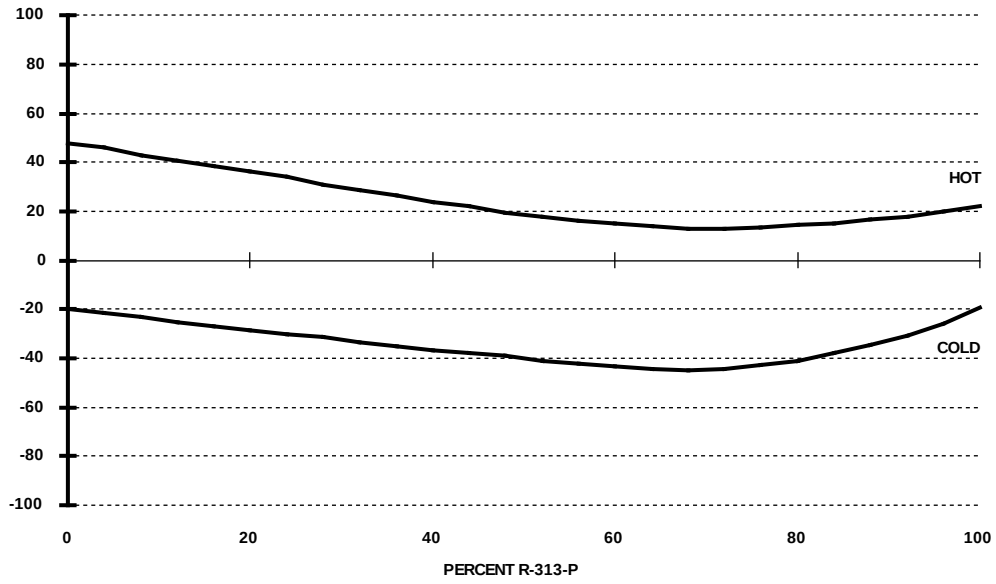
R-300-P SERIES

BLENDING CURVES FOR R-312-P / R-313-P

RESISTANCE VERSUS PERCENT BLEND



TCR VERSUS PERCENT BLEND



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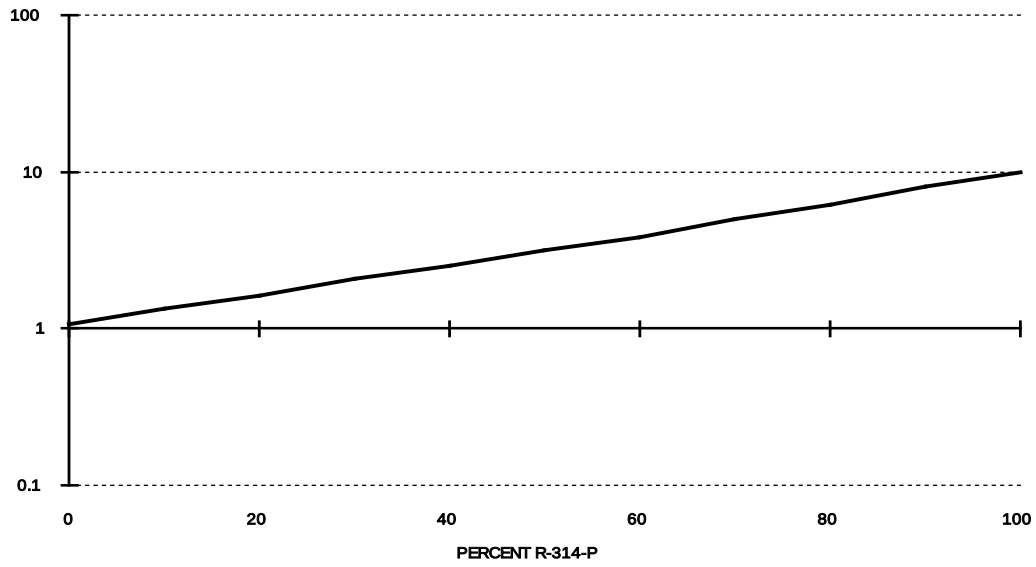
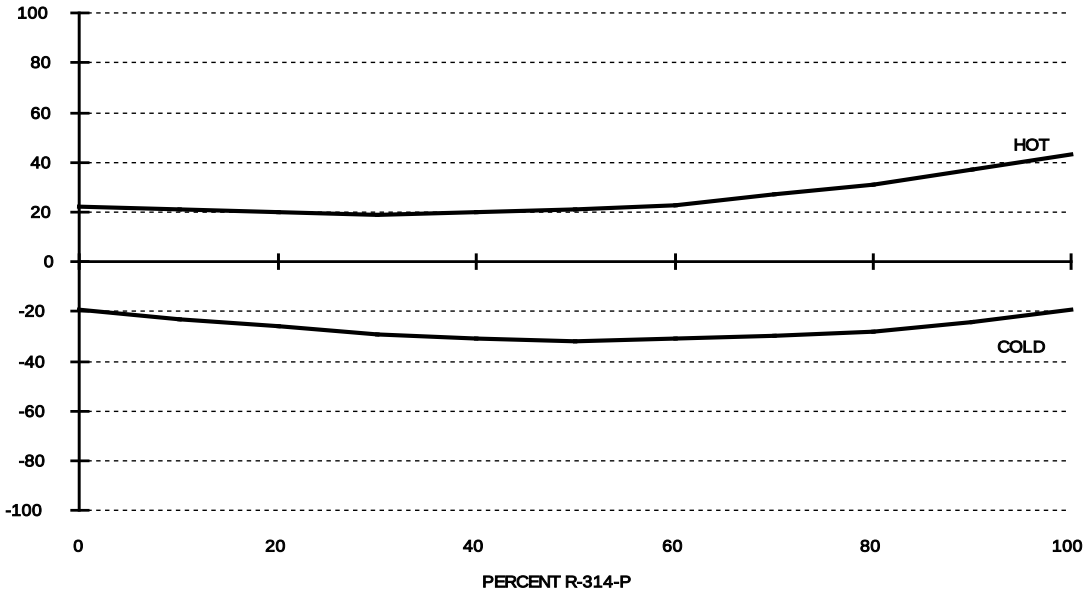
R-300-P SERIES

BLENDING CURVES FOR R-313-P / R-314-P

RESISTANCE VERSUS PERCENT BLEND



TCR VERSUS PERCENT BLEND



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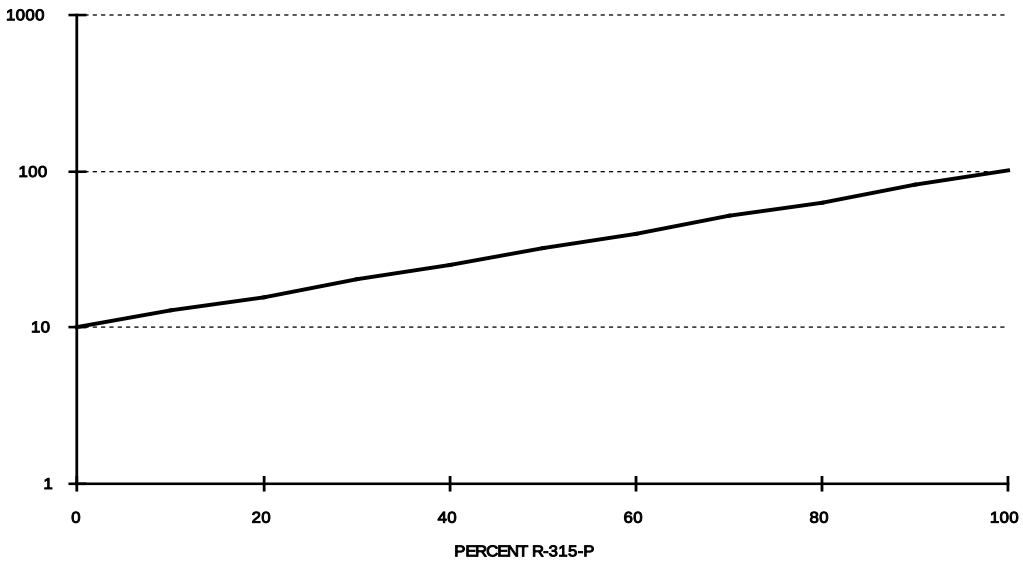
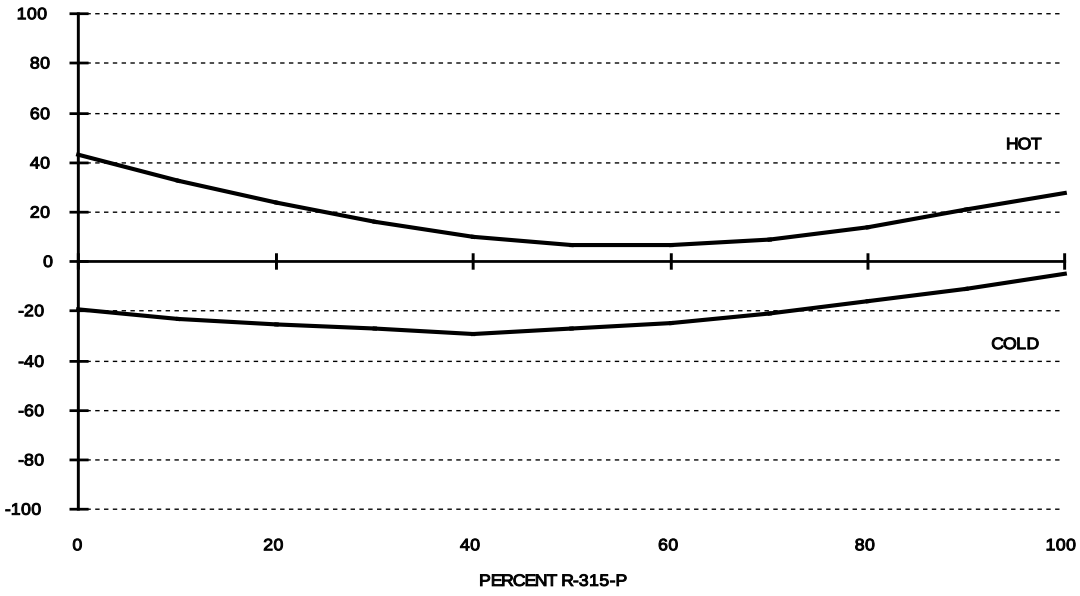
R-300-P SERIES

BLENDING CURVES FOR R-314-P / R-315-P

RESISTANCE VERSUS PERCENT BLEND



TCR VERSUS PERCENT BLEND



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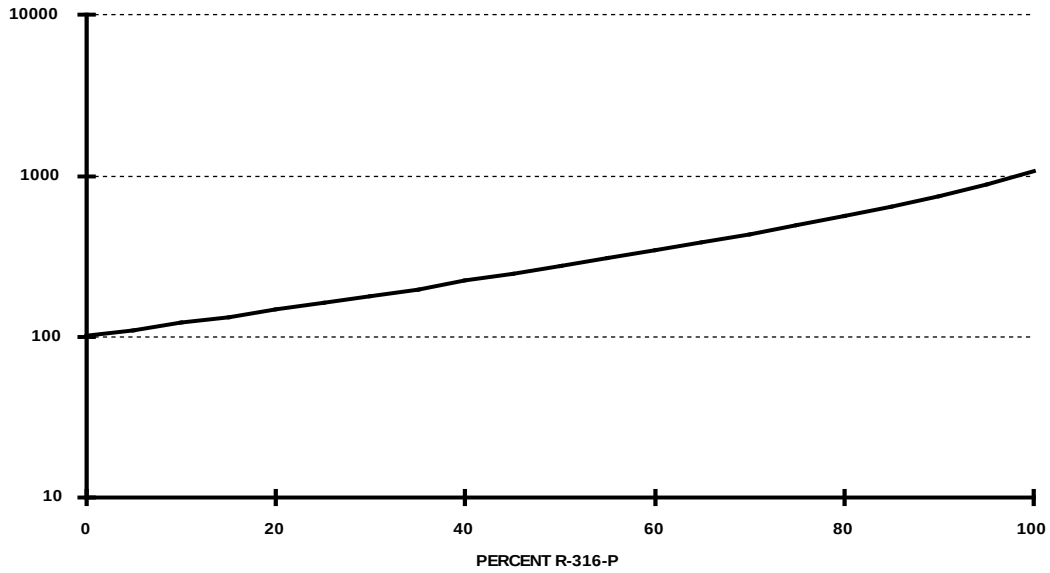
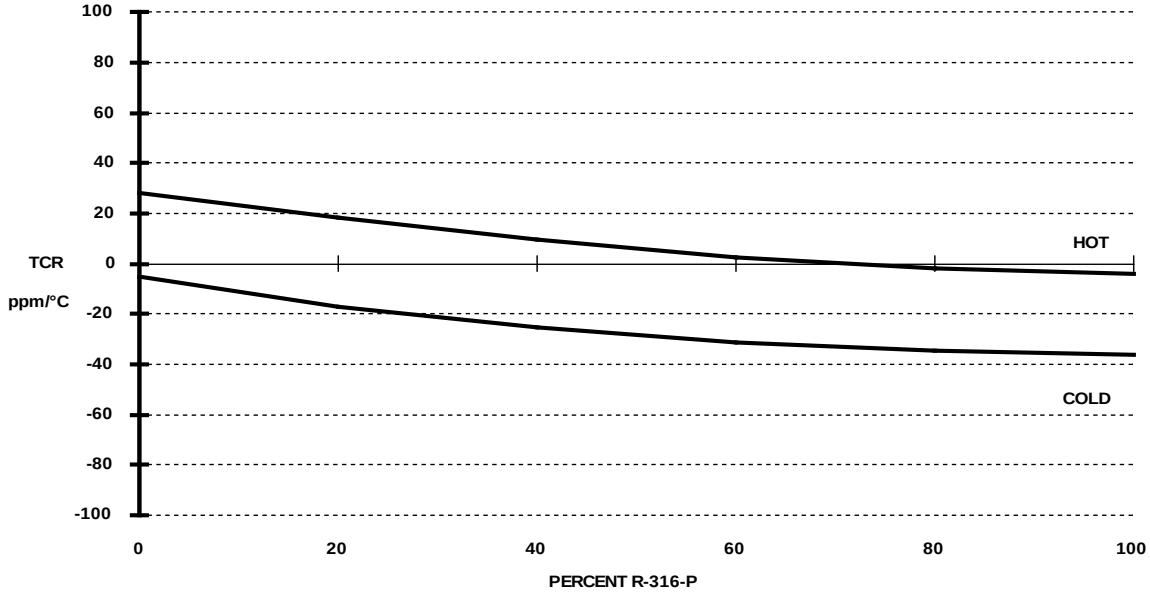
R-300-P SERIES

BLENDING CURVES FOR R-315-P / R-316-P

RESISTANCE VERSUS PERCENT BLEND



TCR VERSUS PERCENT BLEND



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R-300-P SERIES

TYPICAL FIRING SENSITIVITY
R-311-P

NORMALIZED RESISTIVITY
AND TCR (ppm/°C, HOT AND COLD)
(10 MINUTE SOAK TIME)

RESISTOR	**RESISTOR FIRING**	**PEAK RESISTOR FIRING TEMP**					
TERMINATIONS	**CYCLE TIME**	**830°C**		**850°C**		**870°C**	
		R	**TCR**	**R**	**TCR**	**R**	**TCR**
C-951	60 MINUTES	0.913	150/55	0.972	113/8	0.989	92/-3
C-951	30 MINUTES	0.824	177/88	0.848	158/61	0.823	166/79
9695	60 MINUTES			0.985	109/4		
9695	50 MINUTES			1.031	84/-24		
	ESL CALIBRATION			1.000	87/-21		

NOTES:

1. Normalizing Resistivity: (1 mm x 4 mm), 4 squares = 10.54 Ω/sq. ESL calibration: ESL C-951 PtAg terminations, 11 minute soak time, 850°C, 50 minutes firing cycle.
2. TCR, ESL calibration, (ppm/°C, Hot/Cold, +125°C/-55°C) = 87/-21

TYPICAL FIRING SENSITIVITY
R-312-P

NORMALIZED RESISTIVITY
AND TCR (ppm/°C, HOT AND COLD)
(10 MINUTE SOAK TIME)

RESISTOR	**RESISTOR FIRING**	**PEAK RESISTOR FIRING TEMP**					
TERMINATIONS	**CYCLE TIME**	**830°C**		**850°C**		**870°C**	
		R	**TCR**	**R**	**TCR**	**R**	**TCR**
C-951	60 MINUTES	0.901	49/3	0.980	66/-13	1.057	82/23
C-951	30 MINUTES	0.885	73/6	0.864	73/24	0.898	95/51
9695	60 MINUTES			0.886	65/3		
9695	50 MINUTES			0.929	56/-13		
	ESL CALIBRATION			1.000	48/-20		

NOTES:

1. Normalizing Resistivity: (1 mm x 4 mm), 4 squares = 101.08 Ω/sq. ESL calibration: ESL C-951 PtAg terminations, 11 minute soak time, 850°C, 50 minutes firing cycle.
2. TCR, ESL calibration, (ppm/°C, Hot/Cold, +125°C/-55°C) = 48/-20

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R-300-P SERIES

TYPICAL FIRING SENSITIVITY
R-313-P

NORMALIZED RESISTIVITY
AND TCR (ppm/°C, HOT AND COLD)
(10 MINUTE SOAK TIME)

RESISTOR	**RESISTOR FIRING**	**PEAK RESISTOR FIRING TEMP**					
TERMINATIONS	**CYCLE TIME**	**830°C**		**850°C**		**870°C**	
		R	**TCR**	**R**	**TCR**	**R**	**TCR**
C-951	60 MINUTES	0.740	68/51	0.992	32/-1	1.197	6/-45
C-951	30 MINUTES	0.731	92/82	0.928	64/38	1.088	51/4
9695	60 MINUTES			0.971	37/5		
9695	50 MINUTES			1.107	33/-2		
	ESL CALIBRATION			1.000	31/-4		

NOTES:

1. Normalizing Resistivity: (1 mm x 4 mm), 4 squares = 1.039 kΩ/sq. ESL calibration: ESL C-951 PtAg terminations, 11 minute soak time, 850°C, 50 minutes firing cycle.
2. TCR, ESL calibration, (ppm/°C, Hot/Cold, +125°C/-55°C) = 31/-4

TYPICAL FIRING SENSITIVITY
R-314-P

NORMALIZED RESISTIVITY
AND TCR (ppm/°C, HOT AND COLD)
(10 MINUTE SOAK TIME)

RESISTOR	**RESISTOR FIRING**	**PEAK RESISTOR FIRING TEMP**					
TERMINATIONS	**CYCLE TIME**	**830°C**		**850°C**		**870°C**	
		R	**TCR**	**R**	**TCR**	**R**	**TCR**
C-951	60 MINUTES	0.857	62/42	1.002	47/24	1.208	35/1
C-951	30 MINUTES	0.992	76/62	1.080	65/36	1.186	70/46
9695	60 MINUTES			1.030	43/15		
9695	50 MINUTES			1.048	40/14		
	ESL CALIBRATION			1.000	43/19		

NOTES:

1. Normalizing Resistivity: (1 mm x 4 mm), 4 squares = 9.927 kΩ/sq. ESL calibration: ESL C-951 PtAg terminations, 11 minute soak time, 850°C, 50 minutes firing cycle.
   TCR, ESL calibration, (ppm/°C, Hot/Cold, +125°C/-55°C) = 43/19

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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R-300-P SERIES

TYPICAL FIRING SENSITIVITY
R-315-P

NORMALIZED RESISTIVITY
AND TCR (ppm/°C, HOT AND COLD)
(10 MINUTE SOAK TIME)

RESISTOR	**RESISTOR FIRING**	**PEAK RESISTOR FIRING TEMP**					
TERMINATIONS	**CYCLE TIME**	**830°C**		**850°C**		**870°C**	
		R	**TCR**	**R**	**TCR**	**R**	**TCR**
C-951	60 MINUTES	1.069	22/-7	0.899	39/8	0.828	53/35
C-951	30 MINUTES	1.094	23/-6	0.937	41/21	0.809	81/79
9695	60 MINUTES			0.926	37/13		
9695	50 MINUTES			0.997	35/8		
	ESL CALIBRATION			1.000	31/-1		

NOTES:

1. Normalizing Resistivity: (1 mm x 4 mm), 4 squares = 93.33 kΩ/sq. ESL calibration: ESL C-951 PtAg terminations, 11 minute soak time, 850°C, 50 minutes firing cycle.
2. TCR, ESL calibration, (ppm/°C, Hot/Cold, +125°C/-55°C) = 31/-1

TYPICAL FIRING SENSITIVITY
R-316-P

NORMALIZED RESISTIVITY
AND TCR (ppm/°C, HOT AND COLD)
(10 MINUTE SOAK TIME)

RESISTOR	**RESISTOR FIRING**	**PEAK RESISTOR FIRING TEMP**					
TERMINATIONS	**CYCLE TIME**	**830°C**		**850°C**		**870°C**	
		R	**TCR**	**R**	**TCR**	**R**	**TCR**
C-951	60 MINUTES	1.683	-24/-72	0.953	7/-22	0.600	35/18
C-951	30 MINUTES	1.713	-34/-84	1.007	0/-35	0.591	26/12
9695	60 MINUTES			1.056	9/-25		
9695	50 MINUTES			0.992	0/-29		
	ESL CALIBRATION			1.000	2/-28		

NOTES:

1. Normalizing Resistivity: (1 mm x 4 mm), 4 squares = 1.024 MΩ/sq. ESL calibration: ESL C-951 PtAg terminations, 11 minute soak time, 850°C, 50 minutes firing cycle.
   TCR, ESL calibration, (ppm/°C, Hot/Cold, +125°C/-55°C) = 2/-28

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Sealing glasses

4022-F

Low temperature firing sealing glass paste for Soda-Lime glass. Has fine particle size distribution and useful for making thin seal cross-sections.

4026

Glass paste for sealing alumina substrates together at medium temperature. Other similar T.C.E ceramic or glass materials may be bonded.

4026-A

Sealing glass with a T.C.E to match 96% alumina and provide high adhesion.

4030

Glass paste is designed for sealing ceramic (alumina) plates at a low temperature. Green colour.

4031

Glass paste is designed for sealing ceramic (alumina) plates at a low temperature. Blue colour.

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416 EAST CHURCH ROAD
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DIELECTRIC COMPOSITION 4022-F

Low Temperature Firing Sealing Glass for Soda-Lime Glass

ESL 4022-F is a glass paste in screen-printable form, for use in sealing together soda-lime glass plates. It is designed to be processed at low temperatures. Other glass substrates or ceramics having a thermal coefficient of expansion similar to soda-lime glass may also be bonded. ESL 4022-F has a fine particle size distribution and is useful for making thin seal cross-sections. When properly fired, 4022-F produces fairly clear transparent seals for use in a variety of packaging and hermetic seal applications.

PASTE DATA

Rheology:	Thixotropic, screen printable paste
Viscosity: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5 ± 0.5 °C)	125 ± 25 Pa.s
Colour:	Transparent Gray
Shelf Life:	Six months

PROCESSING

Screen Mesh/Emulsion:	200-325/38 µm
Leveling Time:	5 - 10 minutes
Drying at 125° C:	10 - 15 minutes
Firing Temperature:	500°C
Rate of Ascent/Descent:	20 - 40 °C/minute
Substrate for Calibration:	soda-lime glass
Thinner:	ESL 401

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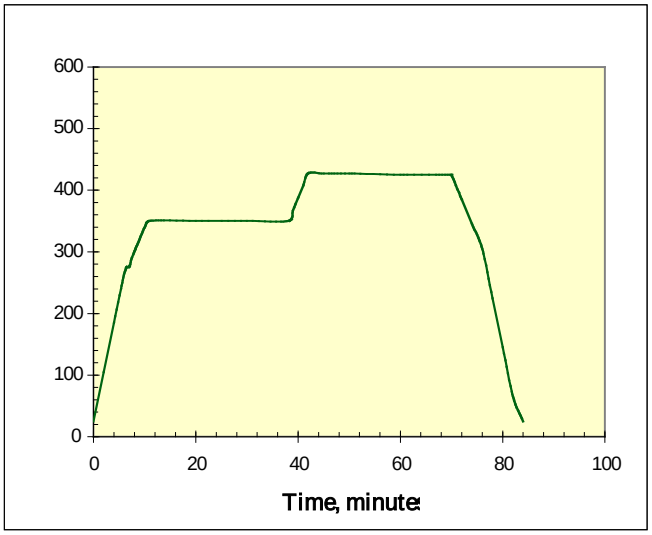
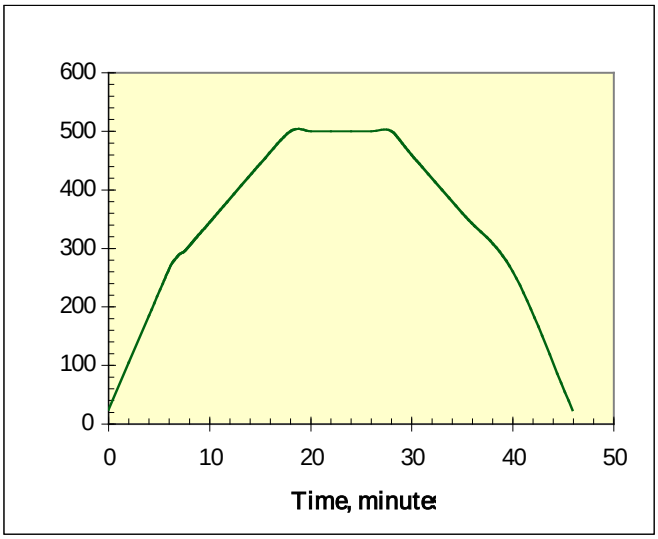
TYPICAL PROPERTIES

Fired Thickness: 18 ± 8 µm

Typical Burnoff and Sintering Cycle



Typical Sealing Cycle



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F: 610-272-6759
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SEALING GLASS PASTE 4026

ESL 4026 is a glass in a screen-printable paste that may be used for sealing alumina substrates together at medium temperature. Other ceramics or glass materials having thermal coefficients of expansion similar to alumina may be bonded as well. The paste contains vitreous, non-pigmented glasses in organic vehicles that burn off before the glasses melt. Failure to accomplish complete burnout may lead to gas leakage of the fired seal and will leave dark carbonaceous residues within the glass layer. The sealing temperature used is dependent upon the time at peak temperature and the degree of pressure (clamps or weights) that may be applied during firing. Longer sealing times and/or higher pressures allow lower temperatures. Weights of 0.5 - 1.0 kg have been used for packages 2 cm². If clamps are used they should be arranged to equalise the pressures around the edge of the seal. This sealing glass is not recommended for sealing substrates that differ in thermal coefficient of expansion (TCE) by more than 10 - 15% from that of the sealant. By prefusing 4026 to alumina and 4011 or 4022 to soda lime glass, seals can be made between alumina and glass. It is also known that these sealing glasses have excellent acid resistance and may be used as chip resistor overglazes.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No.7 spindle, 25.5 ± 0.5 °C)		175 ± 25 Pa.s
Colour:		Clear
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 or 325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:	Burnout:	325 - 375 °C / 15 - 30 min
	Sealing:	550 - 625 °C / 1 - 2.5 hrs
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Thermal Coefficient of Expansion (TCE): 76×10^{-7}/°C

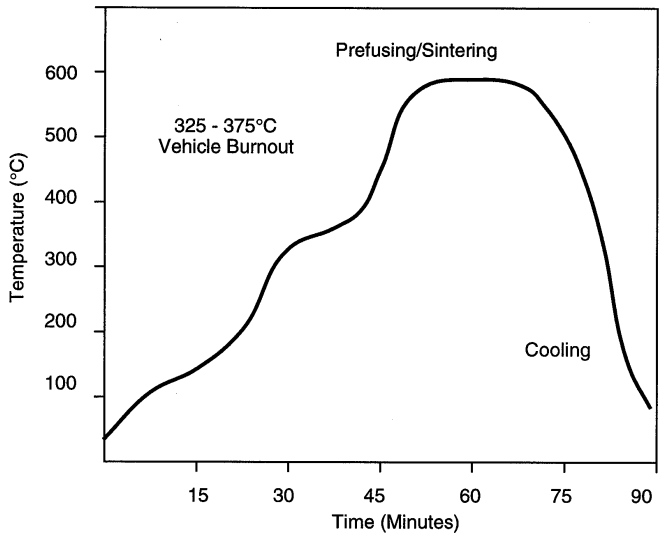

Figure 1: Generalised temperature profile for drying, burnout, prefusing/sintering for 4026

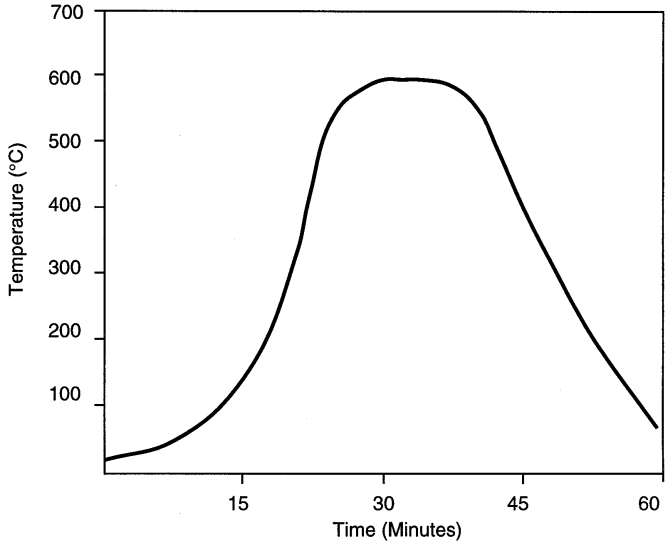

Figure 2: Generalised temperature profile for sealing (for use only after drying, burnout and prefusing/sintering steps) 4026

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F: 610-272-6759
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SEALING GLASS PASTE 4026-A

ESL 4026-A is a sealing glass designed to match the T.C.E. of 96% alumina and provide high adhesion.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, No.7 spindle, 25.5 ± 0.5 °C)	45 ± 15 Pa.s
Colour:	Clear
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 37.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		700 - 730 °C
	Optimum:	720 °C
	Time at peak	8 - 10 min
Rate of Ascent/Descent:		60 - 100° C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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DIELECTRIC COMPOSITION 4030

RoHS Compliant* • Sealing glass

ESL 4030 glass paste is designed for sealing ceramic (alumina) plates at a low temperature. When properly fired, ESL 4030 produces transparent seals that can be used in a variety of packaging and hermetic sealing applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Colour:	Green
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 38 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C): (depending on substrate volume)	10 - 15 min
Firing Temperature Range:	See profiles on next page
Burn-off Cycle (30 min):	325 - 375 °C, Rate 40°C / min
Sintering Cycle (30 min):	375 - 550 °C, Rate 40°C / min
Sealing Cycle (30 min):	550 - 625 °C, Rate 20°C / min
Substrate for Calibration:	96% alumina
Thinner:	ESL 401

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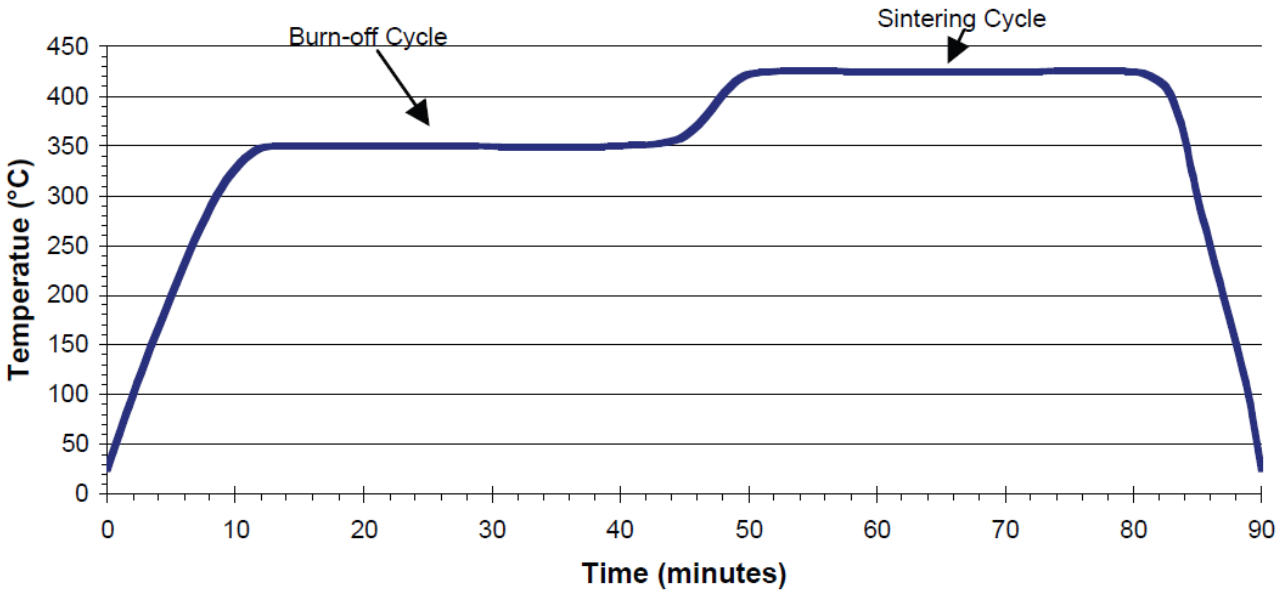
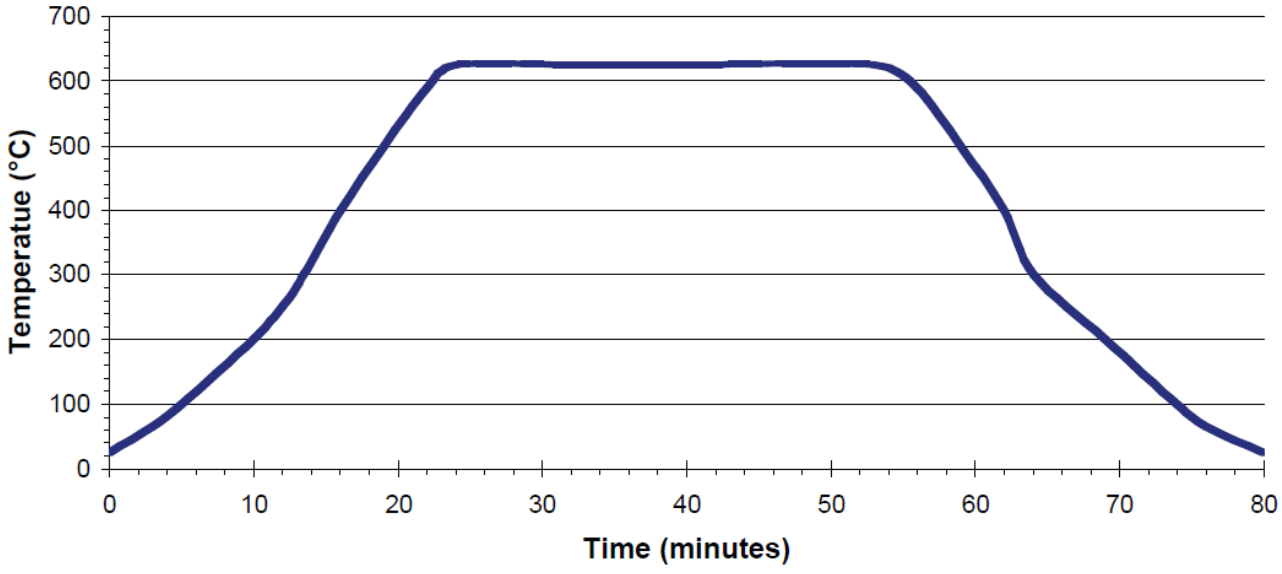
See Caution and Disclaimer on page 2.

TYPICAL PROFILES

Burn-off and Sintering Cycle



Sealing Cycle



***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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DIELECTRIC COMPOSITION 4031

RoHS Compliant* • Sealing glass

ESL 4031 glass paste is designed for sealing ceramic (alumina) plates at a low temperature. When properly fired, ESL 4031 produces transparent seals that can be used in a variety of packaging and hermetic sealing applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Colour:	Blue
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 S/S, 18-38 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C): (depending on substrate volume)	10 - 15 min
Firing Temperature Range:	
Burn-off Cycle (30 min):	375 - 400 °C, Rate 40°C / min
Sintering Cycle (30 min):	450 - 550 °C, Rate 40°C / min
Sealing Cycle (30 min):	530 - 580 °C, Rate 20°C / min
Substrate for Calibration:	96% alumina
Thinner:	ESL 401

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TYPICAL PROPERTIES

Fired Thickness: 30 - 40 µm

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Sensor Materials

3414 Series
High gauge factor resistor pastes for piezo-resistive applications on alumina or other ceramic substrates.

3424
High gauge factor, low noise, resistor paste for piezo-resistive applications on alumina or other ceramic membranes or substrates.

4492
Alumina paste composition for use in planar oxygen sensors

4550
Porous zirconia paste composition for use in planar oxygen sensors

49000
Flexible cast film of fugitive powder dispersed in an organic matrix for use in creating channels in sensors.

5559-B
Platinum conductor designed to be co-fired with alumina tape at high temperatures.

5570
Platinum conductor designed to be co-fired with alumina tape or partially stabilised zirconia tape at high temperatures.

5571
Platinum conductor designed to be co-fired with alumina tape at high temperatures for use as a heater in planar sensors.

5572
Platinum conductor for use as an inner electrode material for partially stabilized zirconia conical oxygen sensors.

5573
Platinum conductor for use as an outer electrode material for partially stabilized zirconia conical oxygen sensors.

5574
Platinum conductor designed to be co-fired with alumina at high temperatures for conical oxygen sensors.

5575

Platinum via-fill conductor designed to be co-fired with alumina tape or partially stabilized zirconia tape at high temperatures.

NTC-2100 Series

Series of thermistor pastes for making negative temperature coefficient thermistor films.

PTC-2600 Series

Series of thermistor pastes for making positive temperature coefficient thermistor films.

PTC-2600-I Series

Series of thermistor pastes for making positive temperature coefficient thermistor films. Withstands high power dissipation.

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CERMET RESISTOR 3414 Series

High Gauge Factor

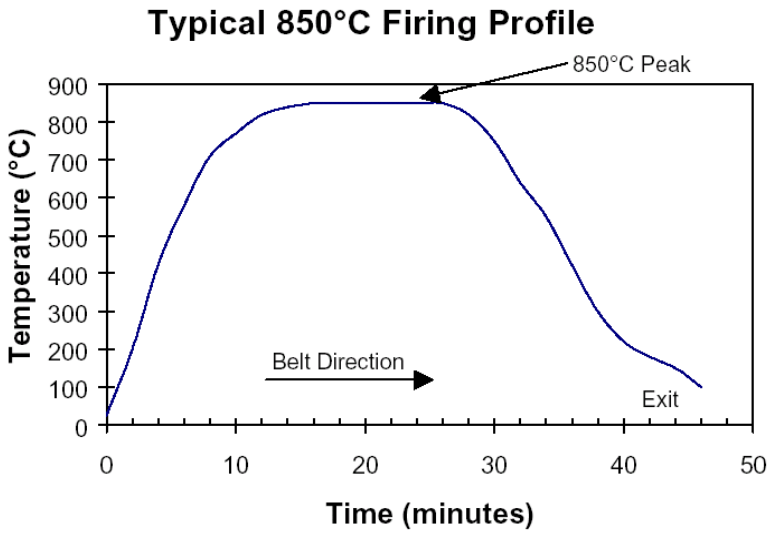
ESL 3414 Series high gauge factor resistor pastes are specifically designed for piezo-resistive applications on alumina or other ceramic membranes or substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 12 min
Firing Temperature:		850°C (in air)
	Time at peak:	10- 12 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		9635-A on 96% alumina
Thinner:		ESL 401



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TYPICAL PROPERTIES:

Fired Resistor Thickness: 11±1 µm

Resistor Terminations: (Pre-fired) ESL 8836

	3414-B-LBM	3414-B-HBM	3414-A	3414-B
Sheet Resistivity:[1] (kΩ/sq.)	1.0 - 1.5	2.5 - 3.0	7.2 - 8.8	3.6 - 4.4
TCR: (in ppm/°C)	±150	±150	±100	±100
Noise Index:[1]	0 dB	3 dB	1 dB	6 dB
Typical Gauge Factor:[2]				
Longitudinal:	15 - 16	17 - 18	14 - 15	18 - 19
Transverse:	8 - 9	10 - 11	8 - 10	10 - 12
Nonlinearity:	1%	1%	1%	3%
Hysteresis:	1%	1%	1%	3%

NOTES:

1. 1.25 mm x 1.25 mm geometry
2. 1.00 mm x 1.00 mm geometry
3. Designing resistors with an active length greater than 1.25 mm may minimize the ESD sensitivity.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET HIGH GAUGE FACTOR RESISTOR SYSTEM

3424

ESL 3424 is a high gauge factor, low noise, resistor paste specifically designed for piezo-resistive applications on alumina or other ceramic membranes or substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 1000°C (in air)
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		9635-A on 96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Dried Print Thickness: (measured on a 1.25 mm x 1.25 mm resistor on 96% alumina)	22.5 ± 2.5 µm
Approximate Coverage:	120 cm^2 / g
Resistivity: (measured on a 1.25 mm x 1.25 mm resistor)	9 - 10 K Ω/□
TCR: (measured on a 1.25 mm x 1.25 mm resistor)	± 100 ppm / °C
Noise Index: (measured on a 1.0 mm x 1.0 mm resistor terminated on 8836)	< - 10 dB

Guage Factor:
(measured on a 1.0 mm x 1.0 mm resistor terminated on 8836)

Longitudinal:	8 - 10
Transverse:	5 - 7
Nonlinearity:	≤ 1%
Hysteresis:	≤ 1%

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ALUMINA DIELECTRIC 4492

RoHS Compliant* Dielectric for Oxygen Sensors

ESL 4492 is an alumina paste composition for use in planar oxygen sensors. It is a screen-printable thick-film paste.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s

PROCESSING

SCREEN PARAMETERS	200 mesh/ 25.4µm emulsion
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
SHELF LIFE: (at 25°C)	6 months

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POROUS ZIRCONIA PASTE 4550

RoHS Compliant* Dielectric for Oxygen Sensors

ESL 4550 is a porous zirconia paste composition for use in planar oxygen sensors. It is a screen-printable thick-film paste.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	250±50 Pa·s

PROCESSING

SCREEN PARAMETERS	200 mesh/ 25.4µm emulsion
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
SHELF LIFE: (at 25°C)	6 months

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FUGITIVE TAPE 49000

Organic-Based Tape for use in Creating Channels in Sensors
RoHS Compliant*

ESL 49000 is a flexible cast film of fugitive powder dispersed in an organic matrix. This material is designed to be burned out in the temperature range of 600°C-700°C to yield a void where the tape was placed. ESL 49000 tape is provided on a silicone-coated polyester film to protect the tape from mechanical damage and aid in handling.

This tape is generally used with zirconia or alumina green tapes and can be co-fired for use in oxygen sensors.

TAPE THICKNESS: 125µm +/- 10%
(custom thicknesses available)

PROCESSING:

Parts are formed by blanking sheets of the tape to the required green size prior to firing. The burnout cycle depends on the part configuration and size.

TYPICAL FIRING PROFILE FOR PARTS: Depends on matrix tapes

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CO-FIRING PLATINUM CONDUCTOR 5559-B

RoHS compliant* co-firable conductor designed for use as a heater in planar sensors

ESL 5559-B is a platinum conductor designed to be co-fired with alumina tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	75 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	90 ± 10 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SUBSTRATE OF CALIBRATION:	alumina tape

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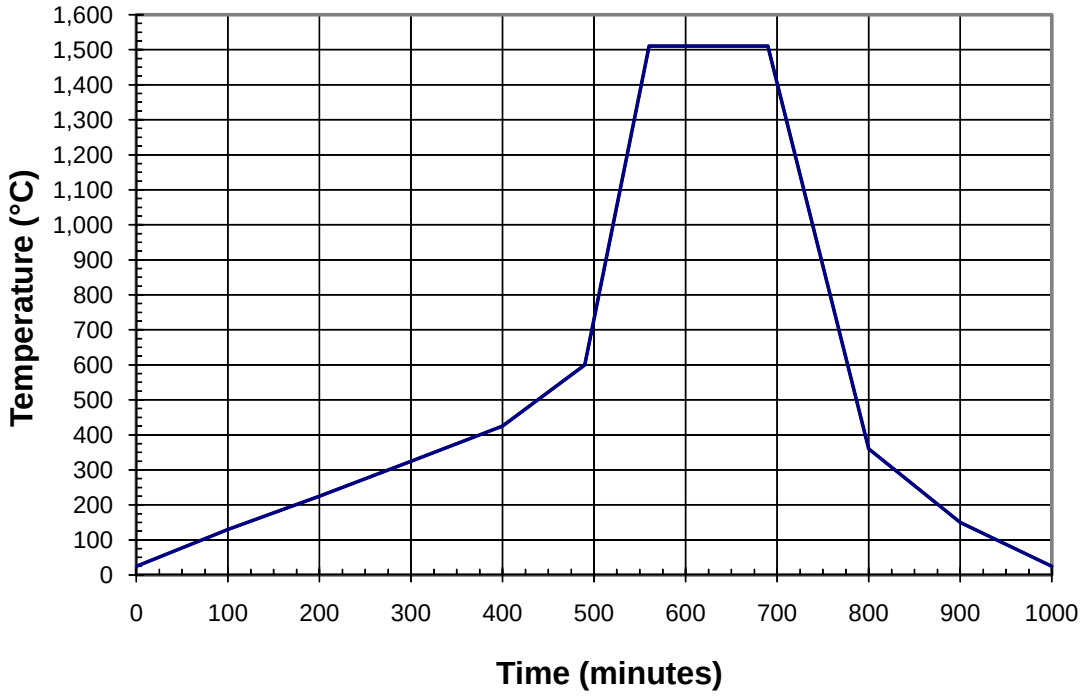
Typical Firing Profile for 5559-B



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CO-FIRING POROUS PLATINUM CONDUCTOR 5570

RoHS compliant* conductor designed for use as an electrode in planar sensors

ESL 5570 is designed to be co-fired with partially stabilized zirconia tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 20.0°C ± 0.5°C)	70 ± 20 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	30 ± 10 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SODIUM CONCENTRATION:	≤ 50 ppm
SUBSTRATE OF CALIBRATION:	partially stabilized zirconia tape

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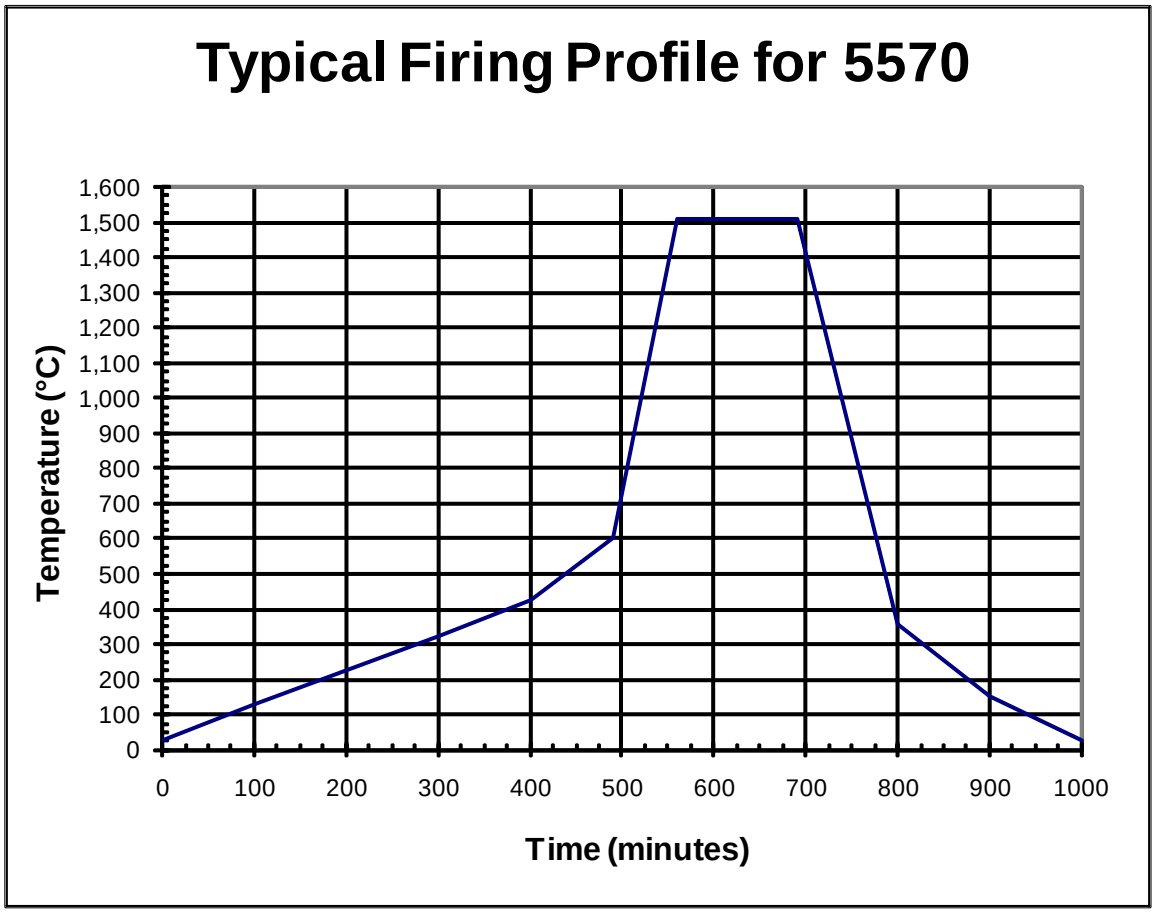

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CO-FIRING PLATINUM CONDUCTOR 5571

RoHS compliant* co-fireable conductor designed for use as a heater in planar sensors

ESL 5571 is a platinum conductor designed to be co-fired with alumina tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable pastes
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	75 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	40 ± 5 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SODIUM CONCENTRATION:	≤ 50 ppm
SUBSTRATE OF CALIBRATION:	alumina tape

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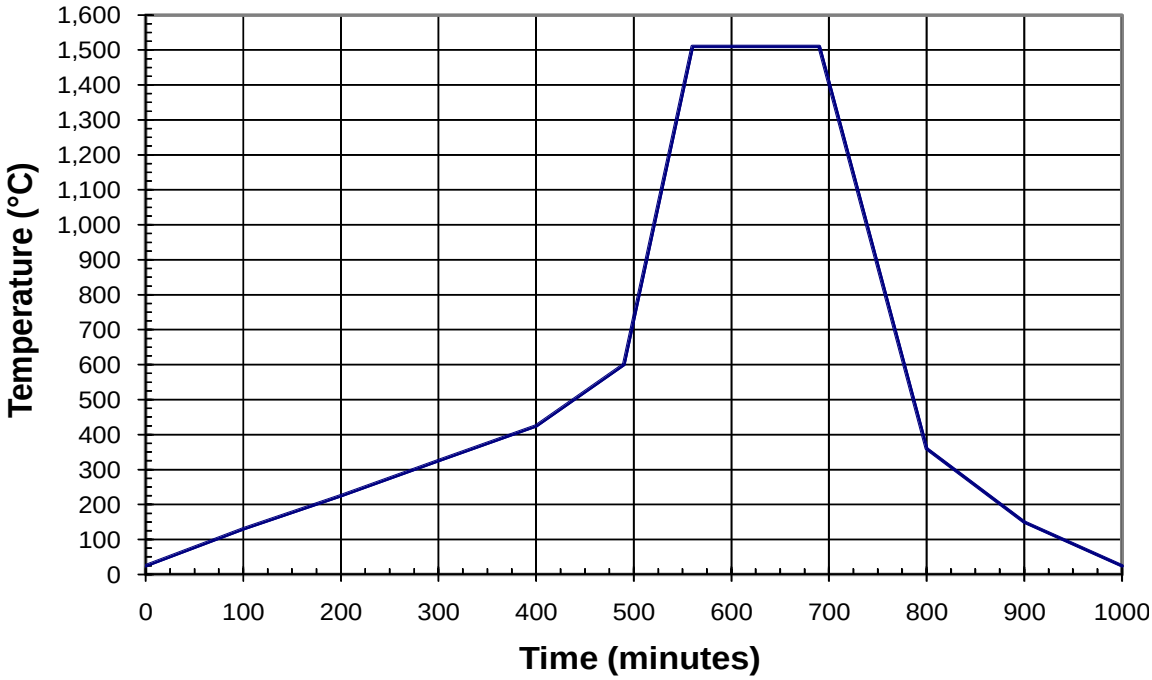
Typical Firing Profile for 5571



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CERMET PLATINUM CONDUCTOR 5572

RoHS Compliant* Conductor for Conical Oxygen Sensors

ESL 5572 is a platinum conductor for use as an inner electrode material for partially stabilized zirconia conical oxygen sensors. A pouring grade is available upon request.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY:	
(Brookfield HBT, cone/plate, 38.4 sec^{-1} at 20°C±0.5°C)	50-100 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION: (Printing Grade)	325/25 μm
DRYING:	10-15 minutes,125°C
FIRING RANGE:	1250°C-1510°C
TIME AT PEAK:	120 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER	ESL 437

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T: 610-272-8000
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CERMET PLATINUM CONDUCTOR 5573

RoHS Compliant* Conductor for Conical Oxygen Sensors

ESL 5573 is a platinum conductor for use as an outer electrode material for partially stabilized zirconia conical oxygen sensors. This material performs well when fired on partially fired ceramic bodies. It is pad-printable.

PASTE DATA

RHEOLOGY:	Pad-printable paste
VISCOSITY:	
(Brookfield HBT, SC4-14/6R, 10 RPM at 25°C±0.5°C)	22-32 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION: (Printing Grade)	325/25 µm
DRYING:	10-15 minutes, 125°C
FIRING RANGE:	1250°C-1510°C
TIME AT PEAK:	120 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER	ESL 437

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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CO-FIRING PLATINUM CONDUCTOR

5574
5574-A

RoHS compliant* co-fireable conductor designed for use as lead or contact pads in planar sensors

ESL 5574 is a platinum conductor designed to be co-fired with alumina at high temperatures. A lower resistivity version is also available (5574-A).

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable pastes
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	70 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:		325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	5574:	≤ 20 mΩ/square
	5574-A:	≤ 12 mΩ/square
FIRING RANGE:		1500°C ± 10°C
		see profile on back
TIME AT PEAK TEMPERATURE:		120 min.
SODIUM CONCENTRATION:		≤ 50 ppm
SUBSTRATE OF CALIBRATION:		alumina tape

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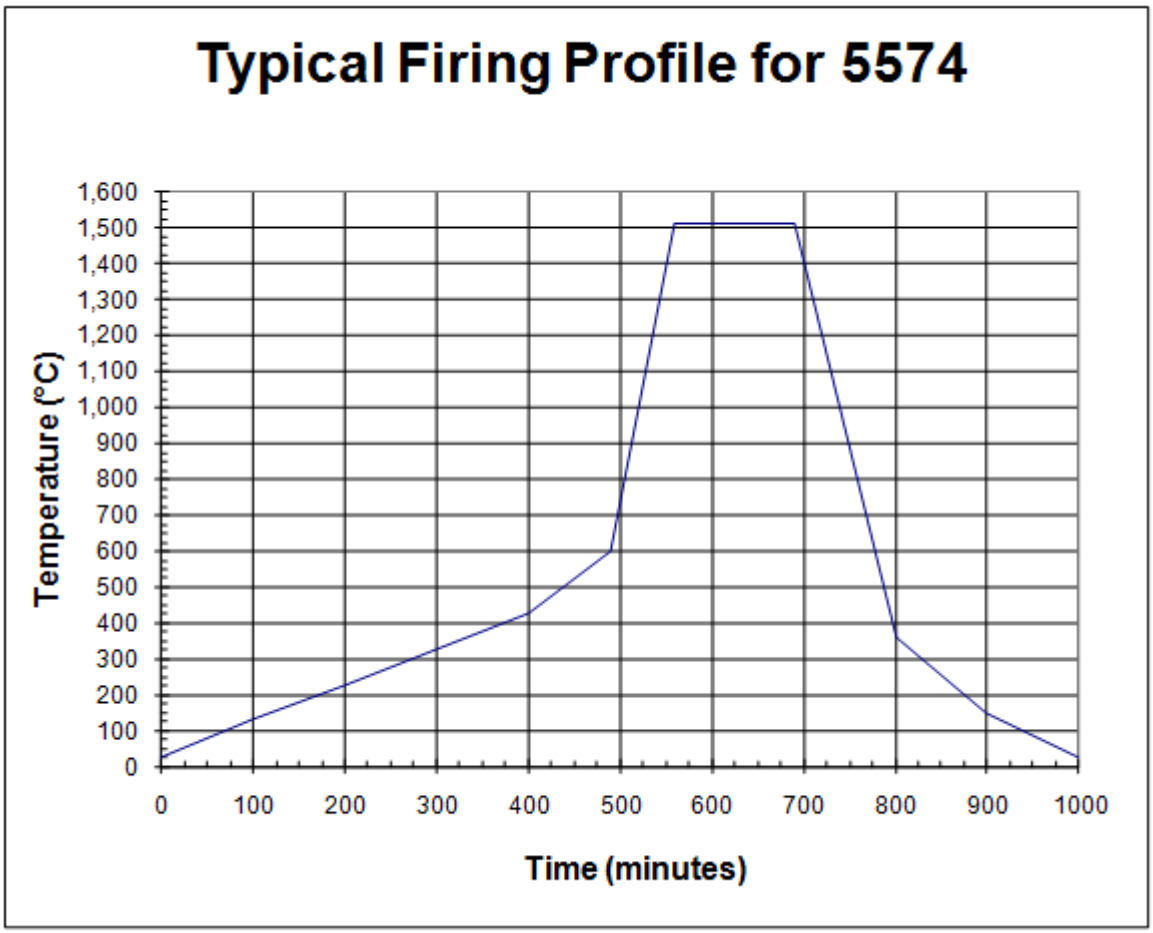

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CO-FIRING PLATINUM VIA-FILL CONDUCTOR 5575

RoHS compliant* co-firable conductor designed for use as a via-fill in planar sensors

ESL 5575 is a platinum via-fill conductor designed to be co-fired with alumina tape or partially stabilized zirconia tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, SC4-14 spindle, 1 RPM at 25.0°C ± 0.5°C)	1300 ± 200 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm in application, use a stencil
RESISTIVITY: (25 µm fired thickness)	50 ± 15 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SUBSTRATE OF CALIBRATION:	alumina tape

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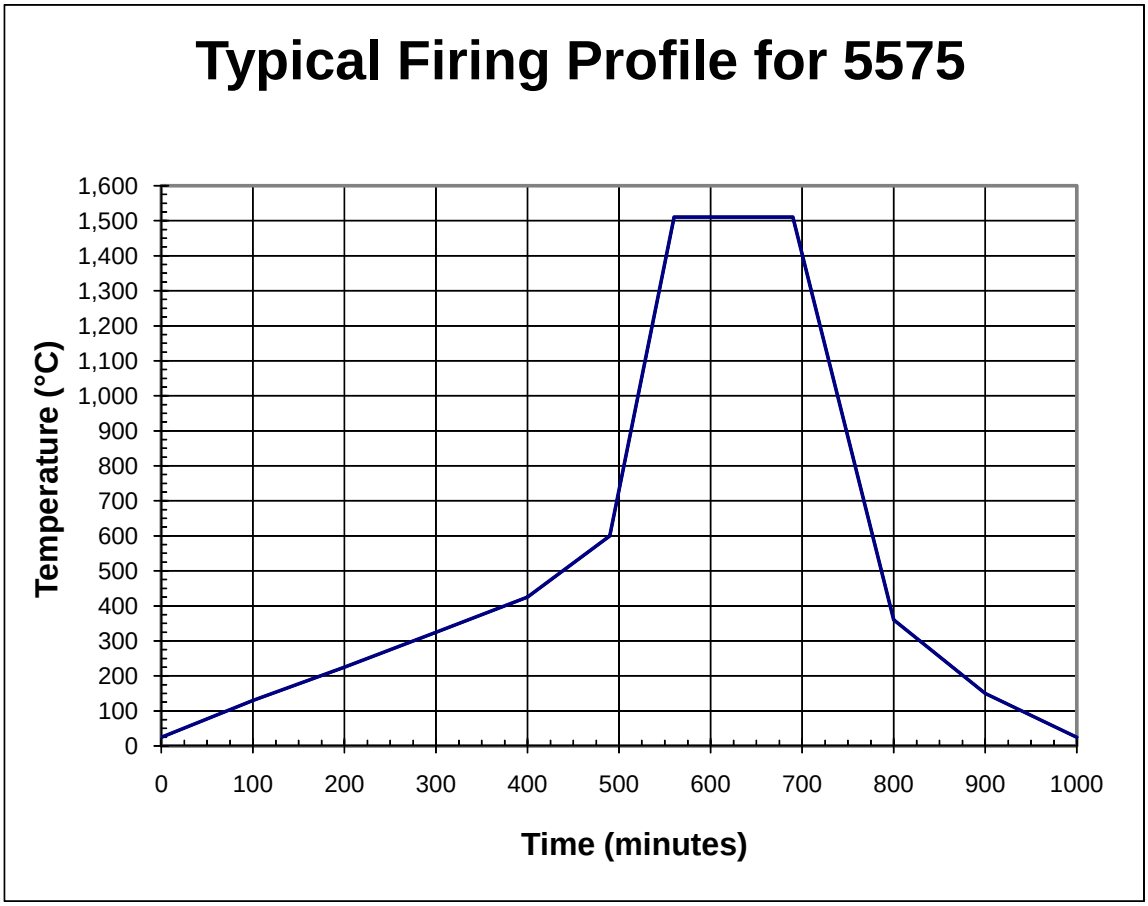

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T: 610-272-8000
F: 610-272-6759
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THERMISTOR COMPOSITION NTC-2100 SERIES

FEATURE DESIGN FLEXIBILITY, SMALLER SIZE, AND ECONOMIC ADVANTAGES COMPARED TO DISCRETE THERMISTORS

The NTC-2100 Series of thermistor pastes are designed for making negative temperature coefficient thermistor films. They are printed and fired on ceramic substrates using typical thick film processing. These materials are used in applications where the thermistor is to be intimately bonded to the substrate, such as temperature compensation of hybrid circuits. This design flexibility, decreased size and lower cost are advantageous when compared to discrete thermistor components.

Designation	Average Beta (ß) -55°C to 125°C	Nominal Sheet Resistivity*	Resistance Range (Ω)**
NTC-2131	300	30	3 to 300
NTC-2112	725	100	10 to 1 k
NTC-2113	1700	1 k	100 to 10 k
NTC-2114	2125	10 k	1 k to 100 k
NTC-2115	2500	100 k	10 k to1 M
NTC-2116	3100	1,000 k	100 k to 10 M

Notes: * 0.040 x 0.040 Resistor, Ω/square at a dry print thickness of 22.5 µm.

** Resistive Element Geometry ranging from 1/10 of a square to 10 squares

Beta Tolerance of ±20%

Resistivity Tolerance of ±20%; except NTC-2115 and NTC-2116, ±30%

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Resistive Element Geometry / Sheet Resistivity

Consider the resistive element (resistor material) between the termination materials as a rectangular solid. It has thickness t, length l, (distance between terminations) and width w, (distance perpendicular to terminations). The ratio of the resistive element length to width (l:w) is called the number of squares. Resistive element geometry is an important consideration when designing a thick film circuit.

A resistance value can be targeted by multiplying the Nominal Sheet Resistivity by the resistive element geometry. ESL NTC-2100 Series materials retain their sheet resistivity over resistive element geometry ranging from 1/10 of a square to 10 squares.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5°C±0.5°C)	250±50 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/10-25 µm
LEVELING TIME:	5-10 minutes
DRYING TIME AT 125°C:	10-15 minutes
FIRING TEMPERATURE:	850°C (in air)
SUBSTRATE FOR CALIBRATION:	96% alumina
RECOMMENDED TERMINATIONS:	5837 (PtAu), 9635-A (AgPd)
OVERGLAZE: (1-2 minutes at a peak temperature of 490°C)	4782
STABILIZATION: (After overglaze)	150°C for 16 hours
THINNER:	ESL 437

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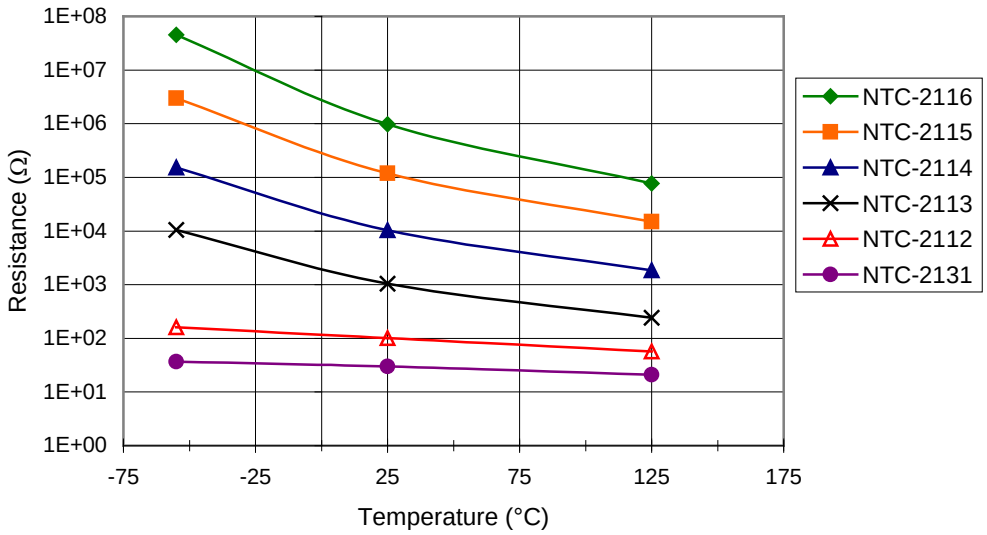
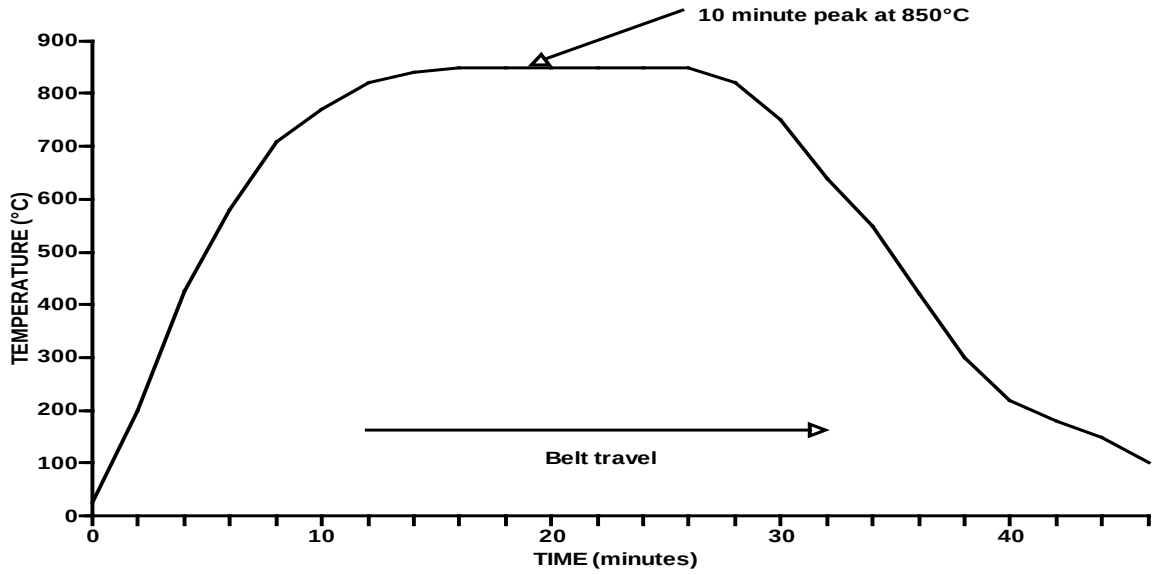
TYPICAL PROPERTIES

DRY PRINT THICKNESS: 20-25 µm

NTC-2100 Series Resistance vs. Temperature



RECOMMENDED PROFILE FOR THE NTC-2100 SERIES THERMISTORS



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T: 610-272-8000
F: 610-272-6759
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CERMET THERMISTOR SYSTEM PTC-2600 SERIES

The PTC-2600 Series of thermistor pastes are designed for making positive temperature coefficient thermistor films. The materials are designed for applications for which thermistors are required to be intimately bonded to the substrate. The materials are useful in applications where temperature compensation of hybrid circuits and fast response sensors is required. When used as temperature sensors, a linear response is obtained from ambient to temperatures in excess of 300°C. The PTC-2600 Series may be used to replace discrete thermistor components with the advantage of reduced size and lower cost.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5°C±0.5°C)	200±30 Pa·s
SHELF LIFE: (20°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/18.0 µm
LEVELING TIME: (20°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING TEMPERATURE: (in air)	850°C
TIME AT PEAK TEMPERATURE:	10 minutes
RATE OF ASCENT/DESCENT:	50°C-60°C/minute
SUBSTRATE FOR CALIBRATION:	96% alumina
RECOMMENDED TERMINATION:	9912-A (Ag)
THINNER:	ESL 401

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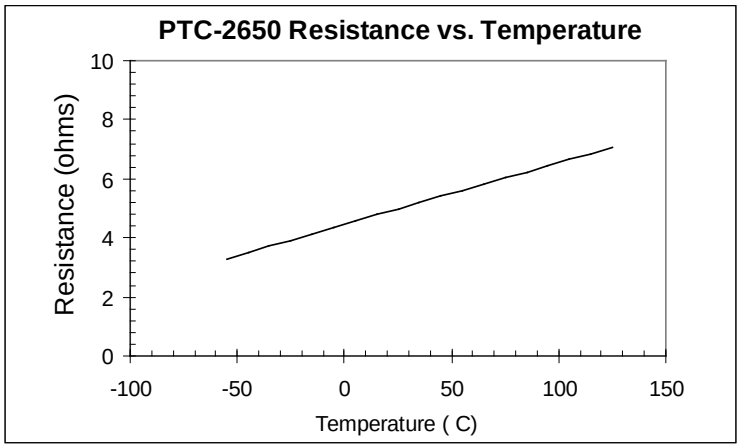
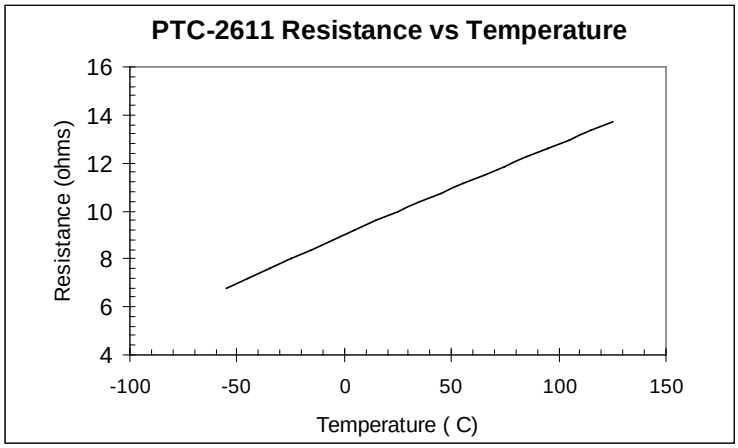
TYPICAL PROPERTIES

DRIED PRINT THICKNESS: (on 96% alumina) 22.5 ± 2.5 µm

	RESISTIVITY	HOT TCR, ppm/°C (+25°C to +125°C)	COLD TCR, ppm/°C (-55°C to +25°C)
PTC-2650	5 Ω/sq.±10%	+4000 ± 500	+4000 ± 500
PTC-2611	10 Ω/sq.±10%	+4100 ± 500	+4100 ± 500





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CERMET RESISTOR SYSTEM PTC 2600-I SERIES

The PTC 2600-I Series of thermistor pastes is designed for making positive temperature coefficient thermistor films. Application where thermistors are required to be intimately bonded to the substrate such as temperature compensation of hybrid circuits and fast response sensors may be achieved with the PTC 2600-I Series. When used as temperature sensors, a linear response is obtained from ambient to temperatures in excess of 300°C with the advantage of reduced size and lower cost. Four values of sheet resistivity are available: 5 Ω/sq., 10 Ω/sq., 100 Ω/sq., and 1 kΩ/sq.

The 2600-I Series is designed to withstand high power dissipation and is ideally suited to the manufacturing of self limiting thick film heater elements for a wide range of consumer and industrial applications.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5°C±0.5°C)	200±30 Pa•s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/18 microns
LEVELING TIME: (20°C-25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING TEMPERATURE RANGE:	825°C-850°C (in air)
OPTIMUM (CALIBRATION):	850°C
TIME AT PEAK TEMPERATURE:	10 minutes

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RATE OF ASCENT / DESCENT:	50°C-60°C/minute
SUBSTRATE FOR CALIBRATION:	96% alumina
RECOMMENDED TERMINATION:	9912-A
THINNER:	ESL 401

TYPICAL PROPERTIES

DRIED PRINT THICKNESS: (on 96% alumina)			22.5 ± 2.5 µm
RESISTIVITY:	2650-I		5 Ω ±30%
	2611-I		10 Ω ±20%
	2612-I		100 Ω ±20%
	2613-I		1 kΩ ±10%
TCR: (Measured on a 2 mm x 20 mm resistor)	2650-I	Hot and Cold sides	3400 ± 400 ppm/°C
	2611-I	Hot and Cold sides	3000 ± 400 ppm/°C
	2612-I	Hot and Cold sides	2200 ± 400 ppm/°C
	2613-I	Hot and Cold sides	1600 ± 400 ppm/°C
VOLTAGE GRADIENT:			> 25V/mm

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Silver Conductors

590 & 590-G
Low cost conductive compositions for applications requiring shielding, solder seal metallisation for axial components and conductive wiring.

599-E
Conductive paste offering versatility and superior performance in many applications. May be processed at temperatures as low as 400°C.

599-G
RoHS Compliant conductive paste offering versatility and superior performance in many applications. May be processed at temperatures as low as 530°C.

902
Pb/Cd/Ni-free silver Via Fill, for use in co-fired LTCC systems

903-A
Pb/Cd/Ni-free silver, for use as a top or inner-layer metallization in co-fired LTCC and other tape systems

903-B
Pb/Cd/Ni-free silver, for use as an inner-layer or ground-plane metallization in co-fired LTCC and other tape systems

903-C
Pb/Cd/Ni-free silver, for use as a solderable top-layer metallization with low dielectric constant co-fired ceramic tape systems. ESL 903-C is designed for use as a post-fired conductor

903-D
Pb/Cd/Ni-free silver, for use as a solderable top-layer metallization in co-fired LTCC and other tape systems

903-E
Silver conductor designed for use as top-layer metallization for use with co-fired and transfer ceramic tape.

9907
Silver conductor designed to be used as a current collector for solid oxide fuel cells (SOFC).

9910-C
Economical silver conductor for use on a variety of low temperature firing substrates including PZT and glass.

9912
Mixed bonded silver paste for general applications for the consumer market. Can be used on PES, alumina and beryllia. Excellent adhesion.

9912-A
Mixed bonded silver paste developed for chip resistors, consumer hybrids, potentiometers and heater elements. Wide firing temperature range.

9912-A Thick Print
Ideally suited to power applications. 160µm fired print thickness can be achieved.

9912-F
Specially formulated for use with ESL resistors. Exhibits excellent adhesion, solderability & leach resistance. Good wire bonding characteristics.

9912-G
Lead, Cadmium and Nickel-free silver paste with excellent solderability and leach resistance. For use on alumina or beryllia.

9912-K
Silver conductor with a wide range of applications including chip resistors, consumer hybrids, potentiometers and heaters.

9912-K FL
A fine-line printing silver conductor having a wide range of applications, for example chip resistors, consumer hybrids, potentiometers and heaters.

9912-K Thick Print
A silver conductive material ideally suited to power applications

9912-LMB
A silver conductor for screen-printing on to ceramics and silicon.

9912-MB
A silver conductor for screen-printing on to ceramics and silicon.

9912-MM Print
A silver conductor for screen-printing on to piezo-electronics

9912-MM Spray
A silver conductor for spraying on to piezo-electronics.

9912-THP
Mixed bonded silver paste developed especially for through hole printing. Excellent solderability and solder leach resistance on alumina.

9913
High-conductivity silver specially formulated for use on aluminium nitride.

9916
Silver conductive electrode material for use with 4150 series and 4200-C series of dielectrics.

9925
Silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells.

9925-G
RoHS Compliant silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells.

9926
Designed for the metallization of single crystal and polycrystalline silicon solar cells

9987
Cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications.

9987-A
Cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications. Designed for an emitter sheet resistivity of 40-65 ohms/square.

9988
Silver paste developed for use as a front-side metallization in photovoltaic applications.

9990
Cermet silver with MICRO-LOK® bonding mechanism. Excellent adhesion on a variety of substrates. Excellent solder wetting & leach resistance.

9996-B
Silver conductor specially designed for Elpor II CCMS (Ceramic Coated Metal Substrates).

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER CONDUCTOR

590
590-G

ESL 590 and 590-G are silver conductors offering versatility and superior performance in many applications. These low-cost compositions may be selected for use as solar cell electrodes, AC and DC plasma displays, shielding, conductive wiring, solder seal metallisation for axial components, termination for monolithic capacitors and capacitor electrodes. 590 and 590-G exhibit excellent adhesion, high-conductivity and electro-platability as well as having very low firing temperature characteristics. Suitable substrates include silicon wafers, various ceramics, porcelain enamelled steel and especially soda-lime and other glasses. The conductive coatings are compatible with various glossy and matte finish dielectrics.

PASTE DATA

Rheology:			Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)		590	250 ± 25 Pa.s
		590-G	250 ± 25 Pa.s
Bonding Mechanism:			Fitted
Shelf Life (20 - 25 °C):			6 months

PROCESSING

Screen Mesh, Emulsion:			325 S/S, 20 µm
Levelling Time (at 20°C):			5 - 10 min
Drying Time (at 125°C):			10 - 15 min
Firing Temperature Range:			450 - 700°C in air
	Optimum:	590	580°C
		590-G	525°C
	Time at peak:		10 min
Rate of Ascent/Descent:			50 - 60°C/min
Substrate for Calibration:			Glass
Thinner:			ESL 401 or 404

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		12.5 ± 2.5µm
Approximate Coverage:		130 cm²/g
Resistivity:		2 - 5 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)		90 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)		
	590	> 3 dips
	590-G	> 5 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	590	2.0 kg
Initial pull strength:	590-G	1.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
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CERMET SILVER CONDUCTOR 599-E

Low Temperature Firing Conductor

ESL 599-E conductive paste offers versatility and superior performance in many applications. It exhibits excellent adhesion and high conductivity. ESL 599-E may be processed at temperatures as low as 400°C.

Suitable substrates include aluminium, various ceramics, porcelain enameled steel, soda-lime and other glass substrates. This conductive coating is compatible with various dielectrics.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Bonding Mechanism:	Fritted
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		400 - 550°C
	Optimum:	450°C
	Time at peak:	10 - 15 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		Glass
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:	12 ± 2.5 µm
Resistivity:	3 - 6 mΩ/square
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RIVIA Flux, 2 sec. dip) 62Sn/36Pb/2Ag (220°C)	Excellent
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	> 10 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
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CERMET SILVER CONDUCTOR 599-G

RoHS Compliant* • Low Temperature Firing Conductor

ESL 599-G conductive paste offers versatility and superior performance in many applications. It exhibits excellent adhesion and high conductivity. ESL 599-G may be processed at temperatures as low as 530°C.

Suitable substrates include aluminium, various ceramics, porcelain enamelled steel, soda-lime and other glass substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	200 ± 50 Pa.s
Bonding Mechanism:	Fritted
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		530 - 580°C
	Optimum:	580°C
	Time at peak:	10 - 15 min
Total Profile Time:		60 min
Substrate for Calibration:		Glass
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:	12 ± 2.5 µm
Resistivity:	≤10 mΩ/square
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RIVIA Flux, 2 sec. dip) 62Sn/36Pb/2Ag (220°C)	Excellent
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	> 10 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERMET SILVER CONDUCTOR 902

Lead-Free Conductor for Use as Via Fill with Co-Fire Ceramic Tape

ESL 902 is a silver conductor designed for use as a via fill with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	250±50 Pa·s
BONDING MECHANISM:	Fritted
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	< 35 µm
RESISTIVITY: (when normalized @ 25 µm & co-fired with ESL 41010 tape)	≤ 5 mΩ/sq.

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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CERMET SILVER CONDUCTOR 903-A

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-A is a silver conductor designed for use as top-layer or inner-layer metallization for use with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	15-25 µm
RESISTIVITY: (when normalized @ 20 µm & co-fired with ESL 41010 tape)	≤ 2 mΩ/sq.

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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CERMET SILVER CONDUCTOR 903-B

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-B is a silver conductor designed for use as an inner-layer or ground-plane metallization with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	75±25 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	9-17 µm
RESISTIVITY: (when normalized @ 20 µm & co-fired with ESL 41010 tape)	≤ 2 mΩ/sq.

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CERMET SILVER CONDUCTOR 903-C

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-C is a silver conductor designed for use as solderable top-layer metallization for use with low dielectric constant co-fired ceramic tape. ESL 903-C is used as a post-fired conductor.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	250±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41110
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	< 15 µm
RESISTIVITY: (when normalized @ 25 µm & post-fired with ESL 41010 tape)	≤ 2 mΩ/sq.
SOLDERED ADHESION:	< 15N

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CERMET SILVER CONDUCTOR 903-D

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-D is a silver conductor designed for use as solderable top-layer metallization for use with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	14-18 µm
RESISTIVITY: (when normalized @ 25 µm & co-fired with ESL 41010 tape)	≤ 2 mΩ/sq.

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER CONDUCTOR 903-E

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-E is a silver conductor designed for use as top-layer metallization for use with co-fired and transfer ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	< 16-24 µm
RESISTIVITY: (when normalized @ 20 µm & co-fired with ESL 41010 tape)	1.5-2.5 mΩ/sq.

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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F: 610-272-6759
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CERMET SILVER CONDUCTOR 9907

RoHS Compliant* Conductor for use with Fuel Cells

ESL 9907 is a silver conductor designed to be used as a current collector for solid oxide fuel cells (SOFC). It can be screen-printed and is also available in syringes for dispensing.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	75 ± 25 Pa.s
Bonding Mechanism:	Fritless
Colour:	Grey
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 15 - 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Optimum: Time at peak:	850 °C 10 - 12 min
Total Firing Cycle:		45 - 60 min
Substrate for Calibration:		ESL 41010
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: 9 - 17 µm

Resistivity:
(when normalized @ 20 µm & co-fired with ESL 41010 tape) < 2 mΩ/sq.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR 9910-C

ESL 9910-C is an economical silver conductor for use on a variety of low-temperature firing substrates including PZT and glass.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Fritted
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 12 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		580 - 700°C in air
	Optimum:	580°C
	Time at peak:	1 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		Soda Lime Glass
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

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TYPICAL PROPERTIES

Fired Thickness: 12.5 ± 2.5µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) <5.0 mΩ/□

Printing Resolution:
(line/space) 0.250 mm / 0.250 mm

Fineness of Grind: 7µ average

Solder Wettability:
(RMA Flux, 5 sec. dip) 95 - 100 %
62Sn/36Pb/2Ag (220°C)

Solder Leach:
(No. of 10 sec. dips to double lowest
resistance of 100 mm x 0.25 mm conductor) 5 dips
62Sn/36Pb/2Ag (220°C)

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength: >1.0 kg

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T: 610-272-8000
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CERMET SILVER CONDUCTOR 9912

ESL 9912 is a mixed-bonded silver conductor developed for a wide range of applications for the consumer market. Due to the wide firing temperature range, this conductor may be processed on a variety of substrates including Porcelain Enamelled Steel (PES), alumina and beryllia. This conductor exhibits excellent adhesion and aged bond retention as well as excellent solderability and solder leach resistance.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:	Alumina	850 - 930°C in air
	Beryllia	850 - 930°C in air
	PES (Porcelain Enamelled Steel):	625°C in air
	Optimum (Alumina):	850°C
	Optimum (Beryllia):	930°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	10 - 15 µm
Approximate Coverage:	100 - 125 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 2.0 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	100%
Solder Leach: (No. of 10 second dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	> 5 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	> 6.4 kg
Aged 48 hours at 150°C:	> 3.2 kg

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CERMET SILVER CONDUCTOR 9912-A

Lead and Cadmium-free*

ESL 9912-A is a mixed-bonded silver conductor particularly developed for a wide range of applications, for example chip resistors, consumer hybrids, potentiometers and heater elements. Due to the wide firing temperature range, this conductor may be processed on a variety of substrates including glass, Porcelain Enamelled Steel (PES), alumina and beryllia. 9912-A is suitable for terminating resistors used in potentiometers and heaters. This conductor may be protected with ESL 4904 overglaze to prevent electrolytic silver migration.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:	Alumina	850 - 930 °C in air
	Beryllia	850 - 930 °C in air
	PES (Porcelain Enamelled Steel):	625 °C in air
	Optimum (Alumina):	850 °C
	Optimum (Beryllia):	930 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401
Lead Content:		<1000 ppm

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	9 - 14 µm
Approximate Coverage:	100 - 125 cm^2 / g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	< 2.0 mΩ/□
Printing Resolution: (line/space)	0.200 mm / 0.200 mm
Solder Wettability: (RMA Flux, 5 sec. dip) 62Sn/36Pb/2Ag (220 ± 5 °C)	100 %
Solder Leach: (No. of 10 second dips to double minimum resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220 °C)	>5 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	>6.4 kg
Aged 48 hours at 150 °C:	>6.4 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERMET SILVER CONDUCTOR

9912-A Thick Print

Lead and Cadmium-free*

ESL 9912-A Thick Print is a silver conductive material ideally suited to power applications. A total fired print thickness of 160 µm can be achieved by using three separate printing and firing cycles and a 200 stainless steel mesh screen.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)		150 ± 25 Pa.s
Bonding Mechanism:		Mixed-bonded
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	16.0 ± 2.0 µm
Approximate Coverage:	90 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	1.5 - 2.0 mΩ/□
Printing Resolution: (line/space)	0.200 mm / 0.200 mm
Solder Wettability: (RMA Flux, 5 sec. dip) 62Sn/36Pb/2Ag (220°C)	100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	>6 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	7 - 10 kg
Aged 48 hours at 150°C:	6 - 9 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERMET SILVER/PALLADIUM CONDUCTOR 9912-F

ESL 9912-F is a mixed-bonded silver conductor especially designed for thick film microwave circuits using frequencies up to 18 GHz. This conductor has the highest conductivity and the greatest tarnish resistance of all the ESL range of silver conductors.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: 11.0 ± 1.0µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Approximate Coverage: 100 - 125 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) 1.5 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:
(RMA Flux, 5 sec. dip) 100%

62Sn/36Pb/2Ag	(220°C)
10Sn/88Pb/2Ag	(325°C)
95Sn/5Ag	(260°C)
63Sn/37Pb	(250°C)

Solder Leach:
(No. of 10 sec. dips to double lowest
resistance of 100 mm x 0.25 mm conductor) > 6 dips

62Sn/36Pb/2Ag	(220°C)
63Sn/37Pb	(250°C)

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	> 6.0 kg
Aged 48 hours at 150°C:	> 5.0 kg

Ultrasonic Al. Wire Bond: 11 - 12 g
(25µm wire)

Aged Al. Wire Bond: 8 - 9 g
(48 hours at 150°C)

Thermosonic Au. Wire Bond: 8 - 10 g
(25µm wire)

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
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CERMET SILVER/PALLADIUM CONDUCTOR 9912-G

RoHS Compliant*

ESL 9912-G is a silver fuel cell and interconnect paste exhibiting excellent conductivity, adhesion to 96% alumina, fuel cell and other tape-cast materials, and excellent solder leach resistance. Its main use is as a ground plane conductor and SOFC Interconnect. It is compatible with 4920 dielectric and SOFC tape-cast materials.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:		850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100 °C / min
Total Cycle:		50 min
Substrate for Calibration:		96 % alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness: 12.5 ± 2.5 µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) ≤3 mΩ / sq.

Printing Resolution:
(line/space) 0.075 mm / 0.075 mm

Solder Wettability:
(RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C) > 95 %

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220 °C) 10 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	> 7.5 kg
Aged 48 hours at 150 °C:	> 7.5 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER CONDUCTOR 9912-K

Lead, Cadmium and Nickel-Free*

ESL 9912-K is a silver conductor having a wide range of applications, for example chip resistors, consumer hybrids, potentiometers and heaters. Due to the wide firing temperature range, this conductor may be processed onto a variety of substrates including glass, Porcelain Enamelled Steel (PES), alumina and special ceramics. Additionally, 9912-K also exhibits excellent gold wire bondability.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:	On alumina/beryllia/ceramics:	850 - 930°C in air
	On Porcelain Enamelled Steel (PES):	625°C in air
	Optimum (alumina):	850°C in air
	Optimum (beryllia):	930°C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

(Note: furnace air must be clean, dry and oil-free)

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

(measurement on alumina after firing at 850°C)

Fired Thickness: 11.5 ± 2.5 µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Approximate Coverage: 100 - 125 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness) < 2.5 mΩ/□

Printing Resolution:
(line/space) 0.200 mm / 0.200 mm

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength: (on most ceramic substrates)	> 7.0 kg
Aged 48 hours at 150°C:	> 4.5 kg

Thermosonic Au Wire Bond:
(25 µm wire; bond length 1 mm; 100% wire breaks; on alumina; 850°C firing) > 8 g

Aged Au Wire Bond:
(24 hours at 200°C) > 7 g

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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CERMET SILVER CONDUCTOR 9912-K FL

Lead, Cadmium and Nickel-Free*
Excellent Fine-Line Capability

ESL 9912-K FL is a fine-line printing silver conductor having a wide range of applications, for example chip resistors, consumer hybrids, potentiometers and heaters. It exhibits excellent line resolution printing 75 micrometer wide lines. Due to the wide firing temperature range, this conductor may be processed onto a variety of substrates including glass, Porcelain Enamelled Steel (PES), alumina and special ceramics.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	310 ± 20 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:	On alumina/beryllia/ceramics:	850 - 930°C in air
	On Porcelain Enamelled Steel (PES):	625°C in air
	Optimum (alumina):	850°C in air
	Optimum (beryllia):	930°C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

(Note: furnace air must be clean, dry and oil-free)

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

(measurement on alumina after firing at 850°C)

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	100 - 125 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	< 2.5 mΩ/□
Printing Resolution: (line/space)	0.075 mm / 0.075 mm
Solder Wettability: (RMA flux, 5 sec. dip, (62Sn/36Pb/2Ag, 220 °C)	100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220 °C)	> 5 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength: (on most ceramic substrates)	> 7.0 kg
Aged 48 hours at 150°C:	> 6.0 kg

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416 EAST CHURCH ROAD
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CERMET SILVER CONDUCTOR

9912-K Thick Print

RoHS Compliant*

ESL 9912-K Thick Print is a silver conductive material that can be applied to ceramic substrates in thick layers and is designed for use in power applications. The fired thickness obtained and the surface roughness of the fired film depends on the screen mesh used. 80 mesh to 200 mesh stainless steel screens may be used. To achieve a total fired print thickness of 200 µm, 2 layers printed with a 165 mesh and 4 layers printed with a 105 mesh are recommended. Each layer should be printed, dried and separately fired. It is also recommended to slightly reduce the dimension of the overprinted layers to maintain the surface flatness.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	80 ± 15 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		80 - 200 S/S, 0 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (using 6 layers - 2x 165 screen mesh & 4x 105 screen mesh)		200 ± 10 µm
Approximate Coverage:		5 cm^2/g
Resistivity: (measured at 200 µm thickness)		<0.15 mΩ/□
Solder Wettability: (RMA Flux, 5 sec. dip, 95.5Sn/3.8Ag/0.7Cu at 250°C)	96% alumina	100 %

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER CONDUCTOR 9912-LMB

RoHS Compliant*

ESL 9912-LMB is a silver conductor for screen-printing on to ceramics and silicon.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	125 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Range:	650 - 900 °C in air
	Optimum:	700 °C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Resistivity:

(measured on a 100 mm x 0.25 mm conductor track)	< 3.0 mΩ/□

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KING OF PRUSSIA, PA 19406-2625, U.S.A
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CERMET SILVER CONDUCTOR 9912-MB

RoHS Compliant*

ESL 9912-MB is a silver conductor for screen-printing on to ceramics and silicon.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	175 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Range:	650 - 900 °C in air
	Optimum:	700 °C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Thinner:		ESL 401

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TYPICAL PROPERTIES

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 2.0 mΩ/□

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CERMET SILVER CONDUCTOR 9912-MM Print

Lead and Cadmium-free*

ESL 9912-MM Print is a silver conductor for screen-printing on to piezo-electronics.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)		150 ± 25 Pa.s
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Range:	650 - 900 °C in air
	Optimum:	700 °C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Thinner:		ESL 401

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TYPICAL PROPERTIES

Resistivity:

(measured on a 100 mm x 0.25 mm conductor track)	< 2.0 mΩ/□

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER CONDUCTOR 9912-MM Spray

Lead and Cadmium-free*

ESL 9912-MM Spray is a silver conductor for spraying on to piezo-electronics.

PASTE DATA

Rheology:		Low viscosity paste
Viscosity: (Brookfield RVT, 10rpm, No. 4 Spindle, 25.5 ± 0.5 °C)		1 - 30 Pa.s
Shelf Life (20 - 25 °C):		6 months (stirring before use)

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Range:	650 - 900 °C in air
	Optimum:	700 °C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Thinner:		ESL 114

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TYPICAL PROPERTIES

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) < 2.0 mΩ/□

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER CONDUCTOR 9912-THP

ESL 9912-THP is a mixed bonded silver paste especially developed for through-hole printing. The recommended firing temperature on 96% alumina is 850°C. This material also exhibits excellent solderability and solder leach resistance with 62 Sn/36 Pb/2 Ag solder on alumina.

PASTE DATA

Rheology:		Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)		44 - 55 Pa.s
Bonding Mechanism:		Mixed-bonded
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Optimum:	850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		ESL 41010
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness:	8 - 12 µm
Approximate Coverage:	75 - 100 cm²/g
Resistivity:	1 - 3 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Good - Very good
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	5 - 8 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)

Initial pull strength:	6 - 9 kg
Aged 48 hours at 150°C:	6 - 8 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET SILVER/PALLADIUM CONDUCTOR 9913

ESL 9913 is a high-conductivity silver specially formulated for use on aluminium nitride.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)		225 ± 25 Pa.s
Bonding Mechanism:		Mixed-bonded
Shelf Life (20 - 25 °C):		6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		850°C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C/min
Substrate for Calibration:		AlN
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: 11.5 ± 2.5 µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) <2 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:
(RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C) Good

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C) 3 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	> 5.0 kg
Aged 48 hours at 150°C:	> 5.0 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CONDUCTIVE ELECTRODE MATERIAL 9916

Silver Based Conductor Designed for use with the 4150 Series and 4200-C Series of Dielectrics

ESL 9916 is a silver based conductor specially developed for use as an electrode with 4150 Series and 4200-C Series of dielectrics. ESL 9916 may also be used with the 4100 Series of dielectrics. When used with ESL 4150 Series and 4200-C Series dielectrics, this conductor provides the optimum performance of the systems. The typical properties of these conductors were derived from printing and firing directly on alumina.

PASTE DATA

Rheology:	Thixotropic, screen printable paste
Viscosity: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5 ± 0.5°C)	200 ± 25 Pa.s
Shelf Life: (25°C)	6 months

PROCESSING

Screen Mesh/Emulsion:	325/25 µm
Leveling Time: (25°C)	5-10 minutes
Drying at 125°C:	10-15 minutes
Firing Temperature Range:	850°C-900°C
Optimum:	900°C
Time at Peak:	10 minutes
Rate of Ascent/Descent:	60 - 100 °C/minute
Substrate of Calibration:	96% alumina
Thinner:	ESL 401 or 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:	12.5 ± 2.5 µm
Printing Resolution: (Line/Space)	125 µm / 125 µm
Resistivity:	≤ 2.0 mΩ/sq.
Solder Leach: (No. of 10 sec. dips to double resistance of 0.25 mm wide x 100 mm long conductor, 62 Sn/36 Pb/2 Ag, 220 ± 5 °C)	≥ 7
Adhesion: (90° pull, 2.0 mm x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220 ± 5 °C)	
Initial pull strength:	≥ 8.2 kg
Aged 48 hours at 150°C:	≥ 6.6 kg

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T: 610-272-8000
F: 610-272-6759
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SOLAR CELL SILVER ALUMINIUM PASTE 9925

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9925 is a silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells. The 9925 is an aluminium-doped silver paste that contains a cadmium-free low-lead glass developed to promote a balance between ohmic contact, solderability, and adhesion. Excellent performance can be achieved over a wide processing window.

The recommended materials to be used in conjunction with 9925 are 9980 Series front-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	170 ± 50 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		180 - 325 S/S, 15 - 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Furnace Set Point:		840 - 910 °C
	Time above 600 °C:	typically 5 - 8 sec
Thinner:		ESL 401 or 413

Note: When used with the ESL 2590 Series materials, 9925 should be printed first. The aluminium paste should be printed second so that it overlaps the silver but leaves an exposed silver pad. The materials, along with the front surface silver, can then be co-fired to provide a solderable contact pad.

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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SOLAR CELL SILVER ALUMINIUM PASTE 9925-G

RoHS Compliant* Photovoltaic Material

ESL 9925-G is a silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells. The 9925-G is an aluminium-doped silver paste that contains a cadmium-free, lead-free glass developed to promote a balance between ohmic contact, solderability, and adhesion.

The recommended materials to be used in conjunction with 9925-G are 9980 Series front-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	100 ± 40 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	180 - 325 S/S, 25 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Time (at 125 °C):	10 - 15 min
Furnace Set Point:	840 - 910 °C
Time above 600 °C:	typically 5 - 8 sec
Thinner:	ESL 401 or 413

Note: When used with the ESL 2590 Series materials, 9925-G should be printed first. The aluminium paste should be printed second so that it overlaps the silver but leaves an exposed silver pad. The materials can then be co-fired to provide a solderable contact pad.

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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KING OF PRUSSIA, PA 19406-2625, U.S.A
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F: 610-272-6759
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SOLAR CELL SILVER ALUMINIUM PASTE 9926

Pure Silver Conductor for Back Surface Solderable Pad

ESL 9926 is designed for the metallization of single crystal and polycrystalline silicon solar cells. The 9926 is designed to be used for the back-surface of the silicon wafer. The paste requires firing in a range of 625°C-850°C with a very short cycle of about 5-8 seconds at the peak temperature.

The recommended materials to be used in conjunction with 9926 are 9980 Series front-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	175 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		625 - 850 °C
	Time above 600 °C:	typically 5 - 8 sec
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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SOLAR CELL SILVER PASTE 9987

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9987 is a cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications. The 9987 provides high efficiency and high fill factor on single crystal and polycrystalline silicon solar cells. ESL 9987 can be processed on solar cells using a fire-through process with silicon nitride or titanium dioxide anti-reflection coating.

The recommended materials to be used in conjunction with the 9987 are 9920 Series back-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield HBT, Shear rate 9.6 sec^{-1}, CP-51 Spindle, 25.0 ± 0.2 °C)	120 ± 30 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 15 - 30 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Furnace Set Point:		840 - 910 °C
	Time above 600 °C:	typically 5 - 8 sec
Thinner:		ESL 401

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SOLAR CELL SILVER PASTE 9987-A

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9987-A is a cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications. The 9987-A provides high efficiency and high fill factor on single crystal and polycrystalline silicon solar cells. ESL 9987-A can be processed on solar cells, using a fire-through process, with silicon nitride or titanium dioxide anti-reflection coating. The 9987-A is designed for an emitter sheet resistivity of 40-65 ohms/square.

The recommended materials to be used in conjunction with the 9987-A are 9920 Series back-surface silver and 2590 Series back-surface aluminium metallizations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield HBT, Shear rate 9.6 sec^{-1}, CP-51 Spindle, 25.0 ± 0.2 °C)	120 ± 30 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	280 - 325 S/S, 15 - 30 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Set Point:	200 - 300 °C
Drying Time:	≤ 3 - 4 sec
Furnace Set Point:	840 - 910 °C
Time above 600 °C:	typically 5 - 8 sec
Thinner:	ESL 401

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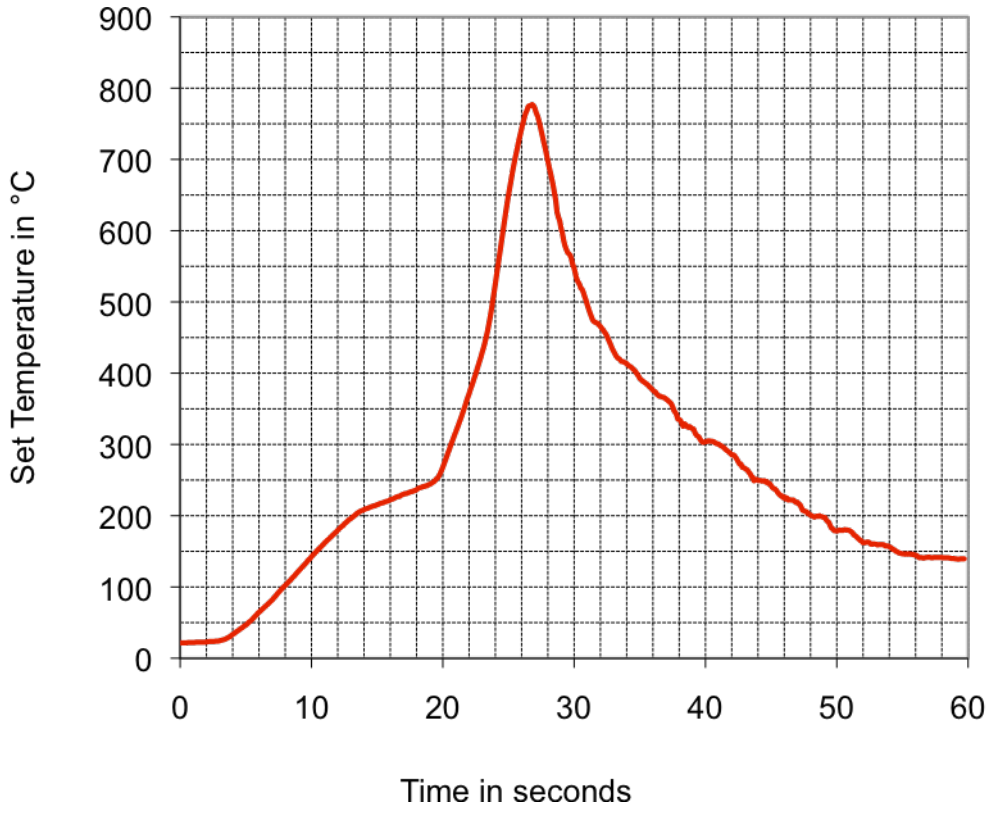
TYPICAL PROPERTIES

Fired Thickness:	12 - 18 µm
Resistivity: (at 25 µm fired thickness)	≤2 mΩ/sq.
Printing Resolution: (line/space)	0.100 mm / 0.125 mm
Solderability: (Tin Silver solder)	Excellent

Typical Firing Profile



Furnace: SierraTherm-5 zone IR with 25 cm peak firing zone
Belt speed: 470 cm/min.

Measured using Datapaq Q18 & type K thermocouple, exposed bead, 1mm sheath

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

SOLAR CELL SILVER PASTE 9988

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9988 is a silver paste developed for use as a front-side metallization in photovoltaic applications. The 9988 provides high efficiency and high fill factor on single crystal and polycrystalline silicon solar cells. ESL 9988 can be processed on solar cells using a fire-through process with silicon nitride or titanium dioxide anti-reflection coating.

ESL 9925 Series silver and ESL 2591 Series aluminium back-surface metallisations are recommended for use with 9987.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield HBT, Shear rate 9.6 sec^{-1}, CP-51 Spindle, 25.0 ± 0.2 °C)	80 ± 20 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 - 325 S/S, 15 - 25 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Time (at 125 °C):	10 - 15 min
Furnace Set Point:	840 - 910 °C
Time above 600 °C:	typically 5 - 8 sec

(See typical firing profile on page 2 - spike profile, fast firing, IR furnace, 4.7 m/minute belt speed.)

Thinner:	ESL 452

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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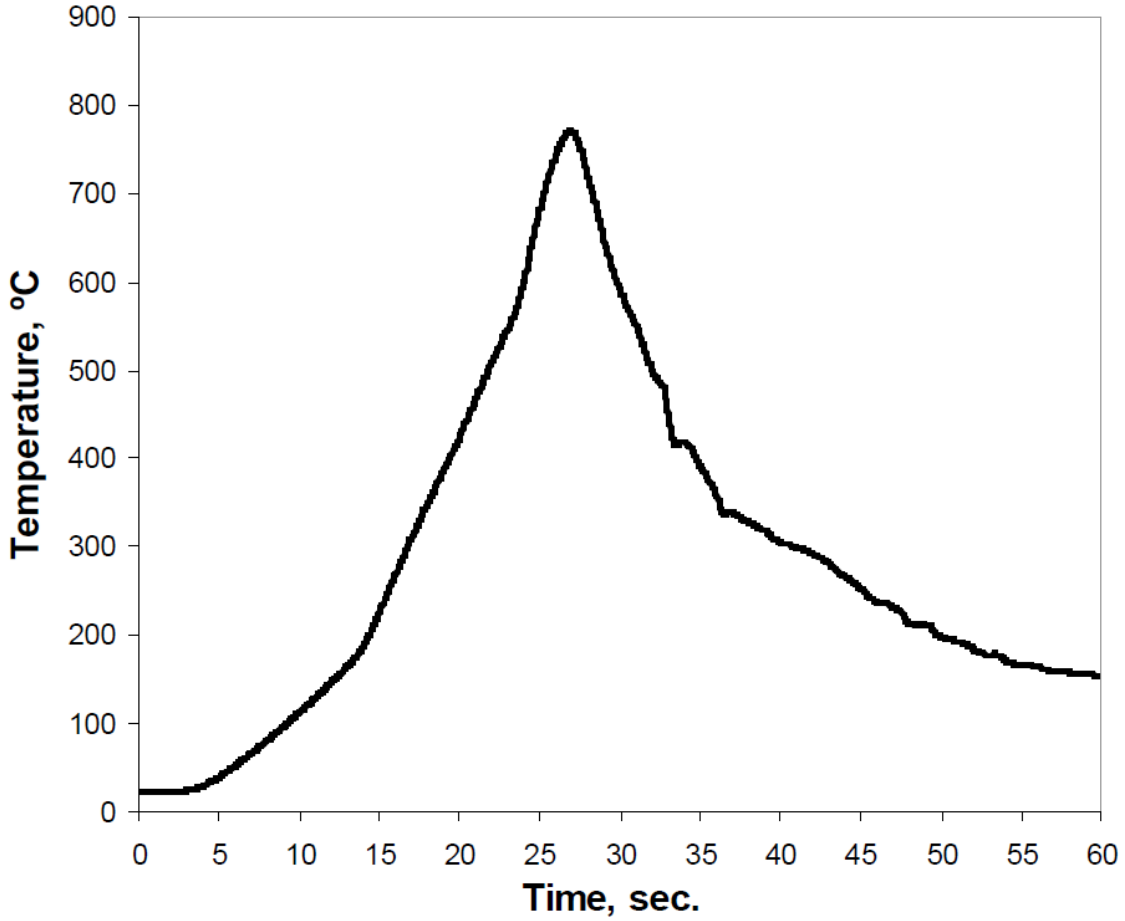
See Caution and Disclaimer on page 2.

TYPICAL FIRING PROFILE



Optimum firing conditions for the best performance must be established by the customer based on cell configuration, thickness and process conditions. For this reason, our recommended firing profile should be taken only as a starting point.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER CONDUCTOR 9990

ESL 9990 silver conductor has been designed to give excellent adhesion properties when printed and fired on a variety of substrates including beryllia, ferrite and 99.5% alumina. This is achieved by means of a reactive bonding mechanism (MICRO-LOK®) which does not require glass frit and gives an excellent solder leach resistance compared with standard silver conductors.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Fritless, MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 950°C in air
	Optimum:	930°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: 11.0 ± 1.0 µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Approximate Coverage: 100 - 125 cm^2/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) 1.5 - 2.5 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:
(RMA Flux, 5 sec. dip)

62Sn/36Pb/2Ag	(2205°C)	100%
10Sn/88Pb/2Ag	(3255°C)	
95Sn/5Ag	(2605°C)	
63Sn/37Pb	(2505°C)	

Solderability After Overglaze:
(500°C, 5 min, 62Sn/36Pb/2Ag) 100%

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor)

62Sn/36Pb/2Ag	(220°C)	> 6 dips
63Sn/37Pb	(250°C)	

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	7 - 11 kg
Aged 48 hours at 150°C:	6 - 9 kg

Ultrasonic Al Wire Bond:
(25µm wire) 7 - 10 g

Thermosonic Au Wire Bond:
(25µm wire) 6 - 10 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PALADIUM CONDUCTOR 9996-B

ESL 9996-B is a silver conductor specially designed for Elpor II CCMS (Ceramic Coated Metal Substrates). It exhibits good solderability, high conductivity, low cost and excellent adhesion.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		625 - 930 °C
	Optimum:	625 °C on Elpor II
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		Elpor II
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:	10 - 17 µm
Approximate Coverage:	60 - 70 cm²/g
Resistivity:	1 - 3 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	4 - 8 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)

Initial pull strength:	≥ 1.5 kg
Aged 48 hours at 150 °C:	≥ 1.0 kg

Ultrasonic Al Wire Bond: (25 µm wire)	7 - 9 g
Thermosonic Au Wire Bond: (25 µm wire)	4 - 6 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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Silver / Palladium Conductors

963
Solderable, with excellent leach resistance, for use in LTCC systems.

9627
Silver/palladium conductor designed for use as a current collector for solid oxide fuel cells.

9633-G
Lead, Cadmium and Nickel-free silver/palladium with excellent leach and migration resistance.

9633-I
A high performance conductor specially formulated for use on aluminium nitride substrates.

9633-T
A high performance conductor specially formulated for use on aluminium nitride substrates.

9635-B
Silver/palladium conductor exhibiting excellent solder leach resistance. High adhesion to alumina.

9635-G
Multi-purpose lead, cadmium and nickel-free silver/palladium conductor.

9635-H
General purpose silver/palladium conductor for use on bare alumina and on dielectric. Retains solderability after firing at overglaze temperatures.

9635-HG
Lead, Cadmium and Nickel-free general-purpose silver/palladium conductor for use on bare alumina and on dielectric. Excellent solderability over ESL dielectrics.

9638
Silver/palladium specially for use as an electrode for ESL 4113-H and 4117 capacitor dielectrics providing high K values.

9647
Palladium/silver conductor with approximately a 3:1 Ag to Pd ratio, designed to have good initial adhesion and good thermal aging adhesion after an extended period of time at temperature.

9693-G
Low-cost, high-conductivity, cadmium-free silver palladium paste suitable for use as buried conductors in multilayer circuits.

9693-SA
Low-cost, high speed printing palladium silver conductor that exhibits excellent adhesion, good solderability, and high conductivity.

9694-SA
Cadmium-free high speed printing palladium silver conductor that exhibits excellent adhesion, good solderability, and high conductivity.

9695
Silver/palladium with a wide firing range. Featuring low cost, excellent adhesion, good solderability and high conductivity. Also for use on PES.

9695-G
Lead, Cadmium and Nickel-free silver/palladium with a wide firing range. Featuring low cost, excellent adhesion, good solderability and high conductivity. Also for use on PES.

9695-P
Low cost, high conductivity silver/palladium conductor for use in potentiometer applications offering excellent wear characteristics, solderability and adhesion.

9695-STEEL
Can be directly printed onto oxidised ferritic stainless steel substrates.

9695-TP
A low-cost, high-conductivity, thick-print silver/palladium conductor for use on alumina.

9697

Low cost via fill silver/palladium conductor for mixed metal multilayer applications. Can be used in combination with ESL 4913-G Series.

9697-G

Lead and cadmium-free low cost via fill silver/palladium conductor for mixed metal multilayer applications. Can be used in combination with ESL 4913-G Series.

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T: 610-272-8000
F: 610-272-6759
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SILVER PALLADIUM CONDUCTOR 963

Conductor for Use as Top or Inner-Layer Electrode With Co-Fire Ceramic Tape

ESL 963 is a silver palladium conductor designed for use as a co-fired top electrode with ceramic tape. ESL 963 may also be used with transfer tape on 96% alumina substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	175±25 Pa•s
BONDING MECHANISM:	Fritted
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

FIRED THICKNESS: (line)	20±4 µm
RESISTIVITY: (20µm fired thickness, co-fired with ESL 41010 tape)	19±7 mΩ/sq.
PRINTING RESOLUTION: (Line/Space)	250 µm x 250 µm
ADHESION:	≥ 20 N
SOLDERABILITY:	good

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR 9627

RoHS Compliant* Conductor for use with Fuel Cells

ESL 9627 is a silver/palladium conductor designed for use as a current collector for solid oxide fuel cells.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield HBT, 10 rpm, SC-14 spindle, 25.5 ± 0.5 °C)	65 ± 25 Pa.s
Bonding Mechanism:	Fritless
Colour:	Grey
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	325 S/S, 15 - 25 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Substrate for Calibration:	ESL 41010
Thinner:	ESL 401

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TYPICAL PROPERTIES

Fired Thickness: 5 - 10 µm

Resistivity:
(when normalized @ 20 µm & co-fired with ESL 41010 tape) ≤100 mΩ/sq.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR

9633-G

Lead, Cadmium & Nickel-Free*

ESL 9633-G is a lead, cadmium and nickel-free conductor. This high palladium product is formulated for use on 96% alumina substrates in hybrid circuits where good conductivity and very good solderability are specified.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 980°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		12.5 ± 2.5 µm
Approximate Coverage:		90 - 110 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)		< 35 mΩ/□
Printing Resolution: (line/space)		0.100 mm / 0.100 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 95.5Sn/3.8Ag/0.7Cu at 250°C)	96% alumina	95 - 100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu at 250°C)		> 2 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)		
	Initial pull strength:	> 5.0 kg
	Aged 48 hours at 150°C:	> 4.0 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERMET SILVER/PALADIUM CONDUCTOR 9633-I

For use on AlN Substrates

ESL 9633-I is a high performance conductor specially formulated for use on aluminium nitride substrates. It exhibits good adhesion, very good solderability, leach resistance, and silver migration resistance.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 - 930 °C
	Optimum:	850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		aluminium nitride
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (2 mm x 2 mm pad)	10 - 15 µm
Approximate Coverage:	75 - 100 cm²/g
Resistivity: (at 12.5 µm fired thickness)	40 - 50 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Very good
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	> 8 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)	
Initial pull strength:	> 7.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALADIUM CONDUCTOR 9633-T

For use on AlN Substrates

ESL 9633-T is a high performance conductor specially formulated for use on aluminium nitride substrates. It exhibits good adhesion, very good solderability, leach resistance, and silver migration resistance.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		850 - 930 °C
	Optimum:	850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		aluminium nitride
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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ESLChina@eslshanghai.net

See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness: (2 mm x 2 mm pad)	10 - 15 µm
Approximate Coverage:	75 - 100 cm²/g
Resistivity: (at 12.5 µm fired thickness)	≤ 50 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Very good
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	> 8 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)	
Initial pull strength:	> 7.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PALLADIUM CONDUCTOR 9635-B

ESL 9635-B is a general-purpose silver/palladium conductor that is used as the conductor termination in the calibration of ESL standard 850°C firing cermet resistors.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		12.5 ± 2.5 µm
Approximate Coverage:		90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)		20 - 40 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)		95 - 100 %
	After re-fire (850°C)	90 - 100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)		>5 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)		
	Initial pull strength:	6.4 - 8.0 kg
	Aged 48 hours at 150°C:	3.2 - 6.0 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR 9635-G

RoHS Compliant*

ESL 9635-G is a general-purpose silver/palladium conductor suitable for use on alumina. It is designed for use with SAC alloy lead-free solders and exhibits excellent adhesion and solder wettability.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		12.5 ± 2.5 µm
Approximate Coverage:		90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)		<30 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 95.5Sn/3.8Ag/0.7Cu at 250°C)	96% alumina	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu at 250°C)		> 2 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)		
	Initial pull strength:	> 5.0 kg
	Aged 48 hours at 150°C:	> 3.5 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR 9635-H

ESL 9635-H is a general-purpose silver/palladium conductor that may be used on bare alumina and on dielectric. 9635-H exhibits excellent solderability over ESL dielectrics.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	10.5 ± 2.5 µm
Approximate Coverage:	90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	<20 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	95 - 100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	⩾4 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	5.0 - 8.0 kg
Aged 48 hours at 150°C:	3.0 - 6.0 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERMET SILVER/PALLADIUM CONDUCTOR 9635-HG

Cadmium, Lead & Nickel-Free*

ESL 9635-HG is a general-purpose silver/palladium conductor that may be used on 96% alumina substrates and on dielectric. The 9635-HG exhibits excellent solderability when used on alumina or over various ESL dielectrics. It is also suitable for large-diameter aluminium wire bonding.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 1000°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		11.5 ± 2.5 µm
Approximate Coverage:		90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)		<20 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 95.5Sn/3.8Ag/0.7Cu at 250°C)	on 96% alumina	95 - 100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu at 250°C)		> 1 dip
Adhesion: (90° pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)		
	Initial pull strength:	> 6.0 kg
	Aged 48 hours at 150°C:	> 4.0 kg
Ultrasonic Al Wire Bond: (500 µm wire; bond length 4 mm)		> 1600 g
Aged Al Wire Bond: (1 hour at 300°C)		> 1400 g

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CERMET SILVER/PALLADIUM CONDUCTOR 9638

ESL 9638 is a silver/palladium conductor specifically designed for use as an electrode in thick film capacitor structures. When this conductor is used with 4113 capacitor dielectric, the apparent dielectric constant (K) is increased by approximately 30%. Further information discussing thick film capacitor design is contained in a paper entitled "High Reliability Thick Film Capacitor Dielectrics" available upon request.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 980°C in air
	Optimum:	930 - 980°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		4113 Capacitor dielectric on 96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	11.0 ± 1.0µm
Approximate Coverage:	90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	15 - 25 mΩ/□
Printing Resolution: (line/space)	0.200 mm / 0.200 mm
Solder Wettability: (RMA Flux, 5 sec. dip) 62Sn/36Pb/2Ag (220°C) 10Sn/88Pb/2Ag (325°C) 95Sn/5Ag (260°C) 63Sn/37Pb (250°C)	90 - 100 %
Solids Content:	90 - 100 %
Solderability after Overglaze: (500°C, 5 min., 62Sn/36Pb/2Ag)	90 - 100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor) 62Sn/36Pb/2Ag (220°C) 63Sn/37Pb (250°C)	> 4 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	> 6.0 kg
Aged 48 hours at 150°C:	> 4.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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PALLADIUM SILVER CONDUCTOR 9647

RoHS Compliant* Conductor with Excellent Adhesion, Solderability, and Wire bondability

ESL 9647 is a palladium silver conductor with approximately a 3:1 Ag to Pd ratio. It is designed to have good initial adhesion and good thermal aging adhesion after an extended period of time at temperature. This conductor also has excellent large-diameter aluminium wire bondability. ESL 9647 is lead, cadmium, and nickel free.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	325 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature:		850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers 96% alumina)	10 ± 3 µm
Resistivity:	≤25 mΩ/sq
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 60Sn/40Pb at 250°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 60Sn/40Pb at 250°C)	≥ 2 dips
Peel Adhesion: (2 mm x 2 mm pads, 60Sn/40Pb solder)	
Initial pull strength:	> 2.0 kg
Aged 1000 hours at 150°C:	> 1.8 kg
Wire Bondability: (250µm Al wire, 100% wire breaks)	≥ 450 g

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR

9693-G

Cadmium-Free

ESL 9693-G is a low-cost, high-conductivity, cadmium-free silver palladium paste suitable for use as buried conductors in multilayer circuits. 9693-G exhibits excellent adhesion, good solderability and gives prints with no centre line depression.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 12.5 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:	Optimum: Time at peak:	850°C 10 - 12 min
Rate of Ascent/Descent:		60 - 100°C/min
Substrate for Calibration:		4913-A dielectric or 96% alumina
Thinner:		ESL 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: 10 - 15 µm
(measured on a 2 mm x 2 mm pad on 96% alumina)

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track) 1.5 - 2.0 mΩ/□

Printing Resolution:
(line/space) 0.100 mm / 0.100 mm

Solder Wettability:
(RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C) >95 %

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C) >10 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	>8.0 kg
Aged 48 hours at 150°C:	>6.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALADIUM CONDUCTOR 9693-SA

ESL 9693-SA is a low-cost, high speed printing palladium silver conductor that exhibits excellent adhesion, good solderability, and high conductivity.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		750 - 950 °C
	Optimum:	850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401 or 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:	10 - 15 µm
Approximate Coverage:	90 - 100 cm^2/g
Resistivity:	≤ 3 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	4 - 8 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)	
Initial pull strength:	> 4.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALADIUM CONDUCTOR 9694-SA

Cadmium-free, High Speed Printing Palladium Silver

ESL 9694-SA is a cadmium-free high speed printing palladium silver conductor that exhibits excellent adhesion, good solderability, and high conductivity. The 9694-SA is also recommended for use with ESL R-300-P and R-300-C series resistors as a termination in trimmer and potentiometer applications.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 20 - 30 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		750 - 950 °C
	Optimum:	850 °C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401 or 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:	8 - 15 µm
Resistivity:	2.0 - 5.0 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	≥ 4 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)

Initial pull strength:	> 6.5 kg
Aged 48 hours at 150°C:	> 3.5 kg

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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR 9695

Cadmium Free

ESL 9695 is a low-cost, high-conductivity silver/palladium conductor for use on alumina. It is also used as a termination for 29XXX series resistors over 4924 dielectric in **Heaters on Steel® (HOS)**. It has a wide-firing temperature range and can also be used on Porcelain Enamelled Steel (PES). This conductor exhibits excellent solderability and adhesion and may be used as a termination for all ESL 850°C-firing resistor systems, as well as many other commercially available systems.

9695 is commonly used for ground plane and buried conductor layers in multilayer hybrid circuits as a substitute for higher palladium content conductors to improve conductivity and lower cost. A typical system consists of 9695, 4905-CH dielectric and 9633-B as the top conductor for excellent solder leach resistance. A potentiometer grade, 9695-P is also available.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum on PES:	625°C
	Optimum on alumina:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	3 - 6 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 62Sn/36Pb/2Ag at 220°C)	95 - 100%
Solderability after overglaze: (500°C, 5 min., 62Sn/36Pb/2Ag)	90 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag at 220°C)	≥ 3 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	≥ 6.4 kg
Aged 48 hours at 150°C:	≥ 4.0 kg

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR 9695-G

RoHS Compliant*

ESL 9695-G is a low-cost, high-conductivity silver/palladium conductor for use on alumina. It is also used as a termination for 29XXX series resistors over 4924 and 4986 dielectric in **Heaters on Steel® (HOS)**. It has a wide-firing temperature range and can also be used on Porcelain Enamelled Steel (PES). This conductor exhibits excellent solderability and adhesion and may be used as a termination for all ESL 850°C firing resistor systems, as well as many other commercially available systems.

The 9695-G is commonly used for ground plane and buried conductor layers in multilayer hybrid circuits as a substitute for higher palladium content conductors to improve conductivity and lower cost. A typical system consists of 9695-G, 4917 dielectric and 9633-G as the top conductor for excellent solder leach resistance.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum on PES:	625°C
	Optimum on alumina:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 12.5 ± 2.5 µm

Approximate Coverage: 90 - 100 cm^2/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness) ≤ 6 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:
(RMA flux, 5 sec. dip
95.5/Sn/3.8Ag/0.7Cu at 250°C) 100%

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu at 250°C) ≥ 1 dips

Adhesion:
(90° Pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)

Initial pull strength:	≥ 8 kg
Aged 48 hours at 150°C:	≥ 6 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR 9695-P

9695-P is a low-cost, high-conductivity silver/palladium conductor for use in potentiometer applications. This conductor exhibits excellent wear characteristics, solderability and adhesion. 9695-P may be used as a termination for all ESL and many commercially available 850°C firing resistor systems. It has a wide firing temperature range.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	3 - 8 mΩ/□
Printing Resolution: (line/space)	0.100 mm / 0.100 mm
Solder Wettability: (RMA flux, 5 sec. dip, 62Sn/36Pb/2Ag at 220°C)	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag at 220°C)	⩾5 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	6.4 - 11.0 kg
Aged 48 hours at 150°C:	3.2 - 6.0 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET SILVER/PALLADIUM CONDUCTOR

9695 Steel

Cadmium-Free

ESL 9695 Steel is a low-cost silver/palladium conductor. It can be directly printed onto oxidised ferritic stainless steel substrates making it useful as an 'earth strap' for automotive circuits printed on insulated stainless steel. A typical system consists of ESL 4924 dielectric, 9695 Steel and ESL 3910.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 110 cm^2/g
Resistivity: (measured on a 408.5 mm x 0.5 mm resistor track with ESL 9695 terminations over ESL 4924 glaze : 18 ± 1 µm dried thickness)	3 - 8 mΩ/□

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR 9695-TP

RoHS Compliant*

ESL 9695-TP is a low-cost, high-conductivity, thick-print silver / palladium conductor for use on alumina.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum on PES:	625°C
	Optimum on alumina:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	17 ± 3 µm
Approximate Coverage:	90 cm^2/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	≤ 4 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag at 220°C)	≥ 5 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	≥ 6.4 kg
Aged 48 hours at 150°C:	≥ 3.5 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
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F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR 9697

ESL 9697 is a low-cost, high-conductivity silver/palladium exhibiting excellent fine line printing characteristics, solderability and adhesion. Used as a via fill material, with 4913 dielectric, it stabilises via resistance and integrity on re-firing, and best results are obtained when it is also used as the buried layer conductor.

Multilayer systems using 9697 as a buried conductor and via fill material with various top conductors are described in a technical paper entitled "Low Ohmic Contact Between Conductors And Via Fills In MCM-C Technology", available on request.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum:	850°C
	PES:	625°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60°C/min
Substrate for Calibration:		96% alumina
Thinner:		401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	3 - 6 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip)	
62Sn/36Pb/2Ag (220°C)	95 - 100 %
63Sn/37Pb (250°C)	95 - 100 %
Solderability: (500°C, 5 min., 62Sn/36Pb/2Ag)	90 - 100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	3 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	6.4 - 11.0 kg
Aged 48 hours at 150°C:	2.3 - 6.0 kg

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416 EAST CHURCH ROAD
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T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PALLADIUM CONDUCTOR 9697-G

RoHS Compliant*

ESL 9697-G is a low-cost, high-conductivity silver/palladium exhibiting excellent fine line printing characteristics, solderability and adhesion. Used as a via fill material, with 4913 dielectric, it stabilises via resistance and integrity on re-firing, and best results are obtained when it is also used as the buried layer conductor.

Multilayer systems using 9697-G as a buried conductor and via fill material with various top conductors are described in a technical paper entitled "Low Ohmic Contact Between Conductors And Via Fills In MCM-C Technology", available on request.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		625 - 930°C in air
	Optimum on PES:	625°C
	Optimum on alumina:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness:
(measured on a 2 mm x 2 mm pad on 96% alumina) 12.5 ± 2.5 µm

Approximate Coverage: 90 - 100 cm²/g

Resistivity:
(measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness) 3 - 6 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:
(RMA flux, 5 sec. dip)

62Sn/36Pb/2Ag at 220°C	95 - 100%
95.5/Sn/3.8Ag/0.7Cu at 250°C	95 - 100%

Solderability after overglaze:
(500°C, 5 min., 62Sn/36Pb/2Ag) 90 - 100%

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor)

62Sn/36Pb/2Ag at 220°C	≥ 5 dips
95.5Sn/3.8Ag/0.7Cu at 250°C	≥ 2 dips

Adhesion:
(90° Pull, 2 mm x 2 mm pads)

62Sn/36Pb/2Ag

Initial pull strength:	≥ 7 kg
Aged 48 hours at 150°C:	≥ 5 kg

95.5Sn/3.8Ag/0.7Cu

Initial pull strength:	≥ 8 kg
Aged 48 hours at 150°C:	≥ 6 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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Silver / Platinum Conductors

953
For terminating capacitors in LTCC

9501-C
Very low cost, high speed printing conductor material exhibiting high conductivity and excellent adhesion and solderability.

9501-CH
Low cost, high speed printing conductor material exhibiting high conductivity and excellent adhesion and solderability.

9512
Mixed bonded platinum/silver paste developed for general applications in the automotive market. Excellent adhesion after 1000 thermal cycles.

9512-G
Lead, Cadmium and Nickel-free platinum/silver paste with excellent printability suitable for general use.

9512-G1
RoHS compliant general purpose, mixed-bonded conductor compatible with ESL 8844-G gold. Exhibits excellent adhesion and is suitable for use with lead-free solder.

9513-G
A fine-line printing platinum silver conductor having a wide range of applications, for example chip resistors, consumer hybrids, potentiometers and heaters

9516
A platinum silver based conductor specially developed for use as an electrode with 4150 Series and 4200-C Series of dielectrics.

9595-A
A silver platinum conductor that exhibits excellent adhesion, solderability, and oxidation resistance.

9597-G
Lead, Cadmium and Nickel-free suitable for a wide temperature range for use on alumina, beryllia, glass and Porcelain Enamelled Steel (PES) substrates. Exceptional solder leach resistance.

9598

A platinum silver conductor specially formulated for high leach resistance

9598-G

Lead, Cadmium and Nickel-free conductor suitable for a wide temperature range. Non-migrating with exceptional solder leach resistance. Can be used to replace Pt / Au in some applications.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

SILVER PLATINUM CONDUCTOR 953

Lead-Free, Leach Resistant Conductor for Use as Top or Inner-Layer Electrode With Co-Fire Ceramic Tape

ESL 953 is a platinum silver conductor designed for use with ceramic tapes. It can be used with ESL co-fired tapes such as ESL 41020 and provides good adhesion and solderability. This conductor is not for use on 96% alumina substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±25 Pa•s
BONDING MECHANISM:	Fritted
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
	5°C/minute rise from room temperature to 425°C, soak for one hour
	then 5°C/minute rise from 425°C to 850°C, soak for 10 minutes, cool naturally
SUBSTRATE OF CALIBRATION:	ESL 41020
	(six layers, pre-laminated)
THINNER:	ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERITIES

FIRED THICKNESS (line)	25 ± 3 µm
RESISTIVITY: (when co-fired with ESL 41020 tape)	≤ 6 mΩ/sq.
PRINTING RESOLUTION: (Line/Space)	250 µm x 250 µm
ADHESION: (2mm x 2mm pads**)**	≥ 20 N
SOLDERABILITY:	good

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PLATINUM CONDUCTOR 9501-C

ESL 9501-C is a low-cost, high-speed printing conductor material exhibiting high-conductivity and excellent adhesion and solderability. 9501-C may be used on a variety of substrates including beryllia, ferrite and 99.5% alumina and is compatible with all ESL 850°C firing resistors.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Rate of Ascent/Descent:		50 - 60 °C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	10.5 ± 2.5 µm
Approximate Coverage:	60 - 70 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	2 - 4 mΩ/□
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	≥5 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	5 - 7 kg
Aged 48 hours at 150°C:	3 - 6 kg
Ultrasonic Al Wire Bond: (25µm wire)	8 g
Thermosonic Au Wire Bond:	
(25µm wire)	6 g
(50µm wire)	20 - 30 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PLATINUM CONDUCTOR 9501-CH

HOS Heaters on Steel® • COS Circuits on Steel® • TFOS Thick Film on Steel®

ESL 9501-CH is a low-cost, high-speed printing conductor material exhibiting high-conductivity and excellent adhesion. 9501-CH may be used contact pads for ESL 29XXX series resistors in HOS (Heaters on Steel)® applications.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	150 ± 20 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	10.5 ± 2.5 µm
Approximate Coverage:	60 - 70 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track)	2 - 4 mΩ/□ max
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	≥5 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	7 - 9 kg
Aged 48 hours at 150°C:	5 - 9 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PLATINUM CONDUCTOR 9512

Low cost, general-purpose, cadmium-free silver/platinum conductor

ESL 9512 is a mixed-bonded platinum/silver paste developed for general applications in the automotive market. It exhibits excellent adhesion after 1000 thermal cycles, -30°C to 110°C, and after 1000 hours of aging at 150°C. This material also exhibits excellent solderability and solder leach resistance with 62Sn/36Pb/2Ag solder on alumina.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 - 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 -12 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	9 -14 µm
Approximate Coverage:	75 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	≤ 3 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	≥ 5 dips
Adhesion: (90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	≥ 6.4 kg
Aged 48 hours at 150°C:	≥ 6.4 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
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CERMET SILVER/PLATINUM CONDUCTOR 9512-G

RoHS Compliant*

ESL 9512-G is a newly developed silver/platinum conductor, which can also be used as an interconnect paste in SOFC and other fuel cells. It exhibits excellent conductivity, adhesion to 96% alumina and tape-cast materials, and solder leach resistance. It is compatible with 4920 dielectric and tape-cast materials that are similarly free of alkali ions and the above metals.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	250 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature:	Optimum:	850 °C
	Time at peak:	10 - 12 min
Total Firing Cycle:		50 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@eslshanghai.net

See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness:	10 - 15 µm
Resistivity: (at 12.5 µm fired thickness)	< 4.0 mΩ/□
Printing Resolution: (line/space)	0.075 mm / 0.075 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	>95% Coverage
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	10 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)

Initial pull strength:	> 7.0 kg
Aged 200 hours at 150°C:	> 7.0 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PLATINUM CONDUCTOR 9512-G1

Cadmium, Lead and Nickel-Free*

ESL 9512-G1 is a new general purpose, mixed-bonded silver/platinum that is compatible with ESL 8844-G gold conductor. This product exhibits good solder wettability, excellent adhesion and is suitable for use with lead-free solder.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	150 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:	Optimum: Time at peak:	850 °C 10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)		11.5 ± 2.5 µm
Approximate Coverage:		75 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)		< 3.0 mΩ/□
Printing Resolution: (line/space)		0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. dip 95.5Sn/3.8Ag/0.7Cu, 250°C)	96% alumina	100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu, 250°C)		> 2 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)		
	Initial pull strength:	> 6.4 kg
	Aged 48 hours at 150°C:	> 6.0 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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416 EAST CHURCH ROAD
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T: 610-272-8000
F: 610-272-6759
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CERMET PLATINUM SILVER CONDUCTOR 9513-G

RoHS Compliant*
Excellent Fine-Line Capability

ESL 9513-G is a fine-line printing platinum silver conductor having a wide range of applications, for example chip resistors, consumer hybrids, potentiometers and heaters. It exhibits excellent line resolution printing 75 micrometer wide lines. Due to the wide firing temperature range, this conductor may be processed onto a variety of substrates including glass, Porcelain Enamelled Steel (PES), alumina and special ceramics.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	310 ± 20 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:	On alumina/beryllia/ceramics:	850 - 930°C in air
	On Porcelain Enamelled Steel (PES):	625°C in air
	Optimum (alumina):	850°C in air
	Optimum (beryllia):	930°C in air
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

(Note: furnace air must be clean, dry and oil-free)

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

(measurement on alumina after firing at 850°C)

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	100 - 125 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	< 3.0 mΩ/□
Printing Resolution: (line/space)	0.075 mm / 0.075 mm
Solder Wettability:	
(RMA flux, 5 sec. dip, (62Sn/36Pb/2Ag, 220 °C)	100 %
(RMA flux, 5 sec. dip, (95.5Sn/3.8Ag/0.7Cu, 250 °C)	100 %

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor)

62Sn/36Pb/2Ag, 220 °C	> 5 dips
95.5Sn/3.8Ag/0.7Cu, 250 °C	2 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag and 95.5Sn/3.8Ag/0.7Cu)

Initial pull strength: (on most ceramic substrates)	> 7.0 kg
Aged 48 hours at 150°C:	> 6.0 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CONDUCTIVE ELECTRODE MATERIAL 9516

Platinum Silver Conductor Designed for use with 4150 Series and 4200-C Series of Dielectrics

ESL 9516 is a platinum silver based conductor specially developed for use as an electrode with 4150 Series and 4200-C Series of dielectrics. ESL 9516 may also be used with the 4100 Series of dielectrics. When used with ESL 4150 Series and 4200-C Series dielectrics, this conductor provides the optimum performance of the systems. The typical properties of these conductors were derived from printing and firing directly on alumina.

PASTE DATA

Rheology:	Thixotropic, screen printable paste
Viscosity: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5 ± 0.5 °C)	200 ± 25 Pa.s
Shelf Life: (25°C)	6 months

PROCESSING

Screen Mesh/Emulsion:	325/25 µm
Leveling Time: (25°C)	5-10 minutes
Drying at 125°C:	10-15 minutes
Firing Temperature Range:	850 - 900°C
Optimum:	900°C
Time at Peak:	10 minutes
Rate of Ascent/Descent:	60 - 100 °C / minute
Substrate of Calibration:	96% alumina
Thinner:	ESL 401 or 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness:	12.5 ± 2.5 µm
Printing Resolution: (line / space)	125 µm / 125 µm
Resistivity:	≤ 3.2 mΩ/sq.
Solder Leach: (No. of 10 sec. dips to double resistance of 0.25 mm wide x 100 mm long conductor, 62 Sn/36 Pb/2 Ag, 220 ± 5 °C)	≥ 10
Adhesion: (90° pull, 2.0 mm x 2.0 mm pads, 62 Sn/36 Pb/2 Ag, 220 ±5 °C)	
Initial pull strength:	≥ 7.6 kg
Aged 48 hours at 150°C:	≥ 5.1 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PLATINUM CONDUCTOR 9595-A

ESL 9595-A is a silver platinum conductor that exhibits excellent adhesion, solderability, and oxidation resistance. This conductor can be used on glass or porcelain enamelled steel. It is compatible with other ESL products suitable for use on the same substrates.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	260 ± 30 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	325 S/S, 25 µm
Levelling Time (at 20°C):	5 - 10 min
Drying Time (at 125°C):	10 - 15 min
Firing Temperature Range:	600 - 930°C (in air)
Optimum: (for PES/glass)	625°C
Optimum: (for alumina)	930°C
Time at peak:	10 - 12 min
Rate of Ascent/Descent:	60 - 100°C / min
Substrate for Calibration:	96% alumina
Thinner:	ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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TYPICAL PROPERTIES

Fired Thickness: 10 - 15 µm
(at least 2 layers 96% alumina)

Resistivity: ≤ 10 mΩ/□

Printing Resolution:
(line/space) 0.125 mm / 0.125 mm

Solder Wettability:

(RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	Good
(RMA Flux, 5 sec. dip, 95Sn/5Ag, 260°C)	Good

Solder Leach:
(No. of 10 sec. dips to double lowest resistance of
100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C) ≥ 2 dips

Adhesion:
(90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	≥ 4.5 kg
Aged 48 hours at 150°C:	≥ 2.5 kg

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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F: 610-272-6759
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CERMET SILVER/PLATINUM CONDUCTOR 9597-G

Lead, Cadmium and Nickel-Free*

ESL 9597-G is a silver/platinum conductor that can be fired on alumina using a wide temperature range. This conductor may be printed onto other substrates including beryllia, glass and Porcelain Enamelled Steel (PES). Its ability to adhere to glass makes it suitable for printing through laser drilled holes in ceramic substrates. 9597-G is a non-migrating conductor with exceptional solder leach resistance and can be used to replace Pt/Au in some applications.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	300 ± 30 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		550 - 980°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	⩽30 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	>10 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	5.0 - 9.0 kg
Aged 48 hours at 150°C:	3.8 - 6.5 kg

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

CERMET SILVER/PLATINUM CONDUCTOR 9598

Platinum Silver Conductor designed for Excellent Leach Resistance

ESL 9598 is a platinum silver conductor specially formulated for high leach resistance. The material withstands at least 20 ten second dips using 63/37 Sn/Pb solder when fired at 930°C. It exhibits a printing definition of 250 micrometers lines and spaces, and initial adhesion greater than 3.5 kg on 96% alumina.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10 rpm, ABZ spindle, 25.5 ± 0.5 °C)	300 ± 30 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 33 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C
	Optimum:	930°C
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness: (at least 2 layers 96% alumina)	10 - 18 µm
Resistivity: (15 µm)	≤ 80 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	≥ 20 dips

Adhesion:
(90° Pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)

Initial pull strength:	≥ 3.5 kg
Aged 48 hours at 150°C:	≥ 1.8 kg

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T: 610-272-8000
F: 610-272-6759
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CERMET SILVER/PLATINUM CONDUCTOR 9598-G

Cadmium, Lead and Nickel-Free*

ESL 9598-G is a silver / platinum conductor that can be fired on alumina using a wide temperature range. The 9598-G is a non-migrating conductor with exceptional solder leach resistance and can be used to replace Pt / Au in some applications.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed-bonded
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		550 - 980 °C in air
	Optimum:	850 °C
	Time at peak:	10 min
Total Firing Cycle:		1 hour
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 100 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	⩽ 80 mΩ/□
Printing Resolution: (line/space)	0.125 mm / 0.125 mm
Solder Wettability: (RMA Flux, 5 sec. Dip, 95.5Sn/3.8Ag/0.7Cu, 250°C)	95 - 100%
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 95.5Sn/3.8Ag/0.7Cu, 250°C)	>10 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 95.5Sn/3.8Ag/0.7Cu)	
Initial pull strength:	> 6.0 kg
Aged 48 hours at 150°C:	> 5.0 kg

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Silver / Platinum / Palladium Conductors

9562-G

Cadmium, lead and nickel-free, low cost ternary conductor.
Excellent large diameter aluminium wire bonding characteristics.

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F: 610-272-6759
www.electroscience.com

CERMET SILVER / PALLADIUM / PLATINUM CONDUCTOR

9562-G

Cadmium, Lead and Nickel-Free*

ESL 9562-G is a low-cost, ternary conductor that has excellent wire bonding characteristics with large diameter aluminium wire as well as gold wire. This conductor exhibits excellent conductivity, adhesion and solderability, and can be used as an economical conductor in automotive and consumer applications. The 9562-G may be protected with 850°C firing ESL 4924 overglaze.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	185 ± 25 Pa.s
Bonding Mechanism:	MICRO-LOK®
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 20 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 - 15 min
Firing Temperature Range:		850 - 930°C in air
	Optimum:	850°C
	Time at peak:	10 min
Total Firing Cycle:		30 min
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
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TYPICAL PROPERTIES

Fired Thickness: (measured on a 2 mm x 2 mm pad on 96% alumina)	12.5 ± 2.5 µm
Approximate Coverage:	90 - 110 cm²/g
Resistivity: (measured on a 100 mm x 0.25 mm conductor track at 12.5 µm fired thickness)	< 4.0 mΩ/□
Printing Resolution: (line/space)	0.150 mm / 0.150 mm
Solder Wettability: (RMA Flux, 5 sec. dip, 62Sn/36Pb/2Ag, 220°C)	100 %
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	> 5 dips
Adhesion: (90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag)	
Initial pull strength:	> 7.0 kg
Aged 48 hours at 150°C:	> 6.0 kg
Ultrasonic Al Wire Bond: (250 µm wire; bond length 4 mm)	> 600 g
Aged Al Wire Bond: (48 hours at 150°C)	> 500 g
Thermosonic Au Wire Bond: (25 µm wire; bond length 1 mm; 100% wire breaks)	> 7 g
Aged Au Wire Bond: (24 hours at 200°C)	> 7 g

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Solar Cell Materials

2591-E
An aluminium paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells.

2597
An aluminium paste designed for the back-surface metallization of thin single crystal and polycrystalline silicon solar cells.

9925
Silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells.

9925-G
RoHS Compliant silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells.

9926
Designed for the metallization of single crystal and polycrystalline silicon solar cells

9987
Cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications.

9987-A
Cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications. Designed for an emitter sheet resistivity of 40-65 ohms/square.

9988
Silver paste developed for use as a front-side metallization in photovoltaic applications.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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SOLAR CELL ALUMINIUM PASTE 2591-E

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 2591-E is an aluminium paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells. The 2591-E is a fritted back electrode material containing a cadmium-free, low-lead glass to provide excellent adhesion.

The 2591-E is not solderable, but may be co-fired with ESL 9925 Series back-surface silver materials to provide solderable pads.

The recommended materials to be used in conjunction with 2591-E are 9925 Series back-surface silver and 9980 Series front-surface silver metallizations.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield HBT, CP-51 Spindle, Shear Rate 9.6 sec^{-1}, 25.0±0.5°C)	40±20 Pa·s
SHELF LIFE: (25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	150-200/15-25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FURNACE SET POINT:	840-910°C
TIME ABOVE 600°C:	typically 5-8 seconds
THINNER:	ESL 452

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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SOLAR CELL ALUMINIUM PASTE 2597

Cadmium-Free, Low Wafer-Distortion Back Surface Conductor

ESL 2597 is an aluminium paste designed for the back-surface metallization of thin single crystal and polycrystalline silicon solar cells. The 2597 is a fritted back electrode material containing a cadmium-free, low-lead glass to provide excellent adhesion. This material is also designed to provide less distortion when used on thinner silicon wafers.

The 2597 is not solderable, but may be co-fired with ESL 9925 Series back-surface silver materials to provide solderable pads.

The recommended materials to be used in conjunction with 2597 are 9925 Series back-surface silver and 9980 Series front-surface silver metallizations.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield HBT, CP-51 Spindle, Shear Rate 9.6 sec^{-1}, 25.0±0.5°C)	40±20 Pa·s
SHELF LIFE: (25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	150-200/15-25 μm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FURNACE SET POINT:	840-910°C
TIME ABOVE 600°C:	typically 5-8 seconds
THINNER:	ESL 452

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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SOLAR CELL SILVER ALUMINIUM PASTE 9925

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9925 is a silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells. The 9925 is an aluminium-doped silver paste that contains a cadmium-free low-lead glass developed to promote a balance between ohmic contact, solderability, and adhesion. Excellent performance can be achieved over a wide processing window.

The recommended materials to be used in conjunction with 9925 are 9980 Series front-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	170 ± 50 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		180 - 325 S/S, 15 - 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Furnace Set Point:		840 - 910 °C
	Time above 600 °C:	typically 5 - 8 sec
Thinner:		ESL 401 or 413

Note: When used with the ESL 2590 Series materials, 9925 should be printed first. The aluminium paste should be printed second so that it overlaps the silver but leaves an exposed silver pad. The materials, along with the front surface silver, can then be co-fired to provide a solderable contact pad.

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T: 610-272-8000
F: 610-272-6759
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SOLAR CELL SILVER ALUMINIUM PASTE 9925-G

RoHS Compliant* Photovoltaic Material

ESL 9925-G is a silver paste designed for the back-surface metallization of single crystal and polycrystalline silicon solar cells. The 9925-G is an aluminium-doped silver paste that contains a cadmium-free, lead-free glass developed to promote a balance between ohmic contact, solderability, and adhesion.

The recommended materials to be used in conjunction with 9925-G are 9980 Series front-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	100 ± 40 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	180 - 325 S/S, 25 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Time (at 125 °C):	10 - 15 min
Furnace Set Point:	840 - 910 °C
Time above 600 °C:	typically 5 - 8 sec
Thinner:	ESL 401 or 413

Note: When used with the ESL 2590 Series materials, 9925-G should be printed first. The aluminium paste should be printed second so that it overlaps the silver but leaves an exposed silver pad. The materials can then be co-fired to provide a solderable contact pad.

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SOLAR CELL SILVER ALUMINIUM PASTE 9926

Pure Silver Conductor for Back Surface Solderable Pad

ESL 9926 is designed for the metallization of single crystal and polycrystalline silicon solar cells. The 9926 is designed to be used for the back-surface of the silicon wafer. The paste requires firing in a range of 625°C-850°C with a very short cycle of about 5-8 seconds at the peak temperature.

The recommended materials to be used in conjunction with 9926 are 9980 Series front-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	175 ± 25 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		625 - 850 °C
	Time above 600 °C:	typically 5 - 8 sec
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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SOLAR CELL SILVER PASTE 9987

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9987 is a cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications. The 9987 provides high efficiency and high fill factor on single crystal and polycrystalline silicon solar cells. ESL 9987 can be processed on solar cells using a fire-through process with silicon nitride or titanium dioxide anti-reflection coating.

The recommended materials to be used in conjunction with the 9987 are 9920 Series back-surface silver and 2590 Series back-surface aluminium metallisations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield HBT, Shear rate 9.6 sec^{-1}, CP-51 Spindle, 25.0 ± 0.2 °C)	120 ± 30 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 15 - 30 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Furnace Set Point:		840 - 910 °C
	Time above 600 °C:	typically 5 - 8 sec
Thinner:		ESL 401

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SOLAR CELL SILVER PASTE 9987-A

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9987-A is a cadmium-free, low-lead silver paste developed for use as a front-side metallization in photovoltaic applications. The 9987-A provides high efficiency and high fill factor on single crystal and polycrystalline silicon solar cells. ESL 9987-A can be processed on solar cells, using a fire-through process, with silicon nitride or titanium dioxide anti-reflection coating. The 9987-A is designed for an emitter sheet resistivity of 40-65 ohms/square.

The recommended materials to be used in conjunction with the 9987-A are 9920 Series back-surface silver and 2590 Series back-surface aluminium metallizations.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield HBT, Shear rate 9.6 sec^{-1}, CP-51 Spindle, 25.0 ± 0.2 °C)	120 ± 30 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	280 - 325 S/S, 15 - 30 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Set Point:	200 - 300 °C
Drying Time:	≤ 3 - 4 sec
Furnace Set Point:	840 - 910 °C
Time above 600 °C:	typically 5 - 8 sec
Thinner:	ESL 401

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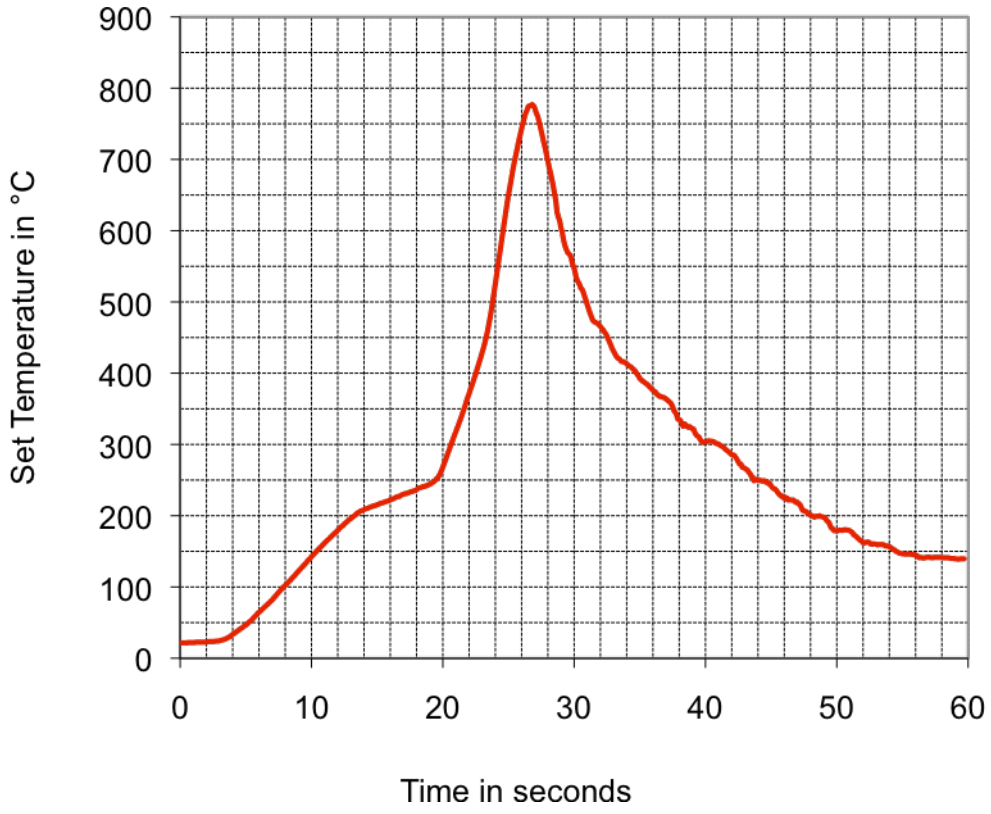
TYPICAL PROPERTIES

Fired Thickness:	12 - 18 µm
Resistivity: (at 25 µm fired thickness)	≤2 mΩ/sq.
Printing Resolution: (line/space)	0.100 mm / 0.125 mm
Solderability: (Tin Silver solder)	Excellent

Typical Firing Profile



Furnace: SierraTherm-5 zone IR with 25 cm peak firing zone
Belt speed: 470 cm/min.

Measured using Datapaq Q18 & type K thermocouple, exposed bead, 1mm sheath

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SOLAR CELL SILVER PASTE 9988

Cadmium-Free, Low-Lead Photovoltaic Material

ESL 9988 is a silver paste developed for use as a front-side metallization in photovoltaic applications. The 9988 provides high efficiency and high fill factor on single crystal and polycrystalline silicon solar cells. ESL 9988 can be processed on solar cells using a fire-through process with silicon nitride or titanium dioxide anti-reflection coating.

ESL 9925 Series silver and ESL 2591 Series aluminium back-surface metallisations are recommended for use with 9987.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield HBT, Shear rate 9.6 sec^{-1}, CP-51 Spindle, 25.0 ± 0.2 °C)	80 ± 20 Pa.s
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:	200 - 325 S/S, 15 - 25 µm
Levelling Time (at 20 °C):	5 - 10 min
Drying Time (at 125 °C):	10 - 15 min
Furnace Set Point:	840 - 910 °C
Time above 600 °C:	typically 5 - 8 sec

(See typical firing profile on page 2 - spike profile, fast firing, IR furnace, 4.7 m/minute belt speed.)

Thinner:	ESL 452

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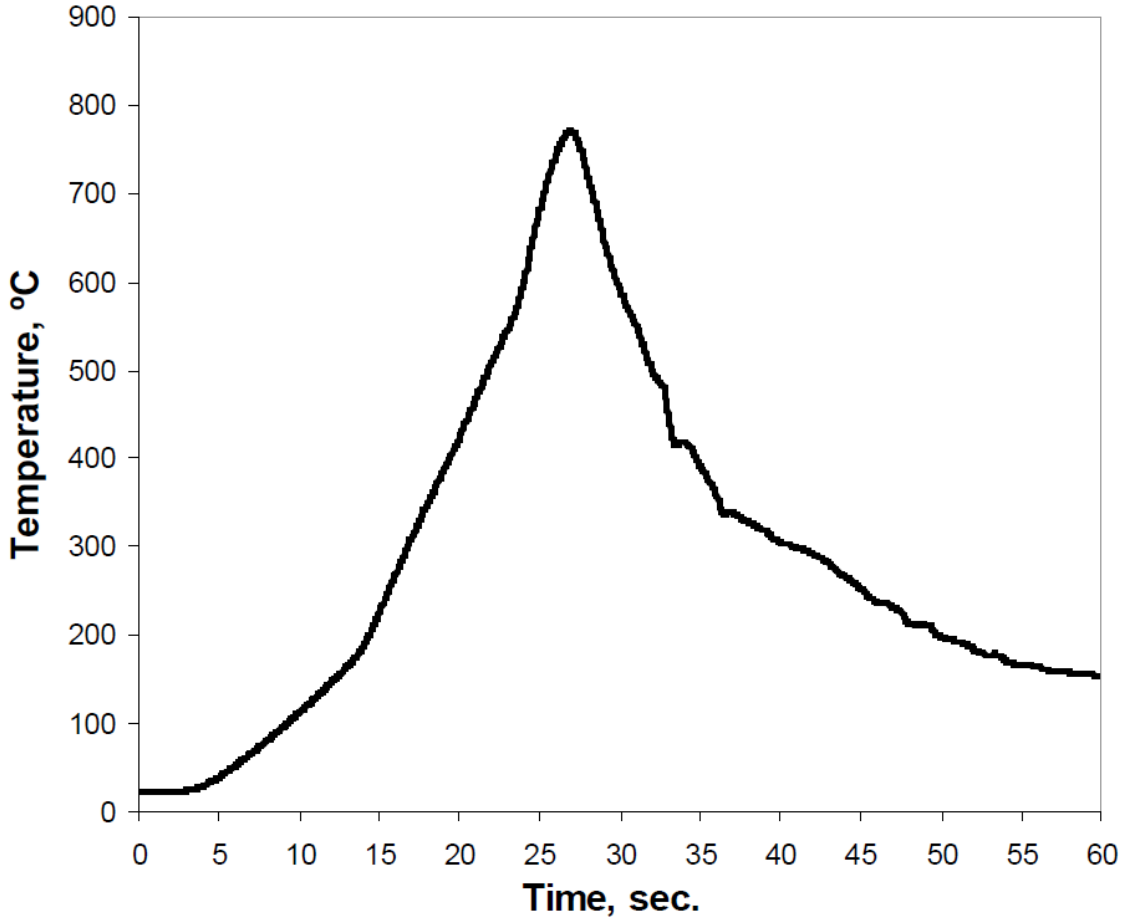
TYPICAL FIRING PROFILE



Optimum firing conditions for the best performance must be established by the customer based on cell configuration, thickness and process conditions. For this reason, our recommended firing profile should be taken only as a starting point.

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Specialty Conductors

2312-A-3
Copper conductor for thick printing on alumina.

2552
An air-firing nickel conductor designed for use as a cathode in D.C. gas discharge displays.

2554-N-1
An air-firing nickel conductor designed for use as a cathode in D.C. gas discharge displays.

8081-A
Thin printing metallo-organic gold that produces a conductive film thinner than 1 micrometer. Used for non-migrating terminations. High coverage.

8081-D
Thin printing metallo-organic gold that produces a conductive film thinner than 1 micrometer. High coverage. Lead, cadmium and nickel-free.

9996-B
Silver conductor specially designed for Elpor II CCMS (Ceramic Coated Metal Substrates).

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COPPER CONDUCTOR 2312-A-3

Conductor Designed for Thick Printing

ESL 2312-A-3 is a copper paste especially designed for thick printing. These thick copper conductor traces will handle higher currents than the normal thick film traces. Using an 80 mesh screen with a 115 micrometers thick emulsion, a fired film thickness of approximately 70 micrometers can be achieved with one print; two prints fired separately will yield a fired film thickness of approximately 160 micrometers. The third layer can be attained using a 165 mesh screen (30 micrometers emulsion) in order to provide a smooth surface, and will give a total thickness of approximately 175-185 micrometers. The desired fired film thickness will be determined by the screen mesh and emulsion thickness used.

This material can be fired at 900°C to 980°C in nitrogen. Optimum performance can be achieved by firing at 980°C.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ spindle, 25.5 ± 0.5 °C)	225 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		80 S/S, 115 µm 165 S/S, 30 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		900 - 980°C
	Optimum:	980 °C
	Time at peak:	10 - 12 min
	Atmosphere:	Nitrogen
Substrate for Calibration:		96% alumina
Thinner:		ESL 401

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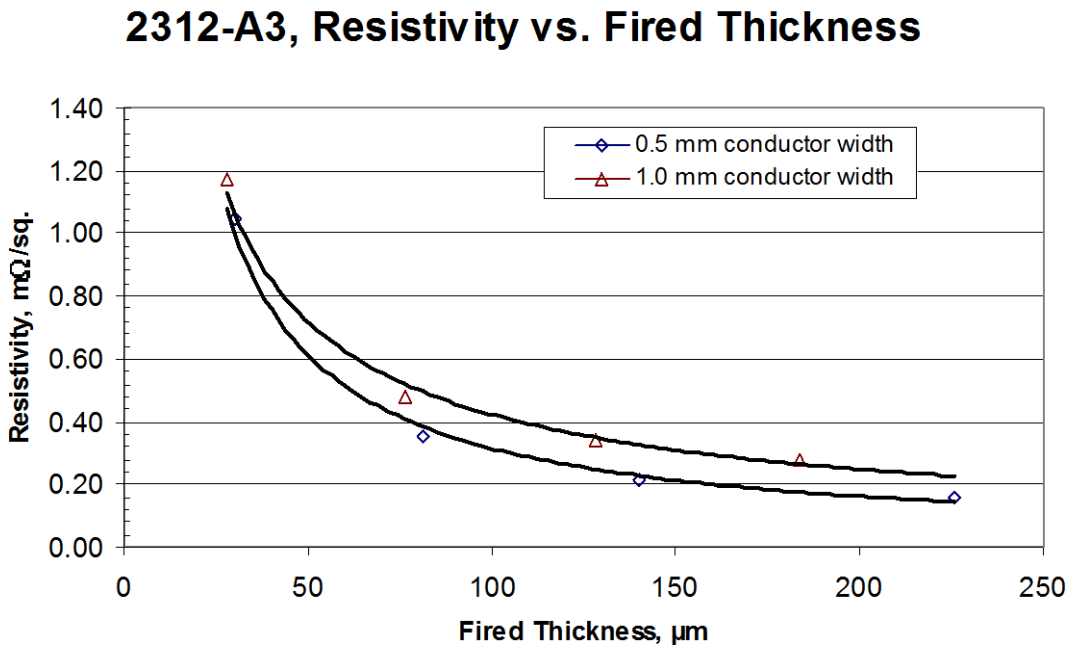
TYPICAL PROPERTIES

Based on RTC IR firing in nitrogen, belt speed of 90 mm/minute

Firing Temperature:	980°C
Fired Thickness, One Layer:	70 - 75 µm
Fired Thickness, Two Layers:	150 - 160 µm
Fired Thickness, Three Layers:	175 -185 µm
Resistivity: (25 µm fired thickness, achieved with 325 mesh/25 µm emulsion screen)	⩽ 1.5 mΩ/sq.
Approximate Coverage:	180 cm² / g
Solderability: (63 Sn/37 Pb solder, 250°C)	Good
Solder Leach Resistance: (No. of 10 sec. dips to double resistance of 0.25 mm wide x 100 mm long conductor, 63 Sn/37 Pb solder, 250°C)	≥ 4
Adhesion: (2 mm x 2 mm pads, 180 µm fired thickness, pull test)	
Initial:	≥ 6.6 kg
100 Hours at 150°C:	≥ 7.1 kg
Aluminium Wire Bond: (300 µm Al wire)	≥ 520g



ESL Europe 2591 0207-C

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CERMET NICKEL CONDUCTOR 2552

ESL 2552 is an air-firing nickel conductor designed for use as a cathode in D.C. gas discharge displays. The resistivity of 2552 varies with the firing temperature, and a graph of resistivity versus firing temperature is included on this data sheet. ESL 2552 can also be used for air fireable resistance thermometers and heaters. For solderable contacts, ESL 9901(silver) is recommended.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	300±25 Pa·s
SHELF LIFE: (25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	200/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING RANGE:	580°C-825°C
OPTIMUM:	580°C
TIME AT PEAK:	10-12 minutes
RATE OF ASCENT/DESCENT:	60°C-100°C/minute
SUBSTRATES OF CALIBRATION:	soda-lime glass, alumina
THINNER:	ESL 401

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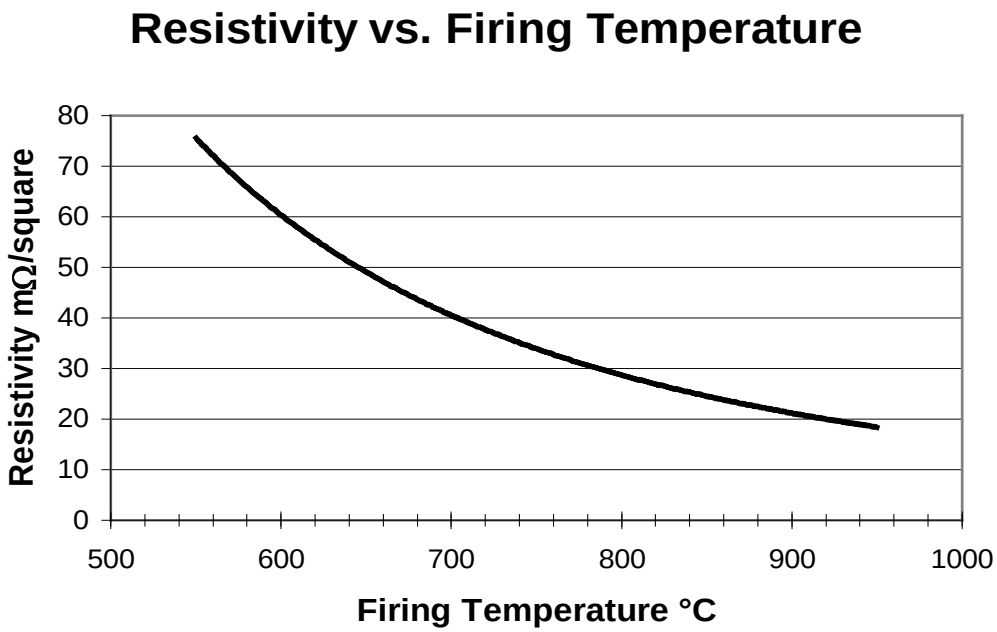
TYPICAL PROPERTIES

FIRED THICKNESS:	20±2.5 µm
RESISTIVITY: (Soda-Lime Glass 580°C firing)	≤ 70 mΩ/sq
PRINTING RESOLUTION: (Line/Space)	250 µm/250 µm
ADHESION: (Soldered on overprinted and co-fired 9901) (90°pull, 2.0 mm x 2.0 mm pads, 62 Sn/36 Pb/2 Ag)	
Initial pull strength:	25-30 N
TCR: (25° - 125°C, 625°C firing)	+4800 ppm/°C



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CERMET NICKEL CONDUCTOR 2554-N-1

Air firing Nickel Conductor

ESL 2554-N-1 is an air-firing nickel conductor designed for use as a cathode in D.C. gas discharge displays. The nickel paste has a firing range of 580°C to 625°C with a time at peak temperature of 10 minutes or longer.

PASTE DATA

RHEOLOGY:		Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	2554-N-1	225-275 Pa•s
SHELF LIFE: (25°C)		6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING TEMPERATURE:	580°C-625°C
OPTIMUM:	580°C
TIME AT PEAK:	≥ 10 minutes
FIRING CYCLE:	3 hours
RATE OF ASCENT/DECENT:	60°C-100°C/minute
SUBSTRATE OF CALIBRATION:	soda lime glass
THINNER:	ESL 401

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FIRED THICKNESS:	< 40 µm
RESISTIVITY: (when normalized @ 25 µm & co-fired with 3 layers of M4023-C)	≤ 60 mΩ/sq.
PRINTING RESOLUTION:	250 µm x 250 µm
DIELECTRIC COMPATIBILITY:	M4023-B
	M4023-C
	M4024-A

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GOLD METALLO- ORGANIC COMPOSITION 8081-A

ESL 8081-A is a thin printing metallo-organic gold that produces a fired conductive film of less than one-micrometer in thickness. It can be used for non-migrating terminations for thick film resistors and is economical because of its high coverage. It is not recommended for wire bonding or soldering because of its thinness. This conductor contains a precious metal composition that decomposes with heat at temperatures above 300°C. At temperatures near 600°C, a "thin" film with good adhesion to the substrate is formed. By printing this conductor to the exact pattern desired, it can be used for many conductive purposes in which direct wire bonding or soldering is not required.

PASTE DATA

Rheology:		Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 5 spindle, 25.5 ± 0.5 °C)		50 ± 10 Pa.s
Shelf Life (20°C):		6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 mesh, 25-33 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		625 - 850°C
	Optimum:	850°C
Rate of Ascent/Descent:		60 - 100 °C min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

ESL Affiliates
ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: < 1 µm

Resistivity: < 400 mΩ/□

NOTES:

1. Adequate air flow and ventilation to remove the burn-off products is essential or unpleasant odors may accumulate.

2. Thinners are not normally required. ESL 413 may be used sparingly. For screen cleaning, ESL413, isopropyl alcohol or acetone may be used.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

GOLD METALLO- ORGANIC COMPOSITION 8081-D

RoHS Compliant*

ESL 8081-D is a thin printing metallo-organic gold that produces a fired conductive film of less than one-micrometer in thickness. It is economical because of its high coverage. This conductor contains a precious metal composition that decomposes with heat at temperatures above 300°C. Depending on the substrate material, at temperatures near 600°C, a "thin" film with good adhesion to the substrate is formed. The paste can be used on alumina, glazed alumina, borosilicate, and soda-lime substrates. By printing this conductor to the exact pattern desired, it can be used for many conductive purposes in which direct wire bonding or soldering is not required.

PASTE DATA

Rheology:	Thixotropic, screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, No. 5 spindle, 25.5 ± 0.5 °C)	50 ± 10 Pa.s
Shelf Life (20°C):	6 months

PROCESSING

Screen Mesh, Emulsion:		325 - 400 mesh, 0-28 µm
Levelling Time (at 20°C):		5 - 10 min
Drying Time (at 125°C):		10 -15 min
Firing Temperature Range:		625 - 850°C
	Optimum:	850°C
Rate of Ascent/Descent:		60 - 100 °C min
Substrate for Calibration:		96% alumina
Thinner:		ESL 413

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

Fired Thickness: < 1 µm

Resistivity: < 800 mΩ/□

NOTES:

1. Adequate air flow and ventilation to remove the burn-off products is essential or unpleasant odors may accumulate.

2. Thinners are not normally required. ESL 413 may be used sparingly. For screen cleaning, ESL413, isopropyl alcohol or acetone may be used.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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CERAMIC TAPES & THICK-FILM MATERIALS
416 EAST CHURCH ROAD
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T: 610-272-8000
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CERMET SILVER/PALADIUM CONDUCTOR 9996-B

ESL 9996-B is a silver conductor specially designed for Elpor II CCMS (Ceramic Coated Metal Substrates). It exhibits good solderability, high conductivity, low cost and excellent adhesion.

PASTE DATA

Rheology:	Thixotropic screen-printable paste
Viscosity: (Brookfield RVT, 10rpm, ABZ Spindle, 25.5 ± 0.5 °C)	300 ± 25 Pa.s
Bonding Mechanism:	Mixed
Shelf Life (20 - 25 °C):	6 months

PROCESSING

Screen Mesh, Emulsion:		200 - 325 S/S, 25 µm
Levelling Time (at 20 °C):		5 - 10 min
Drying Time (at 125 °C):		10 - 15 min
Firing Temperature Range:		625 - 930 °C
	Optimum:	625 °C on Elpor II
	Time at peak:	10 - 12 min
Rate of Ascent/Descent:		60 - 100°C / min
Substrate for Calibration:		Elpor II
Thinner:		ESL 401

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk
ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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See Caution and Disclaimer on page 2.

TYPICAL PROPERTIES

Fired Thickness:	10 - 17 µm
Approximate Coverage:	60 - 70 cm²/g
Resistivity:	1 - 3 mΩ/sq.
Printing Resolution: (line/space)	0.250 mm / 0.250 mm
Solder Wettability: (RMA Flux, 5 sec. dip 62Sn/36Pb/2Ag, 220°C)	Excellent
Solder Leach: (No. of 10 sec. dips to double lowest resistance of 100 mm x 0.25 mm conductor, 62Sn/36Pb/2Ag, 220°C)	4 - 8 dips

Adhesion:
(90° pull, 2 mm x 2 mm pads, 62Sn/36Pb/2Ag, 220°C)

Initial pull strength:	≥ 1.5 kg
Aged 48 hours at 150 °C:	≥ 1.0 kg

Ultrasonic Al Wire Bond: (25 µm wire)	7 - 9 g
Thermosonic Au Wire Bond: (25 µm wire)	4 - 6 g

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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Tape Systems

40010
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free magnetic tape (ferrite), permeability = 50

40011
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free magnetic tape (ferrite), permeability = 200

40012
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free magnetic tape (ferrite), permeability = 500

41010
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
General purpose LTCC tape (K=7.5)

41010-T
Low-Temperature Transfer Tape (LTTT)
General purpose, zero xy shrink (K=7.5)

41020
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free LTCC tape (K=7.5)

41020-T
Low-Temperature Transfer Tape (LTTT)
Pb/Cd/Ni-free, zero xy shrink (K=7.5)

41030-T
Pb/Cd/Ni-free insulator tape, for 430-type ferritic stainless steel

41050
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free LTCC tape (K=13)

41060
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free LTCC tape (K=16)

41110
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free low-K LTCC tape, for high-frequency applications (K=4).

41110-T
Low-Temperature Transfer Tape (LTTT)
Pb/Cd/Ni-free low-K, zero xy shrink (K=4)

41230
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free capacitor tape (K=18)

41240
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free capacitor tape (K=50)

41250
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free capacitor tape (K=100)

41260
Low-Temperature Co-fired Ceramic (LTCC) Dielectric Tape
Pb/Cd/Ni-free capacitor tape (K=250)

42000
High-Temperature Co-fired Ceramic (HTCC) Tape
Yttria-stabilized zirconia (YSZ) tape

42013-A
A flexible cast film of partially stabilized zirconia (PSZ) powder dispersed in an organic matrix. For use in planar sensors.

42400
Ceramic Tape for Fuel Cells
Yttria stabilized zirconia thin electrolyte tape (nominal thickness 15-20 µm)

42401
Ceramic Tape for Fuel Cells
Yttria stabilized zirconia thick electrolyte tape (nominal thickness 125 µm)

42402
Ceramic Tape for Fuel Cells
Scandia stabilized zirconia thick electrolyte tape (nominal thickness 125 µm, 6 mol% Sc)

42405
Ceramic Tape for Fuel Cells
Scandia stabilized zirconia thin electrolyte tape (nominal thickness 15-25 µm, 6 mol% Sc)

42420
Ceramic Tape for Fuel Cells
YSZ/NiO anode tape

42421
Ceramic Tape for Fuel Cells
Porous YSZ/NiO anode tape

42510-x
Zirconia Cover Plates
Porous fired zirconia, available in various sizes

42520-x
Alumina Cover plates
Porous fired alumina, available in various sizes

44000
High-Temperature Co-fired Ceramic (HTCC) Tape
Alumina tape

49000
Flexible cast film of fugitive powder dispersed in an organic matrix for use in creating channels in sensors.

5559-B
Platinum conductor designed to be co-fired with alumina tape at high temperatures.

5570
Platinum conductor designed to be co-fired with alumina tape or partially stabilised zirconia tape at high temperatures.

5571
Platinum conductor designed to be co-fired with alumina tape at high temperatures for use as a heater in planar sensors.

5572
Platinum conductor for use as an inner electrode material for partially stabilized zirconia conical oxygen sensors.

5573
Platinum conductor for use as an outer electrode material for partially stabilized zirconia conical oxygen sensors.

5574
Platinum conductor designed to be co-fired with alumina at high temperatures for conical oxygen sensors.

5575
Platinum via-fill conductor designed to be co-fired with alumina tape or partially stabilized zirconia tape at high temperatures.

802
Gold conductor paste specially developed for use with ESL low temperature co-fired ceramic tapes (LTCC). This material is designed as a via-fill metallization.

803
Pb/Cd/Ni-free gold, for use in LTCC systems

902
Pb/Cd/Ni-free silver Via Fill, for use in co-fired LTCC systems

903-A
Pb/Cd/Ni-free silver, for use as a top or inner-layer metallization in co-fired LTCC and other tape systems

903-B
Pb/Cd/Ni-free silver, for use as an inner-layer or ground-plane metallization in co-fired LTCC and other tape systems

903-C
Pb/Cd/Ni-free silver, for use as a solderable top-layer metallization with low dielectric constant co-fired ceramic tape systems. ESL 903-C is designed for use as a post-fired conductor

903-D
Pb/Cd/Ni-free silver, for use as a solderable top-layer metallization in co-fired LTCC and other tape systems

903-E
Silver conductor designed for use as top-layer metallization for use with co-fired and transfer ceramic tape.

953
For terminating capacitors in LTCC

963
Solderable, with excellent leach resistance, for use in LTCC systems

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

MAGNETIC TAPE 40010

RoHS Compliant* Lo-Fire Tape for Multilayer and High Frequency Applications Requiring Medium Permeability

ESL 40010 is a flexible cast film of magnetic powder dispersed in an organic matrix. It is designed to be fired at 885°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 10.5 MPa and 70°C works well for laminating this tape. Magnetic tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling.

PROCESSING PARAMETERS

LAMINATING:	10.5 MPa at 70°C
FIRING TEMPERATURE:	885°C
TIME AT PEAK TEMPERATURE:	180 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	65-75 µm
COLOR:	brown
SHELF LIFE:	6 months

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FIRED TAPE PROPERTIES (Using co-fired ESL 903-A silver conductor)

PERMEABILITY: (100 KHz)		**≥** 60
INSULATION RESISTANCE: (100 VDC)		≥ 10^8 Ω
BREAKDOWN VOLTAGE:		> 1000 V/25 µm
FIRED SHRINKAGE: (Using recommended processing parameters)	X and Y	17.0±1.0%
	Z	14.0±1.0%
FIRED DENSITY: (Theoretical)		5.40 g/cm^3
COMPATIBLE CONDUCTORS:		ESL 903-A, 903-B, 902

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
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MAGNETIC TAPE 40011

RoHS Compliant* Lo-Fire Tape for Multilayer and High Frequency Applications Requiring High Permeability

ESL 40011 is a flexible cast film of magnetic powder dispersed in an organic matrix. It is designed to be fired at 885°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 10.5 MPa and 70°C works well for laminating this tape. Magnetic tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This material is useful in high frequency applications that require high permeability.

PROCESSING PARAMETERS

LAMINATING:	10.3 MPa (1500 psi) at 70°C
FIRING TEMPERATURE:	900±15°C
TIME AT PEAK TEMPERATURE:	2 – 3 hours

TAPE CHARACTERISTICS

TAPE THICKNESS:	65-75 µm (2.6 – 3.0 mils)
COLOR:	brown
SHELF LIFE:	12 months

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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FIRED TAPE PROPERTIES (Using co-fired ESL 903-A silver conductor)

PERMEABILITY:		
(100 KHz)		**≥** 200
INSULATION RESISTANCE:		
(100 VDC)		$\geq 10^8$ Ω
Thermal Coefficient of Expansion:		
(25°C to 300°C)		9.4 ppm/°C
BREAKDOWN VOLTAGE:		> 1000 VDC/25 µm
FIRED SHRINKAGE:		
(Using recommended processing parameters)	X and Y	18 ± 1 %
	Z	18 ± 1 %
FIRED DENSITY:		
(Theoretical)		5.30 g/cm^3
COMPATIBLE CONDUCTORS:		ESL 903-A, 903-B, 902

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T: 610-272-8000
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MAGNETIC TAPE 40012

RoHS Compliant* Lo-Fire Tape for Multilayer and High Frequency Applications Requiring > 400 Permeability

ESL 40012 is a flexible cast film of magnetic powder dispersed in an organic matrix. It is designed to be fired at 885°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 14 MPa and 70°C works well for laminating this tape. Magnetic tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This material is useful in high frequency applications that require high permeability.

PROCESSING PARAMETERS

LAMINATING:	14 MPa at 70°C
FIRING TEMPERATURE:	885°C
TIME AT PEAK TEMPERATURE:	180 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	65-75 µm
COLOR:	brown
SHELF LIFE:	6 months

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FIRED TAPE PROPERTIES (Using co-fired ESL 903-A silver conductor)

PERMEABILITY:		
(100 KHz)		**≥** 450
INSULATION RESISTANCE:		
(100 VDC)		≥ 10^8 Ω
Thermal Coefficient of Expansion:		
(25°C to 300°C)		9.4 ppm/°C
BREAKDOWN VOLTAGE:		> 1000 V/25 µm
FIRED SHRINKAGE:		
(Using recommended processing parameters)	X and Y	17.0%±1.0%
	Z	16.5%±1.0%
FIRED DENSITY:		
(Theoretical)		5.35 g/cm^3
COMPATIBLE CONDUCTORS:		ESL 903-A, 903-B, 902

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CO-FIRE CERAMIC TAPE 41010

Co-Fire Ceramic Tape For Multilayer and Microwave Applications Requiring Dielectric Constant ~ 7

A flexible cast film of inorganic dielectric powder dispersed in an organic matrix, is designed to be fired at 850°C to 875°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 21 MPa and 70°C works well for laminating this tape. Ceramic tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This material is useful in microwave applications that require a low dielectric constant.

PROCESSING PARAMETERS

LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	850°C-875°C
TIME AT PEAK TEMPERATURE:	10 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	100-130 µm
COLOR:	off white
SHELF LIFE:	6 months

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@eslshanghai.net

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FIRED TAPE PROPERTIES

DIELECTRIC CONSTANT: (1 MHz)		7.0-8.0
DISSIPATION FACTOR: (1 MHz)		≤ 0.5%
INSULATION RESISTANCE: (at 100 VDC)		≥ 10^{12} Ω
THERMAL CONDUCTIVITY:		2.5-3.0 W/(m·K)
TCE: (25°C to 300°C)		7.0 ppm/°C
BREAKDOWN VOLTAGE:		> 1800 V/25 µm
PRESSURE COOKER: (Insulation resistance after 15 minutes at 2 atmospheres)		≥ 10^{12} Ω
FIRED SHRINKAGE: (Using recommended processing parameters)	X and Y	13%±0.5%
	Z	17%±1%
FIRED DENSITY: (Theoretical)		3.16 g/cm^3
COMPATIBLE CONDUCTORS:		803, 902, 903-E, 903-A, 903-D, 963

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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416 EAST CHURCH ROAD
KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

TRANSFER TAPE 41010-T

Ceramic Transfer Tape With Dielectric Constant of 7-8 for 96% Alumina

ESL 41010-T is a flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be laminated to 96% alumina.
The tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling.

TYPICAL PROPERTIES WHEN LAMINATED TO 96% Al_2O_3*

DIELECTRIC CONSTANT (K): (1 MHz)	7.2-8.2
DISSIPATION FACTOR: (1 MHz)	< 0.5%
INSULATION RESISTANCE: (100 VDC)	> 10^{12} Ω
THERMAL CONDUCTIVITY:	2.5-3.0 W/m/°C
BREAKDOWN VOLTAGE:	>1400 V/25 μm
PRESSURE COOKER: (Insulation resistance after 15 minutes at 2 atmospheres)	> 10^{12} Ω
FIRED SHRINKAGE:	
X and Y	0%
Z	37%-47%
FIRED DENSITY: (Theoretical)	3.06 g/cm^3
TAPE THICKNESS:	115-135 μm
COLOR:	off white

* See U. S. Patent # 4,645,552

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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CO-FIRE CERAMIC TAPE 41020

RoHS Compliant* Ceramic Tape for Multilayer and Microwave Applications Requiring Dielectric Constant ~ 8

The 41020 is a flexible cast film of inorganic dielectric powder dispersed in an organic matrix. It is designed to be fired at 875°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 21 MPa and 70°C works well for laminating this tape. Ceramic tape is provided on a silicone coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This material is useful in microwave applications that require low dielectric constant.

PROCESSING PARAMETERS

LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	875°C
TIME AT PEAK TEMPERATURE:	10 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	100-130 µm
COLOR:	blue
SHELF LIFE:	6 months

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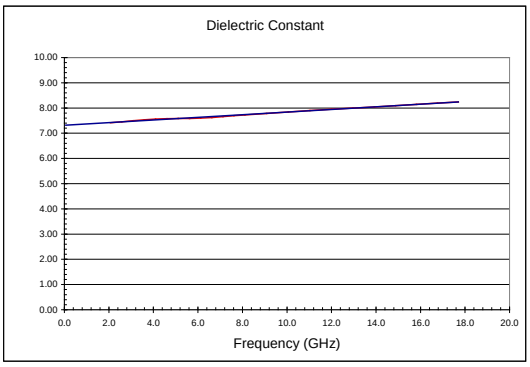
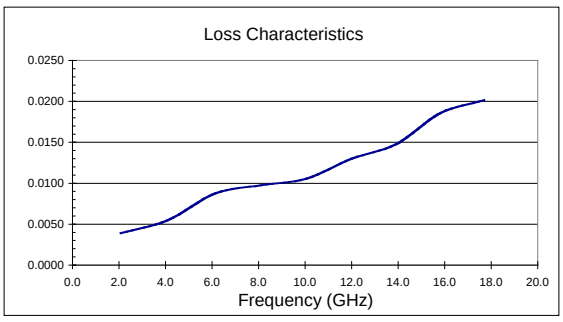
FIRED TAPE PROPERTIES (Tested with ESL 903-A post-fired silver conductor.)

DIELECTRIC CONSTANT: (1 MHz)		7.0-8.5
DIELECTRIC CONSTANT: (GHz, cofired with 903-A silver conductor, see microwave properties below)		7.0-7.5
DISSIPATION FACTOR: (1 MHz)		≤ 0.5%
INSULATION RESISTANCE: (at 100 VDC)		≥ 10^{12} Ω
THERMAL CONDUCTIVITY:		2.5-3.0 W/(m·K)
TCE: (25°C to 300°C)		7.4 ppm/°C
BREAKDOWN VOLTAGE:		> 1000 V/25 µm
PRESSURE COOKER: (Insulation resistance after 15 minutes at 2 atmospheres)		≥ 10^{12} Ω
FIRED SHRINKAGE: (Using recommended processing parameters)	X and Y	14 ± 1%
	Z	14 ± 2%
FIRED DENSITY: (Theoretical)		3.16 g/cm^3
COMPATIBLE CONDUCTORS:		ESL 803, 902, 903-A, 903-B, 903-D 963

MICROWAVE PROPERTIES *





* Data obtained from measurements on ring resonators. Metallization is co-fired ESL 903-A.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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KING OF PRUSSIA, PA 19406-2625, U.S.A
T: 610-272-8000
F: 610-272-6759
www.electroscience.com

TRANSFER TAPE 41020-T

RoHS Compliant* Ceramic Transfer Tape with a Dielectric Constant of 7-9 for use with 96% Alumina

ESL 41020-T is a flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be laminated to 96% alumina. ESL 41020-T will yield a robust dense body after firing at 850°C. A pressure/temperature combination of 1.7-6.9 MPa and 70°C works well for laminating to alumina.

Transfer tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling.

TYPICAL PROPERTIES WHEN LAMINATED TO 96% Al_2O_3*

DIELECTRIC CONSTANT: (at 1 kHz)		7-9
DISSIPATION FACTOR: (at 1 MHz)		≤ 0.5%
INSULATION RESISTANCE: (at 100 VDC, 25°C)		$> 10^{12}\ \Omega$
BREAKDOWN VOLTAGE: (VDC)		≥ 1000 V/25 μm
FIRING TEMPERATURE:		850°C
FIRED SHRINKAGE:		
	X and Y	0%
	Z	40%-55%
FIRED DENSITY: (Theoretical)		3.12 g/cm^3
TAPE THICKNESS:		115-135 μm
COLOR:		Blue

***** See U.S. Patent # 4,645,552

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ESL Europe (Agmet Ltd) • 8 Commercial Road • Reading • Berkshire • England • RG2 0QZ • Tel: +44 (0) 118 918 2400 • Fax: +44 (0) 118 986 7331 • Sales@ESLEurope.co.uk

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T: 610-272-8000
F: 610-272-6759
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TRANSFER TAPE 41030-T

RoHS Compliant* Ceramic Transfer Tape for 430 type Stainless Steel

ESL 41030-T is a flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be applied to a 430 type stainless steel substrate and fired at 850°C. The 41030-T film will yield a dense body after firing. A pressure/temperature combination of 1.7 to 3.4 MPa and 70°C works well for laminating this tape. Transfer tape is provided on a silicone coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling.

DIELECTRIC CONSTANT: (at 1 kHz)		9.0-10.0
DISSIPATION FACTOR: (at 1 MHz)		≤ 0.5 %
INSULATION RESISTANCE: (at 100 VDC, 25°C)		> 10^{12} Ω
BREAKDOWN VOLTAGE: (DC)		> 1000 V/25 μm
FIRING TEMPERATURE:		850°C
FIRED SHRINKAGE: (Using recommended processing parameters)		
	X and Y	0%
	Z	50%-55%
FIRED DENSITY: (Theoretical)		2.82 g/cm^3
TAPE THICKNESS:		110-140 μm
COLOR:		Blue

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ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

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CO-FIRE CERAMIC TAPE 41050

RoHS Compliant* Ceramic Tape for Multilayer and Microwave Applications Requiring Dielectric Constant of 13-14

The 41050 is a flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be fired at 875°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 21 MPa and 70°C works well for laminating this tape. Ceramic tape is provided on a silicone coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This dielectric is useful in microwave applications that require intermediate dielectric constant and low loss.

PROCESSING PARAMETERS

LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	875°C
TIME AT PEAK TEMPERATURE:	30 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	100-130 µm
COLOR:	blue
SHELF LIFE:	6 months

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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FIRED TAPE PROPERTIES (Using post-fired ESL 903-A silver conductor)

DIELECTRIC CONSTANT: (1Mhz)		13-14
DISSIPATION FACTOR: (1Mhz)		0.2%
TCE: (25°C to 300°C)		7.15 ppm/°C
FIRED SHRINKAGE: (Using recommended processing parameters)	X and Y	9.5%±0.5%
	Z	15.0%±1.0%
FIRED DENSITY: (Theoretical)		3.22 g/cm^3
COMPATIBLE CONDUCTORS:		ESL 903-A

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CO-FIRE CERAMIC TAPE 41060

RoHS Compliant* Ceramic Fire Tape for Multilayer and Microwave Applications Requiring Dielectric Constant of 16-17

The 41060 is a flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be fired at 875°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 21 MPa and 70°C works well for laminating this tape. Ceramic tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This dielectric is useful in microwave applications that require intermediate dielectric constant and low loss.

PROCESSING PARAMETERS

LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	875°C
TIME AT PEAK TEMPERATURE:	30 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	100-130 µm
COLOR:	blue
SHELF LIFE:	6 months

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FIRED TAPE PROPERTIES (Using co-fired 903-A silver conductor)

DIELECTRIC CONSTANT: (1 MHz)		16-17
DISSIPATION FACTOR: (1 MHz)		0.2%
TCE: (25°C to 300°C)		7.55 ppm/°C
FIRED SHRINKAGE: (Using recommended processing parameters)	X and Y	9.5%±0.5%
	Z	15.0%±1.0%
FIRED DENSITY: (Theoretical)		3.46 g/cm^3
COMPATIBLE CONDUCTORS:		903-A

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

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CO-FIRE CERAMIC TAPE 41110

RoHS Compliant* Ceramic Tape for Multilayer and Microwave Applications Requiring Low Dielectric Constant

A flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be fired at 850°C to give a dense body. Multilayer parts can be formed by laminating metallized sheets of the tape into a monolithic structure prior to firing. A pressure/temperature combination of 21 MPa and 70°C works well for laminating this tape. Ceramic tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling. This material is useful in microwave applications that require low dielectric constant and low loss.

PROCESSING PARAMETERS

LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	850°C
TIME AT PEAK TEMPERATURE:	10 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	100-130 µm
COLOR:	blue
SHELF LIFE: (when stored in dry N_2)	6 months

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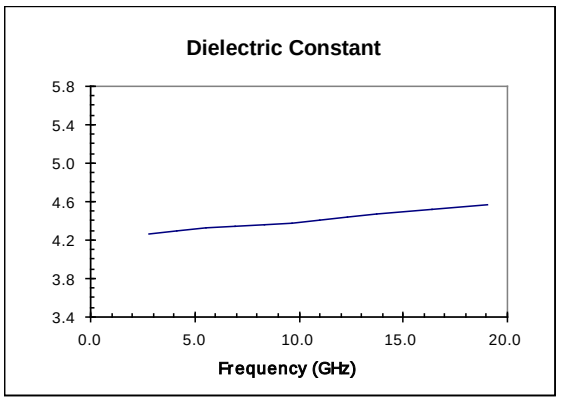
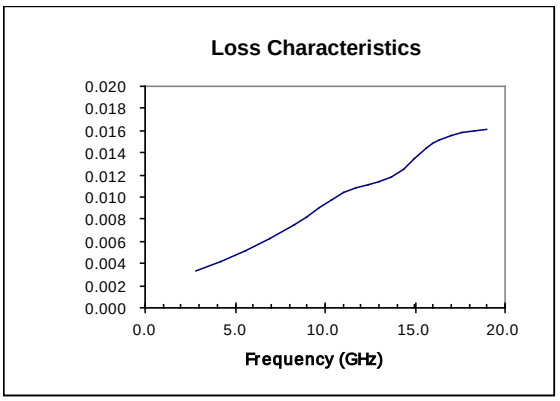
FIRED TAPE PROPERTIES (Tested with ESL 803 post-fired gold conductor)

DIELECTRIC CONSTANT: (1 MHz, using post-fired ESL 903-A silver conductor)		4.0-5.0
DIELECTRIC CONSTANT: (GHz, cofired with ESL 903-A silver conductor, see microwave properties below)		4.3-4.7
DISSIPATION FACTOR: (1 MHz, using post-fired ESL 903-A silver conductor)		≤ 0.4%
INSULATION RESISTANCE: (100 VDC)		≥ 10^{12} Ω
THERMAL CONDUCTIVITY:		2.5-3.0 W/(m·K)
TCE: (25°C to 300°C)		6.4 ppm/°C
BREAKDOWN VOLTAGE:		> 1500 V/25 µm
PRESSURE COOKER: (Insulation resistance after 15 minutes at 2 atmospheres)		≥ 10^{12} Ω
FIRED SHRINKAGE: (Using recommended processing parameters)	X and Y Z	15 ± 1% 16 ± 2%
FIRED DENSITY: (Theoretical)		2.30 g/cm^3
COMPATIBLE CONDUCTORS:	ESL 803, 902, 903-A, 903-B, 903-C, 963	

MICROWAVE PROPERTIES *





* Data obtained from measurements on ring resonators. Metallization is co-fired 903-A silver.

***None of the six substances referred to in the RoHS Directive (2002/95/EC) are used in the formulation of this product.**

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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TRANSFER TAPE 41110-T

RoHS Compliant* Ceramic Transfer Tape with Dielectric Constant ~ 4 for Use with 96% Alumina Substrates

A flexible cast film of inorganic dielectric powder dispersed in an organic matrix, designed to be laminated to and fired on an alumina substrate. A pressure/temperature combination of 1.7-6.9 MPa and 70°C works well for laminating this tape. After lamination, the parts can be fired in a belt furnace at 580°C peak/50 minute cycle burnout followed by an 850°C peak/45 minute cycle for sintering. Multilayer parts can be formed by metallizing laminated and fired sheets progressively. This tape is useful when low dielectric constant and low loss are desired. Transfer tape is provided on a silicone-coated polyester film to minimize environmental contamination, to protect it from mechanical damage, and to aid in handling.

Properties when laminated and fired on 96% Al_2O_3 *

DIELECTRIC CONSTANT: (1 MHz) (using 803)		4.0-5.0
DISSIPATION FACTOR: (1 MHz)		≤ 0.4%
INSULATION RESISTANCE:		> 10^{12} Ω/sq.
THERMAL CONDUCTIVITY:		2.5-3.0 W/m/°C
BREAKDOWN VOLTAGE:		> 1200 V/25 μm
PRESSURE COOKER: (Insulation Resistance after 15 minutes at 2 atmospheres)		>10^{12} Ω/sq.
FIRED SHRINKAGE:	**X and Y**	0
	Z	45%-55%
FIRED DENSITY:(theoretical)		2.26 g/cm^3
TAPE THICKNESS:		115-135 μm
COLOR:		Light blue
SHELF LIFE: (when stored in dry N_2)		6 months
RECOMMENDED CONDUCTORS:		ESL 903-A, 903-C, 902, 803, 963

* See US Patent # 4,645,55

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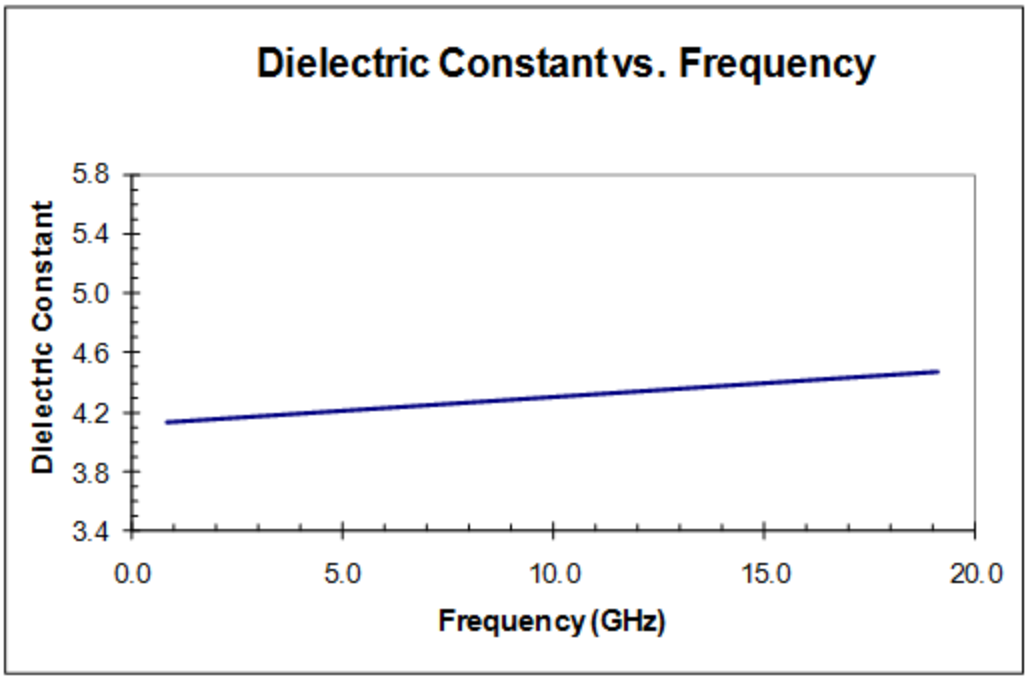
MICROWAVE PROPERTIES



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LO-FIRE TAPE 412xx

RoHS Compliant* Low-Temperature Capacitor Dielectric Tapes with Dielectric Constants of 18 to 250 for Burying in LTCC Tape

These tapes are flexible cast films of inorganic dielectric powder dispersed in an organic matrix and are designed to be used for capacitors buried in LTCC tape. The range of dielectric constant achievable depends on the firing schedule and host tape and is about 18-250. The dissipation factor for the tapes is 1-3% and exhibits X7R temperature characteristics.

PROCESSING PARAMETERS

LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	850°C-930°C
TIME AT PEAK TEMPERATURE:	15-60 minutes

TAPE CHARACTERISTICS

TAPE THICKNESS:	100-130 µm
COLOR:	beige
SHELF LIFE:	6 months

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FIRED TAPE PROPERTIES

(Calibrated on ESL41050/903-A)

PROPERTY	**41230**	**41240**	**41250**	**41260**
FIRED THICKNESS, µm	60-85	60-85	60-85	60-85
DIELECTRIC CONSTANT (K) @ 1kHz				
(fired at 875°C)	18 ± 25%	50 ± 25%	100 ± 25%	250 ± 25%
EIA DESIGNATION	X7R	X7R	X7R	X7R
DISSIPATION FACTOR @1kHz	≤ 1.0%	≤ 1.0%	≤ 2.0%	≤ 3.0%
BREAKDOWN VOLTAGE				
(VDC/25µm. 25°C air)	≥ 200	≥ 200	≥ 200	≥ 200

RECOMMENDED CONDUCTORS ESL 903-A, 953

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PARTIALLY STABILIZED ZIRCONIA TAPE 42000

RoHS Compliant* High Temperature PSZ Tape for use in Gas Diaphragms and Pressure Sensors

The ESL 42000 is a flexible cast film of partially stabilized zirconia (PSZ) powder dispersed in an organic matrix. This material is designed to be sintered in the temperature range of 1400°C-1500°C to yield a dense white colored ceramic. ESL 42000 tape is provided on a silicone-coated polyester film to protect the tape from mechanical damage, and aid in handling.

The high fracture strength of fired PSZ bodies allows the construction of parts having low inertial and thermal mass. Application areas include diaphragms for gas and pressure sensors. The relative flexibility of the fired ceramic suggests uses in medical pressure measurements, weighing and force gauges, automotive pressure and flow controllers.

PROCESSING:

Parts are formed by blanking sheets of the tape to the required green size prior to sintering. A burnout cycle of 3°C/minute to 450°C with a 3-hour dwell removes > 95% of the organic phase. Following the burnout cycle, the recommended sintering schedule is as follows: (This schedule may be modified for larger laminated parts or custom thickness.)

SINTERING SCHEDULE:		3°C per minute to 600°C 10°C per minute to 1000°C 5°C per minute to 1450°C 30 minute dwell at 1450°C
STABILIZING AGENT:		Y_2O_3
STABILIZER CONTENT:		3.0 mol %
CRYSTALLINE PHASE: (Typical)		90% Tetragonal 10% Monoclinic
FIRED SHRINKAGE: (single layer fired at1450°C for 30 minutes)	X, Y Z	22.0±1.0% 22.0±1.0%
FIRED DENSITY: (1450°C for 30 minutes)		> 98% of theoretical

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ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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FRACTURE STRENGTH: (1450°C-30 minutes, 3-point Modulus of Rupture)	≥1000 MPa
SURFACE ROUGHNESS:	0.20 μm (Ra)
TAPE THICKNESS: (Custom thicknesses available)	115±15 μm
COLOR:	paper white

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PARTIALLY STABILIZED ZIRCONIA TAPE 42013-A

RoHS compliant* high temperature PSZ tape for use in planar sensors

ESL 42013-A is a flexible cast film of partially stabilized zirconia (PSZ) powder dispersed in an organic matrix. This material is designed to be sintered in the temperature range of 1450°C-1550°C to yield a dense white-colored ceramic. ESL 42013-A tape is provided on a silicone-coated polyester film to protect the tape from mechanical damage and aid in handling.

This tape is generally used with Pt inks (ESL 5570 Series) that can be co-fired for use in planar sensors.

TYPICAL PROPERTIES:

TAPE THICKNESS: (custom thicknesses available)	125 µm ± 10%

PROCESSING:

Parts are formed by blanking sheets of the tape to the required green size prior to sintering. The burnout cycle depends on the part configuration and size.

TYPICAL PEAK SINTERING TEMPERATURE FOR PARTS:	1500°C for 3 hours
STABILIZING AGENT:	Y_2O_3
STABILIZER CONTENT:	5.0 mol %
FIRED SHRINKAGE: (12-layer bar fired at 1500°C for 3 hours)	X: 17.3 ± 1.0 % Y: 18.3 ± 1.0 %
FIRED DENSITY: (1500°C for 3 hours)	≥ 97% of theoretical

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ELECTROLYTE TAPE 42400

RoHS Compliant* High Temperature 8 mol% YSZ Tape for use in SOFC and other Fuel Cells, Gas Sensors and Pressure Sensors

The ESL42400 is an 8 mol% yttria stabilized zirconia (YSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are fabrication of SOFC and other fuel cells, high-temperature ceramic gas sensors and pressure sensors. In these applications, this electrolyte is designed to be an excellent ionic conductor and a poor electronic conductor at operating temperatures.

STABILIZING AGENT:	8 mol% Y_2O_3
GREEN TAPE THICKNESS:	15 µm ± 5 µm
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa @ 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute ramp to 650°C
	2.5°C/minute ramp to 1450 to 1550°C
	2-hour soak at peak temperature to achieve full density
FIRED DENSITY: (1450°C for 30 minutes)	> 98% of theoretical

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ELECTROLYTE TAPE 42401

RoHS Compliant* High Temperature 8 mol% YSZ Tape for use in SOFC and other Fuel Cells

The ESL42401 is an 8 mol% yttria stabilized zirconia (YSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are composite fabrication of SOFC and other fuel cells. The electrolyte is designed to be an excellent ionic conductor and poor electronic conductor at operating temperatures. This tape may be used as an electrolyte or a support in SOFC fuel cells.

STABILIZING AGENT:	8 mol% Y_2O_3
GREEN TAPE THICKNESS:	125µm ±10%
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa @ 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute to 650°C
	2.5°C/minute to 1450-1550°C
	2 hour soak at peak temperature
FIRED SHRINKAGE:	X,Y: 18-26 %
	Z: 18-22 %
FIRED DENSITY: (1450°C for 30 minutes)	> 98% of theoretical

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ELECTROLYTE TAPE 42402

RoHS Compliant* High Temperature 6 Mol% ScSZ Tape for Use In SOFC And Other Fuel Cells

The ESL 42402 electrolyte is a 6 mol% scandia stabilized zirconia (ScSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are fabrication of SOFC and other fuel cells. The electrolyte is designed to be an excellent ionic conductor and poor electronic conductor at operating temperatures.

STABILIZING AGENT:	6 mol% Sc_2O_3
GREEN TAPE THICKNESS:	125µm ± 10%
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa @ 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute to 650°C
	2.5°C/minute to 1350-1450°C
	2 hour soak at peak temperature
FIRED SHRINKAGE:	X, Y: 18-26 %
	Z: 18-22 %
FIRED DENSITY: (1450 °C for 30 minutes)	> 98% of theoretical

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ELECTROLYTE TAPE 42405

RoHS Compliant* High Temperature 6 Mol% ScSZ Tape for use in SOFC and Other Fuel Cells

The ESL 42405 electrolyte is a 6 mol% scandia stabilized zirconia (ScSZ) ceramic layer prepared by casting on a polyester carrier film, which is coated with a release agent.

Typical applications for this tape are fabrication of SOFC and other fuel cells. The electrolyte is designed to be an excellent ionic conductor and poor electronic conductor at operating temperatures.

STABILIZING AGENT:	6 mol% Sc_2O_3
GREEN TAPE THICKNESS:	20 µm ± 5µm
GREEN TAPE COLOR:	off-white
LAMINATING:	21 MPa at 70°C
TYPICAL SINTERING CYCLE:	0.7°C/minute to 650°C
	2.5°C/minute to 1350 -1450°C
	2 hour soak at peak temperature
FIRED SHRINKAGE:	X, Y: 18-26 %
	Z: 18-22 %
FIRED DENSITY: (1450 °C for 30 minutes)	> 98% of theoretical

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F: 610-272-6759
www.electroscience.com

ANODE TAPE 42420

RoHS Compliant* High Temperature YSZ-Cermet Tape for use in SOFC and other Fuel Cells.

This anode cermet is a blend of nickel oxide and yttria stabilized zirconia (YSZ) in tape form, designed to sinter to near full density as part of the composite structure used in SOFC and other fuel cells. Its purpose is to insure thermal coefficient of expansion (TCE) match between adjacent electrolyte and porous anode layers in the composite assembly, and thus it is chemically compatible with these materials. It is prepared by tape casting a slurry containing the YSZ powder, a thermoplastic binder and surfactant. The slurry is cast on a polyester carrier film which is coated with a release agent.

LAMINATING:	21 MPa @ 70˚C
GREEN TAPE THICKNESS:	15 ± 5 µm
GREEN TAPE DENSITY:	nominal 3.04 g/cm^3, depending on solids loading
GREEN TAPE COLOR:	dark green (typical)
TYPICAL SINTERING CYCLE:	0.7°C/minute ramp to 650°C 2.5°C/minute ramp to 1450 to 1550°C 2-hour soak at peak temperature to achieve full density
FIRED SHRINKAGE: (3 layers using lamination parameters of 3 kpsi – 70°C – 20 minutes) nominal	X, Y: 25% Z: 25%
FIRED DENSITY: (1450°C for 120 minutes)	> 90% of theoretical

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POROUS ANODE TAPE 42421

RoHS Compliant* High Temperature YSZ-Cermet Tape for use in SOFC and other Fuel Cells

The porous anode cermet is a blend of nickel oxide and yttria stabilized zirconia (YSZ) in tape form. It provides the catalytic activity required to promote the reaction necessary to produce fuel ions, such as hydrogen or CO. It is porous so that fuel gas can reach the three-phase boundary present near the electrolyte. In SOFC anode-supported cells, thick anode layers are required to provide mechanical strength for the cell. It is prepared by tape casting a slurry containing the YSZ powder, a thermoplastic binder and surfactant. The slurry is cast on a polyester carrier film which is coated with a release agent.

LAMINATING:	21 MPa @ 70˚C
GREEN TAPE THICKNESS:	nominal 180 µm
GREEN TAPE DENSITY:	nominal 3.2 g/cm^3, depending on solids loading
GREEN TAPE COLOR:	dark green – gray (typical)
TYPICAL SINTERING CYCLE:	0.7°C/minute ramp to 650°C 2-1/2°C/minute ramp to 1450 to 1550°C 2-hour soak at peak temperature to achieve full density
FIRED SHRINKAGE: (3 layers using lamination parameters of 3 kpsi – 70°C – 20 minutes), nominal	X, Y: 21% Z: 21%
FIRED DENSITY: (1450 °C for 120 minutes)	< 85 % of theoretical

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POROUS ZIRCONIA COVER PLATE 42510-x

RoHS Compliant*

ESL 42510 is a porous, fired zirconia ceramic plate used to cover green ceramic parts during firing. The weight of the porous plate enhances the flatness of fired parts while retaining gas permeability during organic removal, thus allowing single firing. The plate may also be used as a setter to promote more uniform burnout of binders during firing. Uses include Fuel Cell applications such as SOFC electrolyte substrates, and other processing of ceramic tape.

ESL cover plates are available in several standard sizes as shown below, and in customer-specific configurations.

DATA:

THICKNESS:	1 mm nominal or as required
THICKNESS TOLERANCE	mean ± 10%
CAMBER (parallel plate gauge)	0.5 mm/100 mm
MAXIMUM USE TEMPERATURE	up to 1550°C
RECOMMENDED USE TEMPERATURE	up to 1450°C
RE-FLATTENING TEMPERATURE	1550°C

SIZES AVAILABLE (mm)

42510-2 50 x 50

42510-3 75 x 75

42510-4 100 x 100

42510-5 125 x 125

42510-6 150 x 150

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POROUS ZIRCONIA COVER PLATE 42520-x

RoHS Compliant*

ESL 42520 is a porous, fired zirconia ceramic plate used to cover green ceramic parts during firing. The weight of the porous plate enhances the flatness of fired parts while retaining gas permeability during organic removal, thus allowing single firing. The plate may also be used as a setter to promote more uniform burnout of binders during firing. Uses include Fuel Cell applications such as SOFC electrolyte substrates, and other processing of ceramic tape.

ESL cover plates are available in several standard sizes as shown below, and in customer-specific configurations.

DATA:

THICKNESS:	1 mm nominal or as required
THICKNESS TOLERANCE	mean ± 10%
POROSITY:	40% nominal
CAMBER (parallel plate gauge)	0.5 mm/100 mm
MAXIMUM USE TEMPERATURE	up to 1550°C
RECOMMENDED USE TEMPERATURE	up to 1450°C
RE-FLATTENING TEMPERATURE	1550°C

SIZES AVAILABLE (mm)

42520-2 50 x 50

42520-3 75 x 75

42520-4 100 x 100

42520-5 125 x 125

42520-6 150 x 150

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ALUMINA TAPE 44000

High Temperature Co-Fired Ceramic

The ESL 44000 is a flexible cast film of 96% alumina powder in an organic matrix prepared by casting on a polyester carrier film, which is coated with a release agent.

This material is designed to be fired at 1500°C to yield a dense white-colored alumina ceramic. The 44000 is provided on a polyester film to protect the tape from mechanical damage and aid in handling.

GREEN TAPE THICKNESS:	200µm ± 10%
GREEN TAPE COLOR:	blue
LAMINATING:	21 MPa at 70°C
FIRING TEMPERATURE:	1500°C
TIME AT PEAK:	2 hours
SHRINKAGE:	X, Y: 16.0 - 18.0 %
FIRED DENSITY:	≥ 3.6 g/cc

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FUGITIVE TAPE 49000

Organic-Based Tape for use in Creating Channels in Sensors
RoHS Compliant*

ESL 49000 is a flexible cast film of fugitive powder dispersed in an organic matrix. This material is designed to be burned out in the temperature range of 600°C-700°C to yield a void where the tape was placed. ESL 49000 tape is provided on a silicone-coated polyester film to protect the tape from mechanical damage and aid in handling.

This tape is generally used with zirconia or alumina green tapes and can be co-fired for use in oxygen sensors.

TAPE THICKNESS: 125µm +/- 10%
(custom thicknesses available)

PROCESSING:

Parts are formed by blanking sheets of the tape to the required green size prior to firing. The burnout cycle depends on the part configuration and size.

TYPICAL FIRING PROFILE FOR PARTS: Depends on matrix tapes

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CO-FIRING PLATINUM CONDUCTOR 5559-B

RoHS compliant* co-firable conductor designed for use as a heater in planar sensors

ESL 5559-B is a platinum conductor designed to be co-fired with alumina tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	75 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	90 ± 10 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SUBSTRATE OF CALIBRATION:	alumina tape

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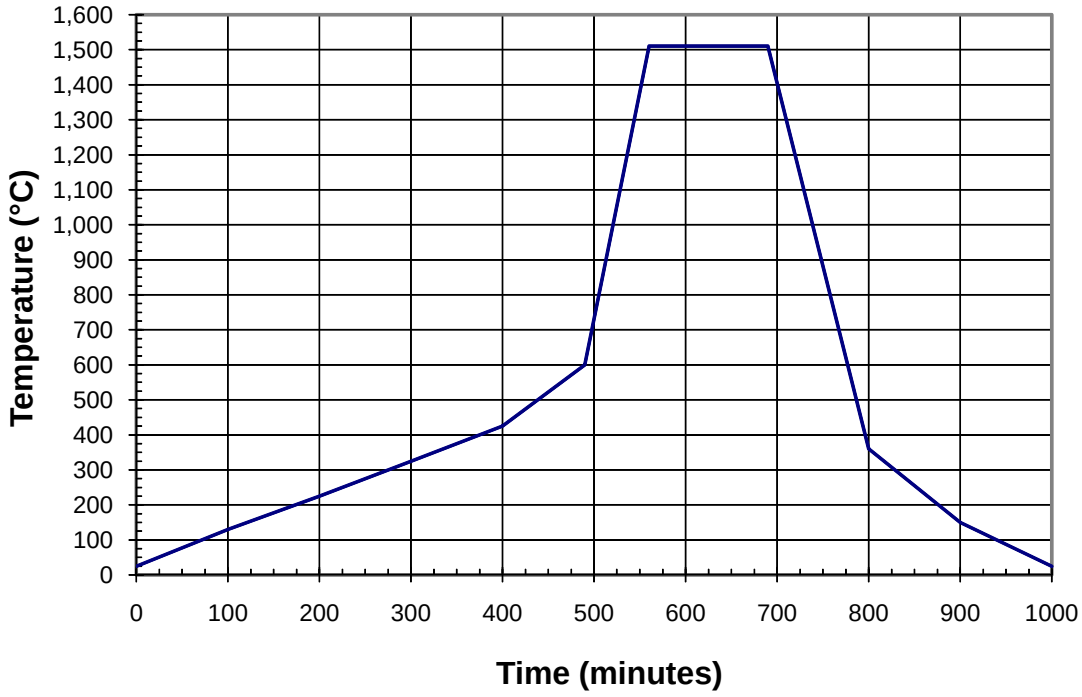
Typical Firing Profile for 5559-B



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CO-FIRING POROUS PLATINUM CONDUCTOR 5570

RoHS compliant* conductor designed for use as an electrode in planar sensors

ESL 5570 is designed to be co-fired with partially stabilized zirconia tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 20.0°C ± 0.5°C)	70 ± 20 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	30 ± 10 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SODIUM CONCENTRATION:	≤ 50 ppm
SUBSTRATE OF CALIBRATION:	partially stabilized zirconia tape

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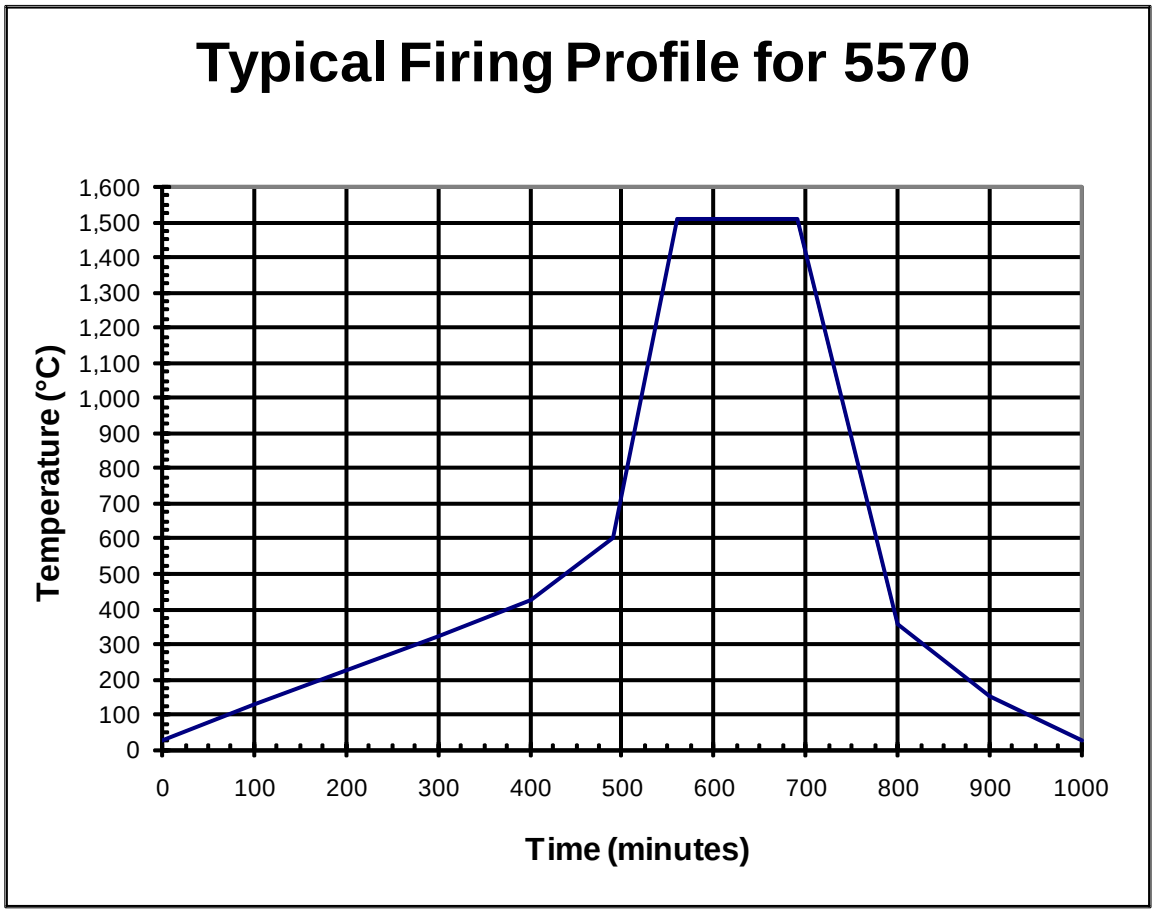

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CO-FIRING PLATINUM CONDUCTOR 5571

RoHS compliant* co-fireable conductor designed for use as a heater in planar sensors

ESL 5571 is a platinum conductor designed to be co-fired with alumina tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable pastes
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	75 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	40 ± 5 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SODIUM CONCENTRATION:	≤ 50 ppm
SUBSTRATE OF CALIBRATION:	alumina tape

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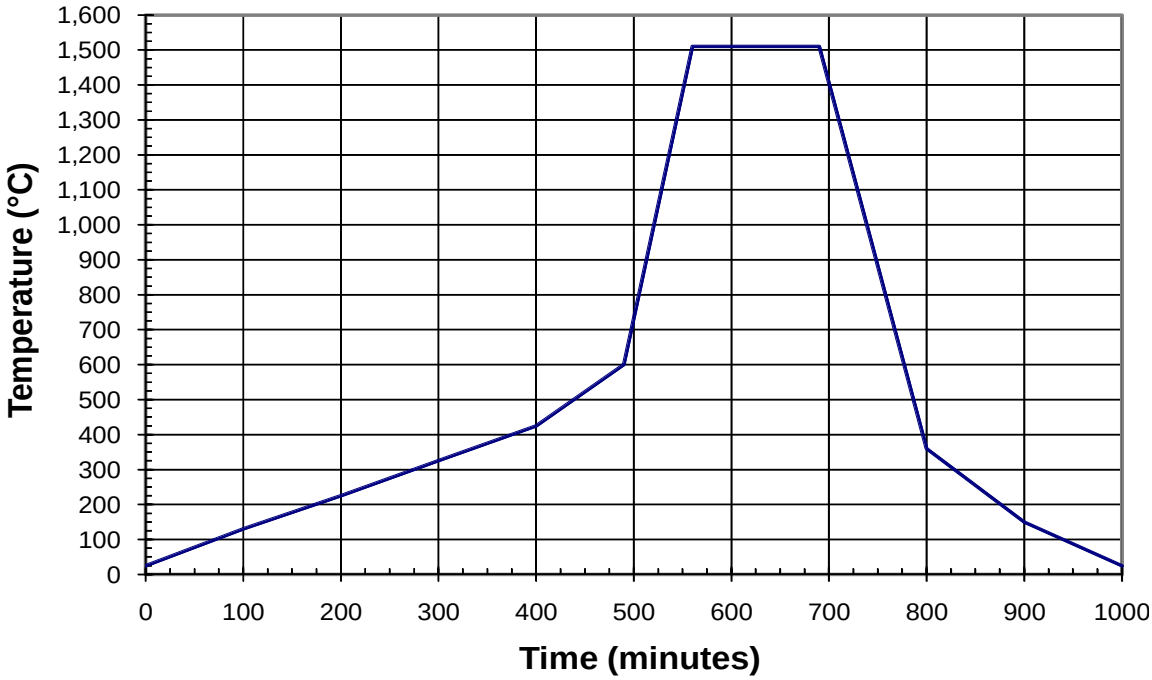
Typical Firing Profile for 5571



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T: 610-272-8000
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CERMET PLATINUM CONDUCTOR 5572

RoHS Compliant* Conductor for Conical Oxygen Sensors

ESL 5572 is a platinum conductor for use as an inner electrode material for partially stabilized zirconia conical oxygen sensors. A pouring grade is available upon request.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY:	
(Brookfield HBT, cone/plate, 38.4 sec^{-1} at 20°C±0.5°C)	50-100 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION: (Printing Grade)	325/25 μm
DRYING:	10-15 minutes,125°C
FIRING RANGE:	1250°C-1510°C
TIME AT PEAK:	120 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER	ESL 437

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CERMET PLATINUM CONDUCTOR 5573

RoHS Compliant* Conductor for Conical Oxygen Sensors

ESL 5573 is a platinum conductor for use as an outer electrode material for partially stabilized zirconia conical oxygen sensors. This material performs well when fired on partially fired ceramic bodies. It is pad-printable.

PASTE DATA

RHEOLOGY:	Pad-printable paste
VISCOSITY:	
(Brookfield HBT, SC4-14/6R, 10 RPM at 25°C±0.5°C)	22-32 Pa·s
SHELF LIFE:	6 months

PROCESSING

SCREEN MESH/EMULSION: (Printing Grade)	325/25 µm
DRYING:	10-15 minutes, 125°C
FIRING RANGE:	1250°C-1510°C
TIME AT PEAK:	120 minutes
SUBSTRATE OF CALIBRATION:	96% alumina
THINNER	ESL 437

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CO-FIRING PLATINUM CONDUCTOR

5574
5574-A

RoHS compliant* co-fireable conductor designed for use as lead or contact pads in planar sensors

ESL 5574 is a platinum conductor designed to be co-fired with alumina at high temperatures. A lower resistivity version is also available (5574-A).

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable pastes
VISCOSITY: (Brookfield HBT, cone/plate, 38.4 sec^{-1} at 25.0°C ± 0.5°C)	70 ± 15 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:		325 mesh / 25 ± 5 µm
RESISTIVITY: (12.5 µm fired thickness)	5574:	≤ 20 mΩ/square
	5574-A:	≤ 12 mΩ/square
FIRING RANGE:		1500°C ± 10°C
		see profile on back
TIME AT PEAK TEMPERATURE:		120 min.
SODIUM CONCENTRATION:		≤ 50 ppm
SUBSTRATE OF CALIBRATION:		alumina tape

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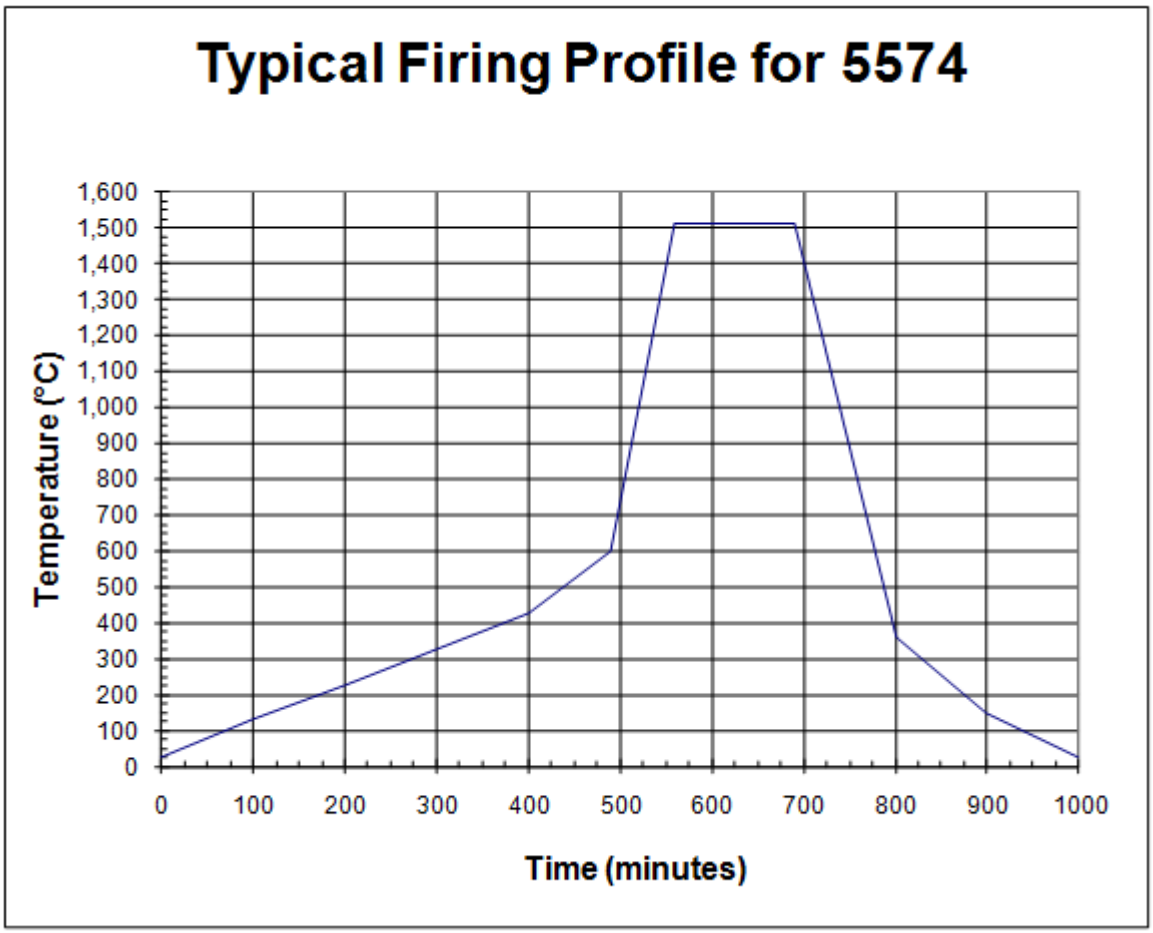

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CO-FIRING PLATINUM VIA-FILL CONDUCTOR 5575

RoHS compliant* co-firable conductor designed for use as a via-fill in planar sensors

ESL 5575 is a platinum via-fill conductor designed to be co-fired with alumina tape or partially stabilized zirconia tape at high temperatures.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield HBT, SC4-14 spindle, 1 RPM at 25.0°C ± 0.5°C)	1300 ± 200 Pa•s
SHELF LIFE:	6 months

TYPICAL PROPERTIES

SCREEN MESH/EMUSLION:	325 mesh / 25 ± 5 µm in application, use a stencil
RESISTIVITY: (25 µm fired thickness)	50 ± 15 mΩ/square
FIRING RANGE:	1500°C ± 10°C see profile on back
TIME AT PEAK TEMPERATURE:	120 min.
SUBSTRATE OF CALIBRATION:	alumina tape

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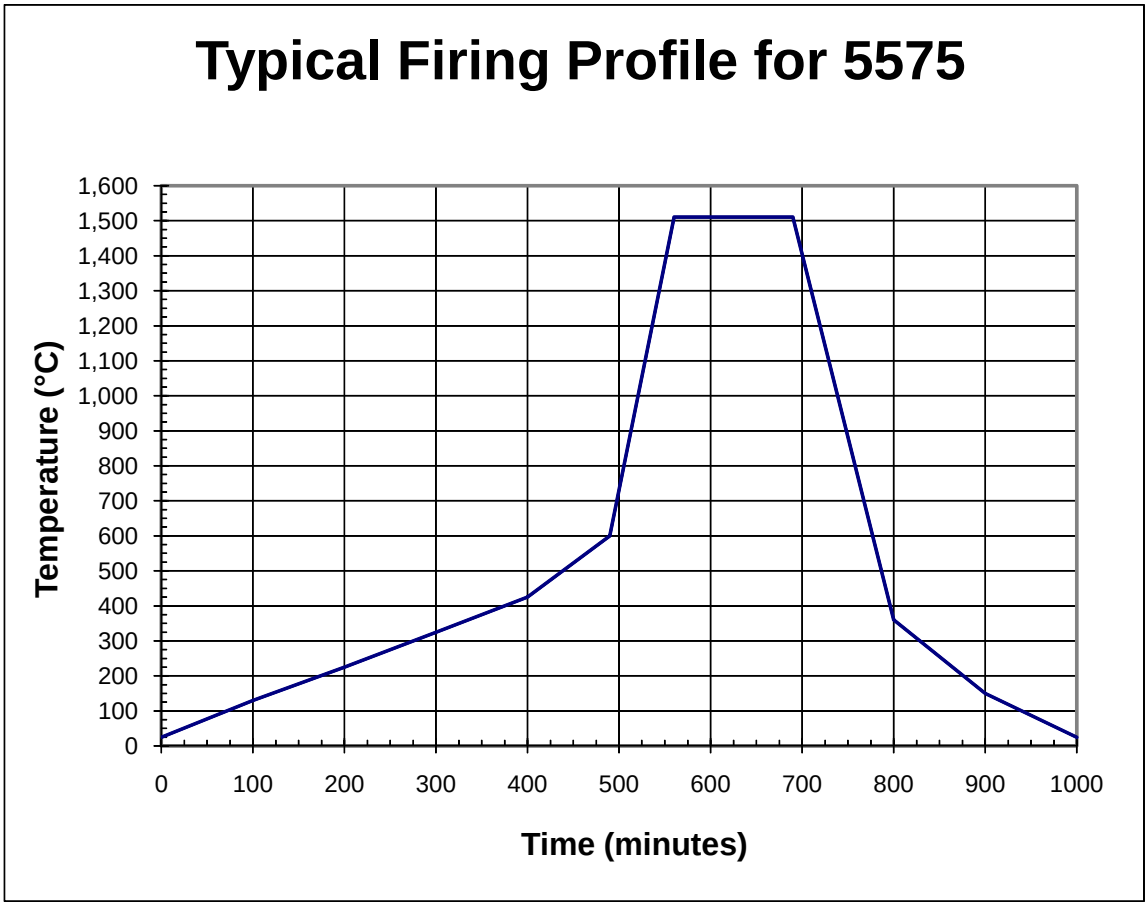

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GOLD CONDUCTOR 802

Conductor for Low Temperature Co-fired Ceramic Tapes

ESL 802 is a gold conductor paste specially developed for use with ESL low temperature co-fired ceramic tapes (LTCC). This material is designed as a via-fill metallization.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield RVT, ABZ spindle, 10 rpm, 25.5 ± 0.5 °C)	275 ± 25 Pa.s
SOLIDS CONTENT:	87.5 ± 1.5 %
SHELF LIFE: (at 25 °C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325 / 25 ± 12 µm
LEVELING TIME: (at 25°C)	5 - 10 min
DRYING TIME: (at 80°C)	10 -15 min
FIRING TEMPERATURE:	Co-fired with LTCC
RATE OF ASCENT/DESCENT:	60°C - 100°C/minute
SUBSTRATE FOR CALIBRATION:	ESL 41010
THINNER:	ESL 401

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TYPICAL PROPERTIES

FIRED THICKNESS:
(measured on a 2 mm x 2 mm pad) 15 - 25 µm

RESISTIVITY:
(measured on a 100 mm x 0.25 mm conductor track) ≤ 30 mΩ/square

NOTES: All data was collected using ESL 41010 or similar tape, co-fired at 850ºC.

CAUTION: Proper industrial safety precautions should be exercised in using these products. Use with adequate ventilation. Avoid prolonged contact with skin or inhalation of any vapours emitted during use or heating of these compositions. The use of safety eye goggles, gloves or hand protection creams is recommended. Wash hands or skin thoroughly with soap and water after using these products. Do not eat or smoke in areas where these materials are used. Refer to appropriate MSDS sheet.

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GOLD CONDUCTOR 803

Conductor for Low Temperature Co-fired Ceramic Tapes

ESL 803 is a gold conductor paste specially developed for use with ESL low temperature co-fired ceramic tapes (LTCC). This material is designed for use as an inner layer or top layer metallization.

PASTE DATA

RHEOLOGY:	Thixotropic, screen-printable paste
VISCOSITY: (Brookfield RVT, ABZ spindle, 10 rpm, 25.5 ± 0.5 °C)	225 ± 50 Pa.s
SOLIDS CONTENT:	77.0 ± 1.5 %
SHELF LIFE: (at 25 °C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325 / 25 ± 12 µm
LEVELING TIME: (at 25°C)	5 - 10 min
DRYING TIME: (at 80°C)	10 -15 min
FIRING TEMPERATURE:	Co-fired with LTCC
RATE OF ASCENT/DESCENT:	60°C - 100°C/minute
SUBSTRATE FOR CALIBRATION:	ESL 41010
THINNER:	ESL 401

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TYPICAL PROPERTIES

FIRED THICKNESS: (measured on a 2 mm x 2 mm pad)	6 - 12 µm
RESISTIVITY: (measured on a 100 mm x 0.25 mm conductor track at 9 µm fired thickness)	≤ 10 mΩ/square
SOLDER WETTABILITY: (80 Au / 20 Sn solder)	Good
WIREBONDABILITY: (25 µm Au wire) **INITIAL PULL STRENGTH:**	≥ 10 grams
ADHESION: (90º pull, 2.0 mm x 2.0 mm pads) **INITIAL PULL STRENGTH:**	≥ 13 N

NOTES: All data was collected using ESL 41010 or similar tape, co-fired at 850ºC.

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CERMET SILVER CONDUCTOR 902

Lead-Free Conductor for Use as Via Fill with Co-Fire Ceramic Tape

ESL 902 is a silver conductor designed for use as a via fill with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	250±50 Pa·s
BONDING MECHANISM:	Fritted
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	< 35 µm
RESISTIVITY: (when normalized @ 25 µm & co-fired with ESL 41010 tape)	≤ 5 mΩ/sq.

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CERMET SILVER CONDUCTOR 903-A

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-A is a silver conductor designed for use as top-layer or inner-layer metallization for use with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	15-25 µm
RESISTIVITY: (when normalized @ 20 µm & co-fired with ESL 41010 tape)	≤ 2 mΩ/sq.

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CERMET SILVER CONDUCTOR 903-B

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-B is a silver conductor designed for use as an inner-layer or ground-plane metallization with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	75±25 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	9-17 µm
RESISTIVITY: (when normalized @ 20 µm & co-fired with ESL 41010 tape)	≤ 2 mΩ/sq.

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CERMET SILVER CONDUCTOR 903-C

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-C is a silver conductor designed for use as solderable top-layer metallization for use with low dielectric constant co-fired ceramic tape. ESL 903-C is used as a post-fired conductor.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	250±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING AT 125°C:	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41110
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	< 15 µm
RESISTIVITY: (when normalized @ 25 µm & post-fired with ESL 41010 tape)	≤ 2 mΩ/sq.
SOLDERED ADHESION:	< 15N

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CERMET SILVER CONDUCTOR 903-D

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-D is a silver conductor designed for use as solderable top-layer metallization for use with co-fired ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	14-18 µm
RESISTIVITY: (when normalized @ 25 µm & co-fired with ESL 41010 tape)	≤ 2 mΩ/sq.

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F: 610-272-6759
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CERMET SILVER CONDUCTOR 903-E

Lead-Free Conductor for Use with Ceramic Tape

ESL 903-E is a silver conductor designed for use as top-layer metallization for use with co-fired and transfer ceramic tape.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±50 Pa·s
BONDING MECHANISM:	Fritless
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

TYPICAL PROPERTIES

FIRED THICKNESS:	< 16-24 µm
RESISTIVITY: (when normalized @ 20 µm & co-fired with ESL 41010 tape)	1.5-2.5 mΩ/sq.

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SILVER PLATINUM CONDUCTOR 953

Lead-Free, Leach Resistant Conductor for Use as Top or Inner-Layer Electrode With Co-Fire Ceramic Tape

ESL 953 is a platinum silver conductor designed for use with ceramic tapes. It can be used with ESL co-fired tapes such as ESL 41020 and provides good adhesion and solderability. This conductor is not for use on 96% alumina substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	200±25 Pa•s
BONDING MECHANISM:	Fritted
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
	5°C/minute rise from room temperature to 425°C, soak for one hour
	then 5°C/minute rise from 425°C to 850°C, soak for 10 minutes, cool naturally
SUBSTRATE OF CALIBRATION:	ESL 41020
	(six layers, pre-laminated)
THINNER:	ESL 401

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TYPICAL PROPERITIES

FIRED THICKNESS (line)	25 ± 3 µm
RESISTIVITY: (when co-fired with ESL 41020 tape)	≤ 6 mΩ/sq.
PRINTING RESOLUTION: (Line/Space)	250 µm x 250 µm
ADHESION: (2mm x 2mm pads**)**	≥ 20 N
SOLDERABILITY:	good

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F: 610-272-6759
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SILVER PALLADIUM CONDUCTOR 963

Conductor for Use as Top or Inner-Layer Electrode With Co-Fire Ceramic Tape

ESL 963 is a silver palladium conductor designed for use as a co-fired top electrode with ceramic tape. ESL 963 may also be used with transfer tape on 96% alumina substrates.

PASTE DATA

RHEOLOGY:	Thixotropic, screen printable paste
VISCOSITY: (Brookfield RVT, ABZ Spindle, 10 rpm, 25.5°C±0.5°C)	175±25 Pa•s
BONDING MECHANISM:	Fritted
SHELF LIFE: (at 25°C)	6 months

PROCESSING

SCREEN MESH/EMULSION:	325/25 µm
LEVELING TIME: (25°C)	5-10 minutes
DRYING: (at 80°C)	10-15 minutes
FIRING:	850°C
SUBSTRATE OF CALIBRATION:	ESL 41010
THINNER:	ESL 401

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TYPICAL PROPERTIES

FIRED THICKNESS: (line)	20±4 µm
RESISTIVITY: (20µm fired thickness, co-fired with ESL 41010 tape)	19±7 mΩ/sq.
PRINTING RESOLUTION: (Line/Space)	250 µm x 250 µm
ADHESION:	≥ 20 N
SOLDERABILITY:	good

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Solder Pastes

3601 NF
80Au:20Sn for use on Au thick films.

EnviroFlo Series
95.5Sn:3.8Ag:0.7Cu Lead free solder paste.

OptiFlo Series
62Sn:36Pb:2Ag Range of no clean solder pastes.

NC-3701-GE SP
62Sn:36Pb:2Ag No clean solder paste.

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GOLD/TIN SOLDER PASTE 3601 NF

Lead-free*

3601 NF is a gold / tin solder paste with excellent wetting properties. It is designed for applications requiring soldering to gold or gold alloy metallisation. On reflow the flux does not char and the residues can be easily removed.

TYPICAL PROPERTIES

Solder Alloy:	80% Au / 20% Sn
Eutectic Temperature:	280°C
Reflow:	320 ± 5 °C (see typical reflow profile on back page)
Particle Size:	-325 / +500 mesh
Viscosity: (ABZ spindle, 10 rpm, 25.5 ± 0.5 °C)	400 ± 50 Pa.s
Solids:	90 ± 2 %
Flux:	Mildly activated
Flux Residue Removal:	IPA, acetone or proprietary cleaning solutions
Shelf Life (20 - 25 °C):	6 months

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Japan: ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
China: ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
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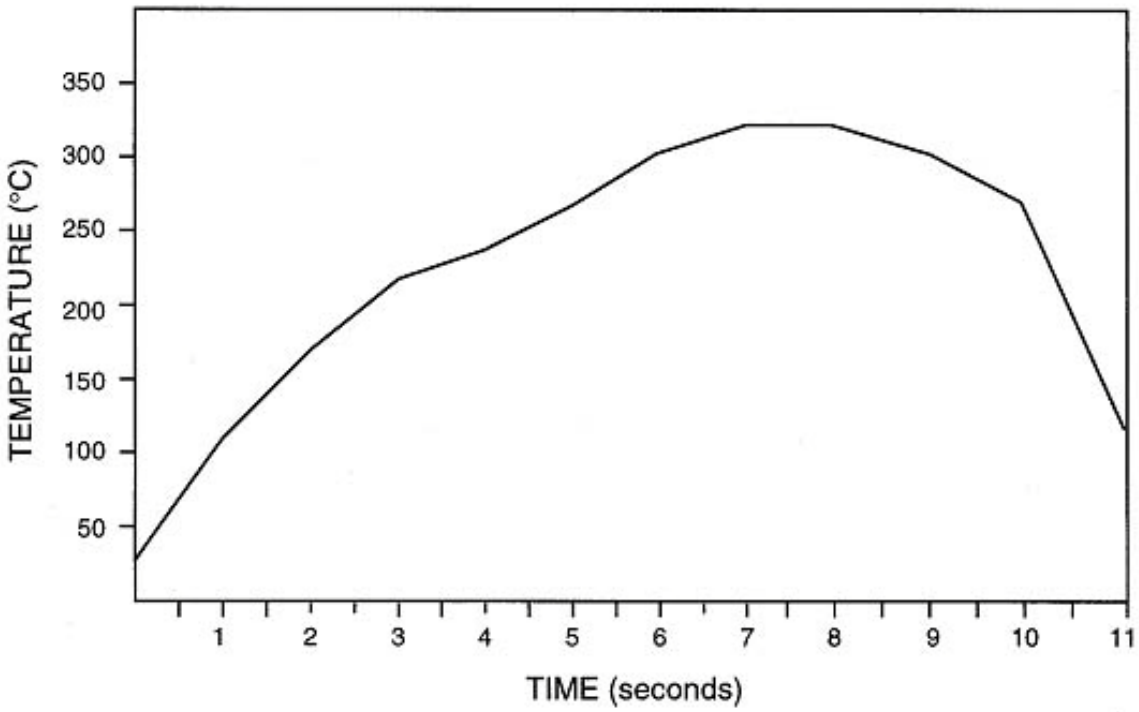
TYPICAL REFLOW PROFILE FOR 3601 NF GOLD-TIN SOLDER



***Complies with RoHS**

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ENVIROFLO™ SERIES
Lead-free Solder Pastes

RoHS COMPLIANT

A well established product designed to meet the demands of the surface mount industry as a reliable replacement for conventional lead solders.

Based on the 95.5Sn/3.8Ag/0.7Cu (SAC387) alloy, 217°C eutectic, EnviroFlo offers superior paste performance exhibiting excellent screen life, printing characteristics, component acceptance, anti-slump and reflow properties. The resin is colophony-free and the clear benign residue may be left on the processed board or removed using commercially available cleaning solvents.

The EnviroFlo™ Series options:

EnviroFlo™ 350: Dispensing range of lead-free solder paste with a viscosity of 350 ± 25 kcps.

EnviroFlo™ & EnviroFlo™ SP: Stencil and mesh screen-printing range of lead-free solder pastes with a viscosity of 725 ± 25 kcps.

RESIDUE PERFORMANCE DATA

Test	Specification	Result
Silver Chromate Paper Test: (Test for Halides)	J-STD-004 / IPC-TM-650	Pass
Copper mirror Test:	J-STD-004 / IPC-TM-650	Pass
Surface Insulation Resistance:	J-STD-004 / IPC-TM-650	Pass
Electro-migration:	J-STD-004 / IPC-TM-650	Pass

Every batch of solder paste manufactured by ESL is screen-printed, populated with live components and reflowed using a 4 zone convection oven for product testing before final QA inspection.

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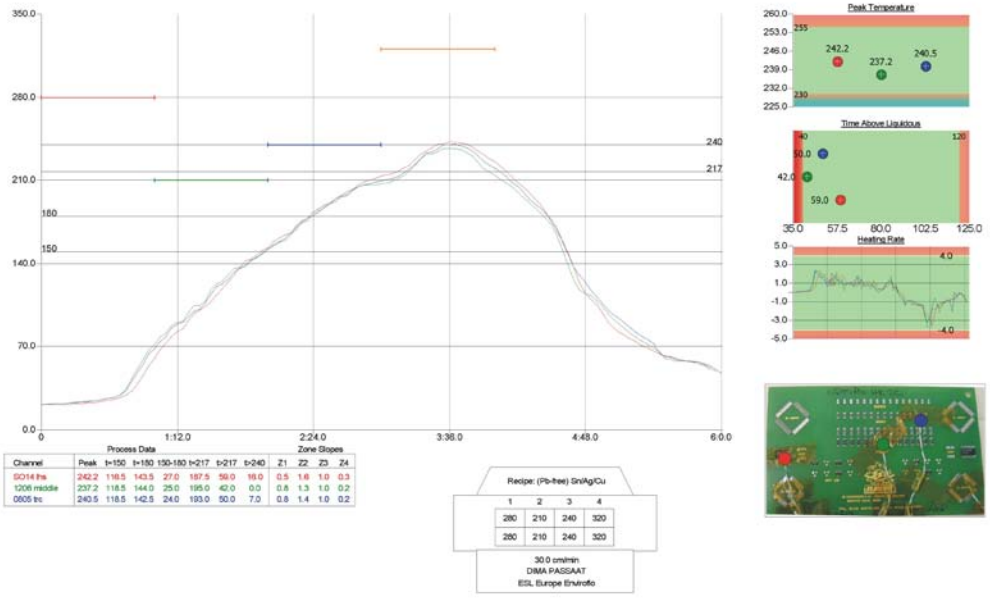
PASTE DATA: **Alloy:** SAC (95.5Sn / 3.8Ag / 0.7Cu) - 90% nominal solids
Particle Size: 25 - 45 microns (Type 3)
Packaging: 500g or 1000g Jars, Green Semco Cartridges and 800g ProFlow™ Cassettes
Storage: 4°C - 20°C - May be refrigerated - Paste will need to be taken out of the fridge at least 4 hours before use.
Viscosity: 725 ± 25 kcps
Shelf Life (at 20°C): 6 months

PRINTING: **Screen:** Recommended 120 microns thick, electro-formed, laser cut stencil with 5 - 15% reduction in aperture compared to pad area to eliminate mid-chip beading.
Print speed: 20 - 100 mm/sec
Screen-life: > 8 hours @ 19 - 28 °C
Tack time: > 24 hours @ 19 - 28 °C

REFLOW: A standard reflow profile is shown. This is used to test EnviroFlo™ paste. The following guidelines are used:
Ramp up: 0.5 - 2.5 °C / sec.
Liquidus: Hold above 217°C for between 40 and 120 seconds (typically 15 - 35 °C above liquidus).
Cool down: 2 - 5 °C / sec.

CLEANING: Not usually required but populated boards can be cleaned in commercially available solvents.



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ESL EUROPE
SOLDER PASTES & THICK-FILM MATERIALS
8 COMMERCIAL ROAD
READING, BERKSHIRE, RG2 0QZ, UK
T: +44 (0) 118 918 2400
F: +44 (0) 118 986 7331
www.solderpaste.co.uk

NO CLEAN SOLDER PASTE NC-3701-GE SP

GE Flux Has Been Independently Tested To Meet The Bellcore Specification

NC-3701-GE SP is a no-clean RMA solder paste. The paste can be screen printed up to speeds of 200 mm/sec and reflowed according to ESL's standard solder paste processing procedures. Reflowing results in shiny solder joints with a small amount of a hard, clear, benign residue that requires no removal. The rheology is suitable for fine pitch applications. The screened paste exhibits excellent tack properties and anti-slump characteristics. Before use, gentle stirring is recommended for 15 seconds.

PASTE DATA

Solder Alloy: (Meets QQ-S-571-E specifications)	62%Sn / 36%Pb / 2% Ag
Particle Size:	-325 / +500 mesh
Rheology:	
Viscosity: (TF spindle, 5 rpm, 25.5 ± 0.5 °C)	775 ± 25 Pa.s
Solids:	90 ± 0.5 %
Shelf Life: (3 - 20°C, may be refrigerated)	6 months
Flux:	Rosin mildly activated

TECHNICAL DATA

Test	Specification	Result
Silver Chromate Paper Test: (Test For Halides)	Bellcore TR-NWT-000078 IPC-TM-650	No colour change
Copper Mirror Test:	Bellcore TR-NVVT-000078 (no breakthrough)	Type L IPC-TM-650
Surface Insulation Resistance:	TR-NWT-000078	1.39×10^{12} (after 96 hrs) 35°C/85% R.H

Visual examination - no evidence of Blue-Green corrosion and dendritic growth was observed on patterns

Electro-migration:	Bellcore TR-NWT-000078	85°C / 85% R.H 2.10×10^{10} (after 500 hrs)

Visual examination - no evidence of electro-migration on test samples

ESL Worldwide
U.S.A: ESL Electro-Science • 416 East Church Road • King of Prussia • PA 19406-2625 • U.S.A • Tel: +1 610-272-8000 • Fax: +1 610-272-6759 • Sales@ElectroScience.com
Japan: ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp
China: ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338 ESLChina@sh.cnuninet.net

See Caution and Disclaimer on other side.

TYPICAL PROPERTIES

(175 ± 25 µm wet print thickness)

Approximate Coverage:	12.5 cm^2 / g
Printing Resolution: (line / space)	0.400 mm / 0.400 mm
Screen time:	> 8 hours
Tack Time:	> 30 hours
Packaging:	500 - 1000 grams in jars 500 - 1000 grams in cartridges

PROCESSING:

Screen Mesh, Emulsion:	80 S/S, 150 - 200 µm
Stencil Material, Thickness:	laser cut, nickel formed, etched S/S, 150 - 200 µm
Reflow Temperature:	Standard reflow profiles used for RMA pastes are appropriate. This paste is designed to be reflowed in air, but it may also be reflowed in N_2.
Flux Removal:	Not required. Note: If cleaning is desired; residue can be removed using standard flux solvent or saponifier cleaning methods.
Thinner:	ESL 401

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OPTIFLO ™ Series

NO CLEAN SOLDER PASTE

H-SERIES

A paste family suitable for high performance fine pitch applications, developed by ESL Europe to give the widest possible process window for general-purpose surface mount applications. OptiFlo™ H series solder pastes are available in several alloys with a range of flux chemistries, rheology and solids options allowing ESL to engineer the OptiFlo™ H series solder pastes to meet your specific needs.

Features	Benefits
Fine pitch printing at 0.4mm or less	*- suitable for all SMT designs*
Long screen and tack life	*- improved process window*
No slump at ambient (15-25°C)	*- improved process window*
No hot slump at 150°C	*- improved process window*
Reduction in mid chip beading	*- less rework/wider process window*
Low volume residues	*- optimised inspection*
Clear residues	*- excellent cosmetics*
Reduced viscosity/temp change	*- improved process window*
Low VOC content: (less than 1%)	*- minimal environmental impact*
Refrigeration possible	*- extended shelf life.*

The OptiFlo™ Series options:

H-2 Outstandingly long stencil and screen life, developed to minimise the tendency to "dry out" on the stencil, plus a very long wet tack life. Added benefits include a wide application process window and good hot slump resistance. Suitable as a no-clean or cleanable solder paste and available in a range of viscosities, High (HV), Medium (MV) and Low (LV), so ESL can meet your optimum processing requirements.

H-5 LS Low solids residue, no clean flux residue with superb cosmetics that are clear and non-sticky. Yet can be penetrated by test probes for ATE. Good stencil life, withstanding high temps up to 32°C. Outstanding tack life for delayed printing. Excellent delayed reflow performance 48 hrs after printing.

H-K Lower viscosity, typically 700 – 750 kcPs, excellent rheology. Suitable for conventional and high speed printing including closed head pressure printing systems coupled with a wide application process window for conventional printing.

Further developments are continually evolving. Contact ESL Europe for latest news and improvements

ESL Worldwide
U.S.A: ESL Electro-Science • 416 East Church Road • King of Prussia • PA 19406-2625 • U.S.A • Tel: +1 610-272-8000 • Fax: +1 610-272-6759 • Sales@ElectroScience.com

Japan: ESL Nippon • Sukegawa Bldg. • 6th floor • 3-4 Yanagibashi 1-chome • Taito-ku • Tokyo 111, Japan • Tel: +81-3-3864-8521 • Fax: +81-3-3864-9270 • Sales@ESL-Nippon.co.jp

China: ESL China • Room #1707, Tower A, City Center of Shanghai • 100 Zunyi Road • Shanghai, China 200051 • Tel: +86-21-6237-0336 and 0337 • Fax: +86-21-6237-0338
ESLChina@sh.cnuninet.net

See Caution and Disclaimer on other side.

PASTE DATA

Solder Alloy:		62% Sn / 36% Pb / 2% Ag
(Meets national & international specifications)		63% Sn / 37% Pb
		Others available on request
Particle Size:		-325 / +500 mesh (45 - 20 microns)
		Others available on request
Viscosity:		Can be engineered to suit most applications
(Brookfield TF Spindle, 5 rpm, 25.5°C ± 0.5 °C)		Typically in the range 600 – 1000 Pa.s
Solids:		Typically in range 88 - 90.5 %
Slump: (ambient 10 - 25 °C)		No loss of definition at 0.4 mm pitch
Hot Slump: (at 150 °C)		No loss of definition at 0.4 mm pitch
Shelf Life:	(15 °C - 25 °C)	Ambient, typically 3 months
	(Refrigerated)	Refrigerated up to 6 months

TYPICAL PROPERTIES

(175 ± 25 µm wet print thickness)

Approximate Coverage:	12.5 cm^2 / g
Printing Resolution: (line / space)	Better than 0.400 mm / 0.400 mm
Screen time:	Up to 10 hours
Tack Time:	Up to 72 hours
Packaging:	250 - 1000 grams in jars
	500 - 1000 grams in cartridges

PROCESSING

Screen Mesh, Emulsion:	80 S/S, 150 - 200 µm
Stencil Material, Thickness:	laser cut, nickel formed, etched S/S, 150 - 200 µm
Reflow Temperature:	Standard reflow profiles used for RMA pastes are appropriate. Although this paste is designed to be reflowed in air, it may also be reflowed in N_2.
Flux Removal:	Not required. Note: If cleaning is desired; residue can be removed using standard flux solvent or saponifier cleaning methods.
Thinner:	Not recommended

RESIDUE PERFORMANCE DATA:

Test	**Specification**	**Result**
Silver Chromate Paper Test:		
(Test for Halides)	J-STD-004 / IPC-TM-650	Pass
Copper mirror Test:	J-STD-004 / IPC-TM-650	Pass
Surface Insulation Resistance:	J-STD-004 / IPC-TM-650	Pass
Electro-migration:	J-STD-004 / IPC-TM-650	Pass

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