DUPONT™ LFX0A SERIES

LEAD FREE RESISTOR COMPOSITIONS

All values reported here are results of experiments in our laboratories intended to illustrate product performance potential with a given experimental design. They are not intended to represent the product's specifications.

Product Description

The DuPont™ LFx0A resistor series has been proven to have excellent performance properties for hybrid applications. Designed to give an ideal balance of properties, this lead-free(Pb)* and cadmium(Cd)-free* resistor series is fully blendable between adjacent members.

Product Benefits

- Resistors are compatible with Pb-free conductors
- Lead free* and Cadmium free*
- Excellent ESD Stability
- Good power handling stability
- Reach compliant

Processing Features

- Thin printing 12 micron dried thickness
- Fast firing –850°C/30 minute profile
- Narrow TCR gaps
- Linear blend behavior

*Lead and Cadmium "free" as used herein means that these are not intentionally added to the referenced product. Trace amounts however may be present.

Recommended Processing Conditions

Substrates

Reported properties are based on tests with 96% alumina substrates. Substrates of other compositions may yield variation in performance properties.

Termination

DuPont LFx0A resistors were designed for use with high silver-containing Pb-free terminations. Reported properties are based on tests using LF171 Ag/Pt and LF121 Ag/Pd conductor terminating materials. Similar performance properties have been observed with other DuPont gold and silver-bearing conductors, however using different terminations may result in a shift of resistance and TCR values.

Printing

Properties are based on resistors printed to 12 ±2µm dried thickness. A 325 mesh stainless steel screen with 10-15 um emulsion is recommended. Each composition must be thoroughly mixed before use. This is best achieved by slow, gentle, hand-stirring with a clean flexible burr-free spatula (plastic) for .5-1 minute.

Thinner

DuPont LFx0A Series has been optimized for screen printing and thinning is not normally required or recommended. DuPont 8250 thinner may be added sparingly to compensate for evaporative losses.

Drying

Allow prints to level at room temperature for 5-10 minutes, then dry at 150°C for 10-15 minutes in a well-ventilated oven.

Firing

Properties are based on a 30 minute firing cycle (100°C -100°C) with 10 minutes at a peak temperature of 850°C. Sample profile is shown in Figure 1.

Blending

There are two 10K Ohm blend members. Composition LF40A is to be blended with the lower 1k Ohm member LF30A, while composition LF49A is to be blended with the higher 100k Ohm member LF59A. Only adjacent members are blendable.

Encapsulation

QQ620 is the recommended Pb-free encapsulant material that may be used to provide mechanical protection from extreme environments. QQ620 is recommended to be screen printed and fired over the pre-fired resistor prior to laser trimming.

Laser Trimming

Please see Table 1 for recommended laser trim parameters. Use of encapsulant will improve trim stability performance of certain decade members.

Table 1 Laser Trimming

Resistor	Power	Q-Rate	Bite Size
1Ω	P=2.0 W	QR=3000	BS=150
10Ω	P=2.0 W	QR=3000	BS=150
100Ω	P=2.0 W	QR=3000	BS=200
1k	P=2.0 W	QR=4000	BS=200
10k	P=2.0 W	QR=3000	BS=150
10k	P=2.0 W	QR=3000	BS=150
100k	P=2.0 W	QR=3000	BS=200
1 MΩ	P=2.0 W	QR=5000	BS=200
10 MΩ	P=2.0 W	QR=3000	BS=150

Storage and Shelf Life

Containers should be stored, tightly sealed, in a clean, stable environment at room temperature (<25°C). Shelf life of material in unopened containers is six months from date of shipment. Some settling of solids may occur and compositions should be thoroughly mixed prior to use.

Safety and Handling

For Safety and Handling information pertaining to this product, read the Material Safety Data Sheet (MSDS).

Composition Properties

Viscosity (PaS) (Brookfield HAT, UC&Sp [SC4-14/6R], 10 rpm, 25°C ± 0.2°C)	150-240
Thinner	8250
Shelf Life (months)	6

Fired Properties – Glazed with QQ620

Fired Properties[1]

	LF01A	LF10A	LF20A	LF30A	LF40A	LF49A	LF59A	LF69A	LF79A
Resistance (Ω/sq)	1	10	100	1K	10K	10K	100K	1M	10M
HTCR[2] (ppm/C)	±100	±100	±100	±100	±100	±100	±100	±100	±100
CTCR[2] (ppm/C)	±100	±100	±100	±100	±100	±100	±100	±100	±100
Quan-tech Noise (dB)	–14.7	–22.6	–36.9	–26.0	–14.7	–15.5	–12.6	–10.2	—
STOL[3] (V/mm)	15	9.5	30	91	264	257	450	>630	>630
SWV[4] (V/mm)	6	3.8	12	36.4	105.6	102.8	180	252	252
MRPD[5] (mW/mm2)	20721	804	962	886	746	707	215	57.4	0.8
ESD (%ΔR after 1x5kV pulse)	N/A	N/A	<.01	–0.1	–2.5	–2.0	–1.1	–.1	N/A

Test Procedure

[1] Typical fired properties are based on the following:

- Termination: LF171 Ag/Pt
- Dry Thickness: 12 ± 2µm
- Resistor geometry: 1.0mm x 1.0mm
- Firing: 30 minute cycle 850°C peak for 10 minutes.
- Substrate: 96% alumina
- Resistance and TCR, Quan-tech Noise, and ESD are measured on untrimmed resistors.

[2] Temperature Coefficient of Resistance in PPM/°C measured 25°C to 125°C (Hot TCR) and 25°C to –55°C (cold TCR). NOTE: To obtain ±100 ppm/C, LF01A is measured using 8 squares.

[3] STOL: Short Time Overload Voltage (V/mm); Voltage required in a 5 second duration to induce a resistance change of 0.25%, at 25°C, in a 1mmx1mm resistor trimmed to 1.5x fired value with a single plunge cut. NOTE: 630 volts is the equipment limit.

[4] SWV: Standard Working Voltage = 0.4x short term overload voltage

[5] MRPD: Maximum Rated Power Dissipation = (standard working voltage)²/trimmed resistance

ESD measured on 1mm x 1mm resistors untrimmed pulsed 1x2kV and 1x5kV on same resistor

Fired Properties – [Unglazed]

Preliminary Fired Properties[1]

	LF01A	LF10A	LF20A	LF30A	LF40A	LF49A	LF59A	LF69A	LF79A
Resistance (Ω/sq)	1	10	100	1K	10K	10K	100K	1M	10M
Shipping specification	80-1.20	8.0-12.0	80.0-120	800-1.2k	12.0-18.1k	7.11k-11.9k	80k-120k	0.80k-1.20M	8.0k-12.0M
HTCR[2] (ppm/C)	±100	±100	±100	±100	±100	±100	±100	±100	±100
CTCR[2] (ppm/C)	±100	±100	±100	±100	±100	±100	±100	±100	±100
Quan-tech Noise (dB)	–14.5	–22.5	–34.1	–26.3	–14.1	–15.4	–13.3	–9.4	—
STOL[3] (V/mm)	2	9.5	30	105	188	180	175	142	230
SWV[4] (V/mm)	0.8	3.8	12	42	75	72	70	57	92
MRPD[5] (mW/mm2)	371	803	958	1448	403	345	32	2.8	4.4
ESD (%ΔR after 1x5kV pulse)	–0.21	–0.02	0.001	–0.13	–1.82	–1.69	–0.63	–0.04	–0.04

Test Procedure

[1] Preliminary fired properties are based on the following:

- Termination: LF171 Ag/Pt
- Dry Thickness: 12 ± 2µm
- Resistor geometry: 1.0x1.0 mm
- Firing: 30 minute cycle 850°C peak for 10 minutes.
- Substrate: 96% alumina
- No encapsulation
- Resistance and TCR, Quan-tech Noise, and ESD are measured on untrimmed resistors.

[2] Temperature Coefficient of Resistance in PPM/°C measured 25°C to 125°C (Hot TCR) and 25°C to –55°C (cold TCR).

[3] STOL: Short Time Overload Voltage (V/mm); Voltage required in a 5 second duration to induce a resistance change of 0.25%, at 25°C, in a 1mmx1mm resistor trimmed to 1.5x fired value with a single plunge cut.

[4] SWV: Standard Working Voltage = 0.4x short term overload voltage

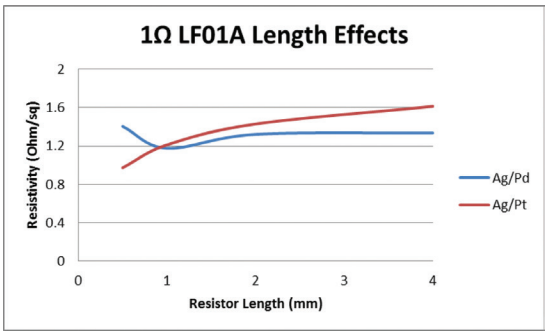
[5] MRPD: Maximum Rated Power Dissipation = (standard working voltage)^2/resistance

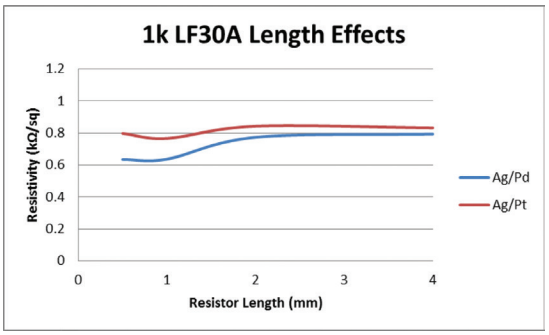
ESD measured on 1mm x 1mm resistors untrimmed pulsed 1x2kV and 1x5kV on same resistor

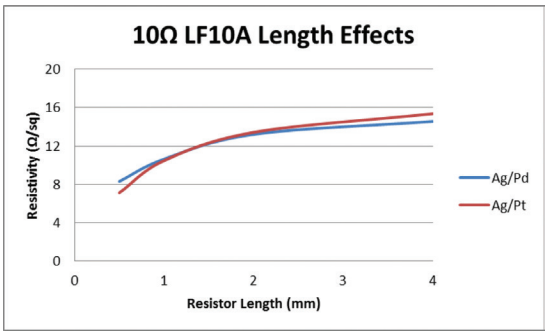
Resistor Termination Dependence

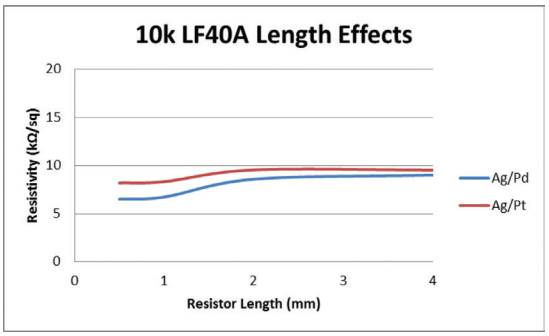
(Length Effect Curves) Resistivity

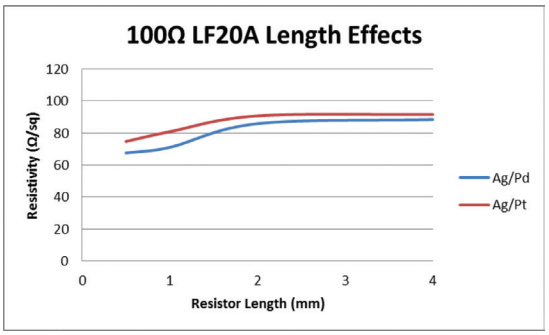
Data based on 1.0 mm width resistors with DuPont LF121 3:1 Ag/Pd and DuPont LF171 Ag/Pt Pb-free terminations

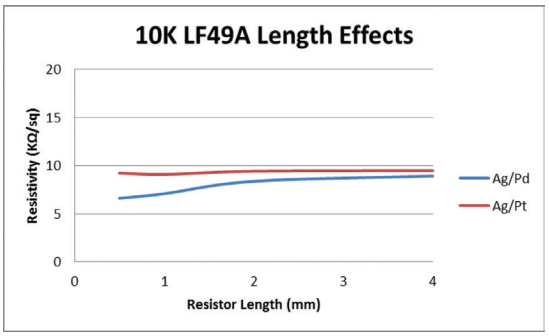


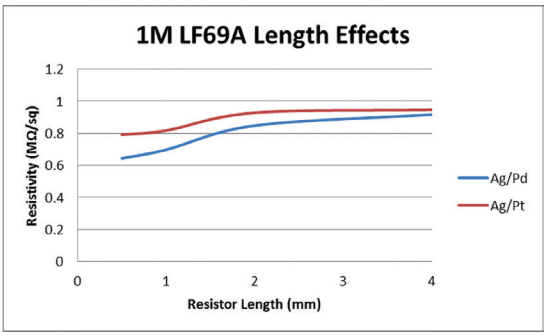


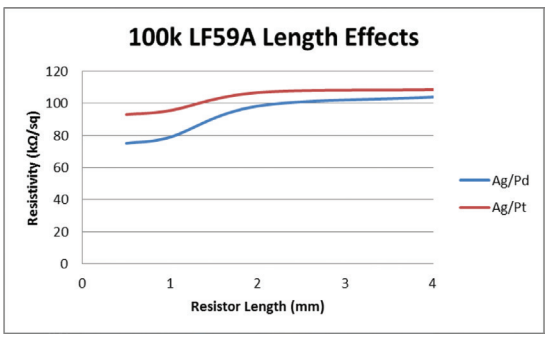


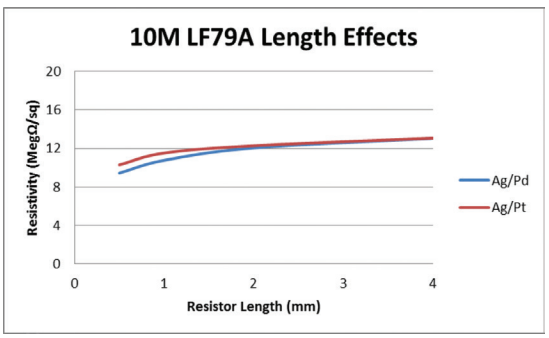








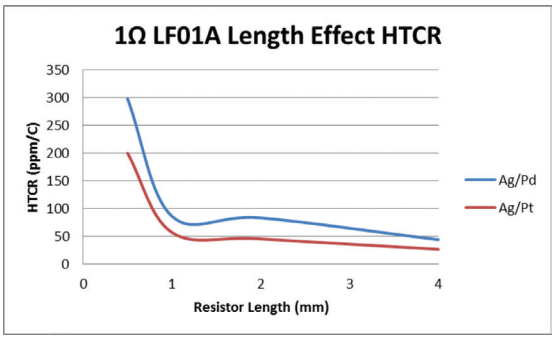


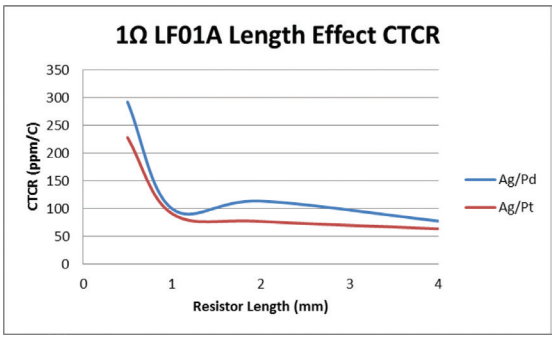


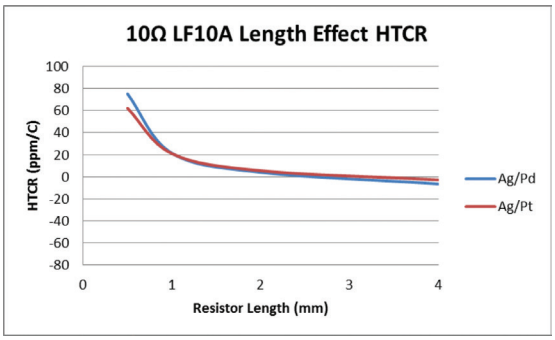
Resistor Termination Dependence

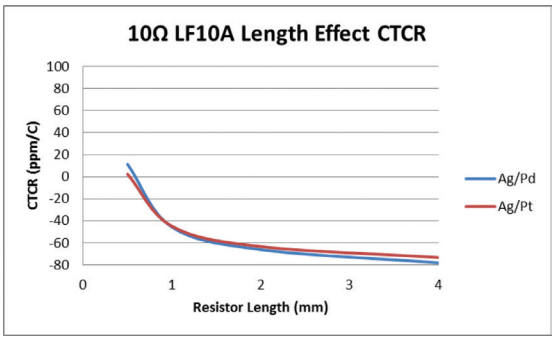
(Length Effect Curves) Hot & Cold TCR

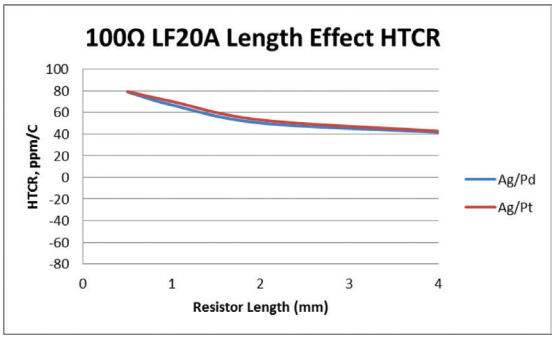
Data based on 1.0 mm width resistors with LF121 Ag/Pd and LF171 Ag/Pt Pb-free terminations

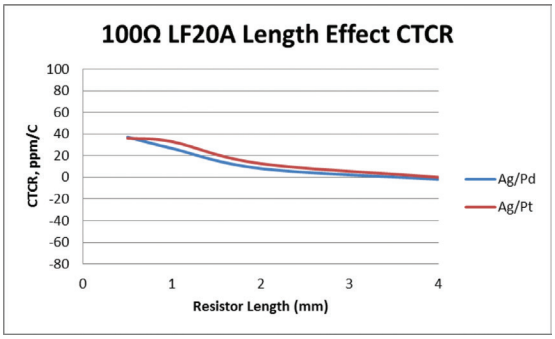


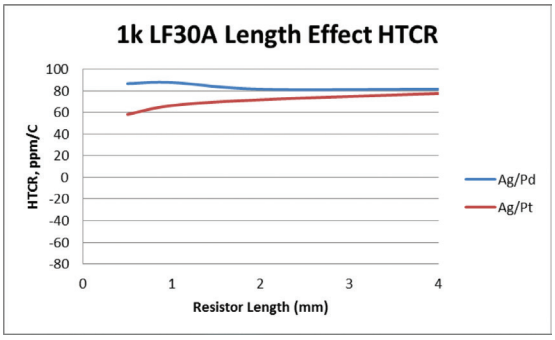


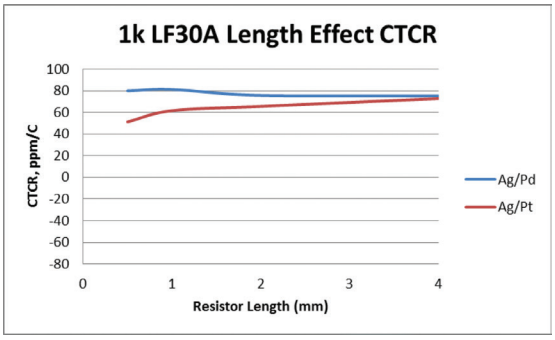


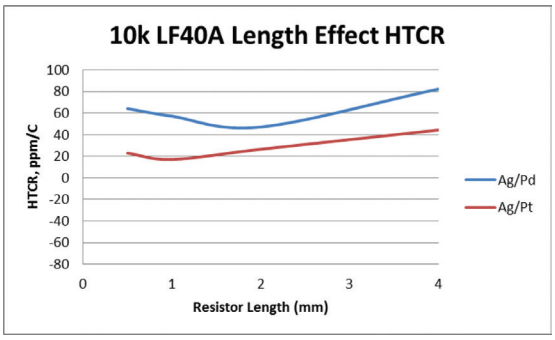


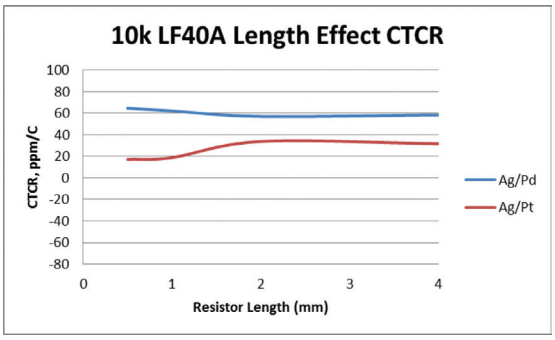








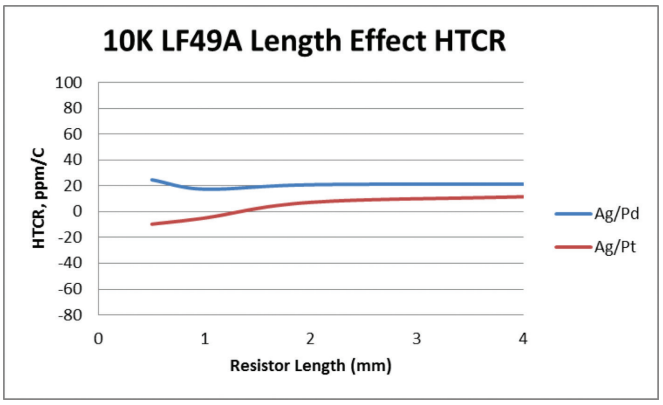


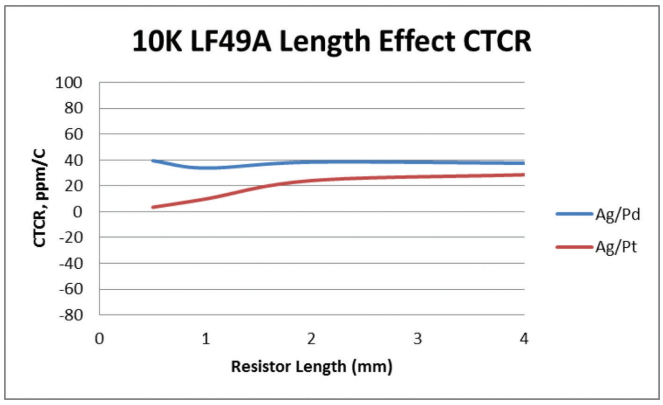


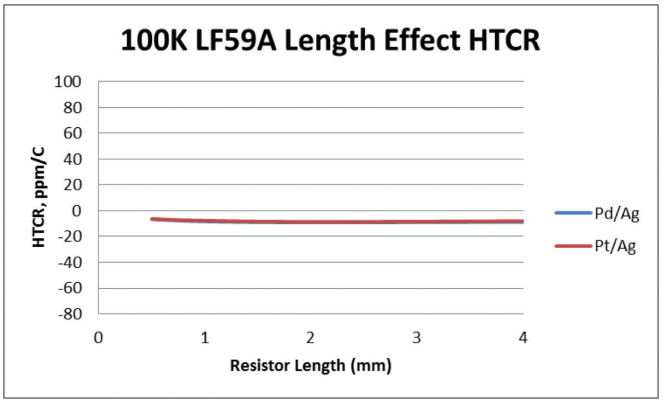
Resistor Termination Dependence (continued)

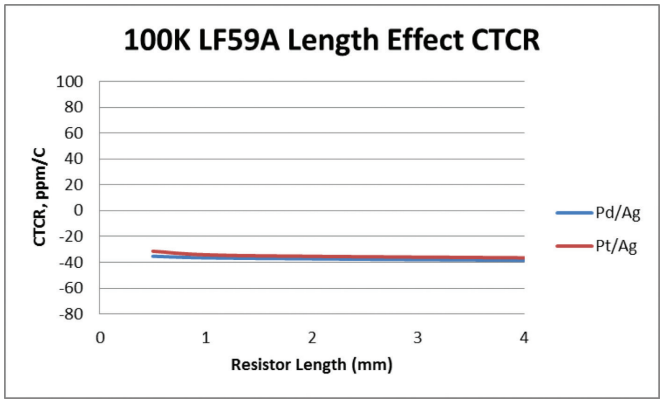
(Length Effect Curves) Hot & Cold TCR

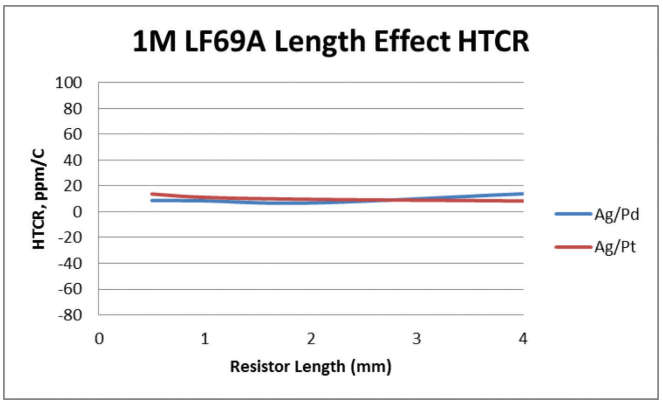
Data based on 1.0 mm width resistors with LF121 Ag/Pd and LF171 Ag/Pt Pb-free terminations

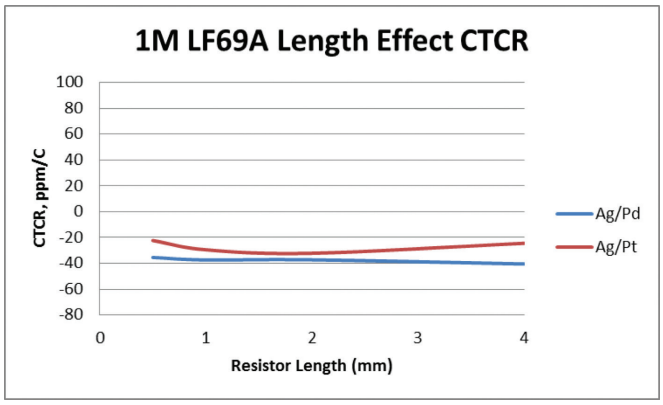


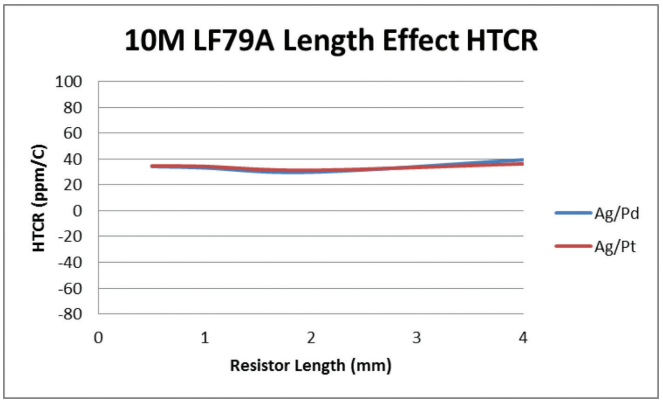


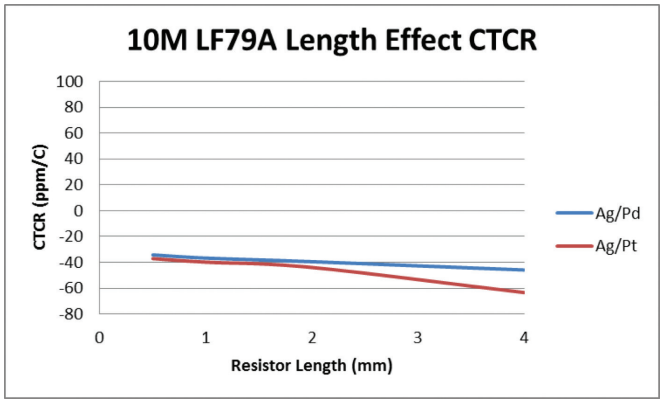






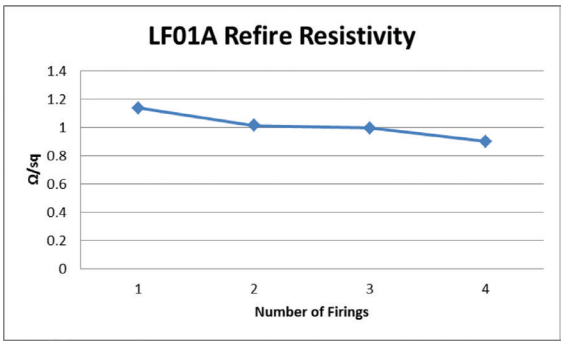


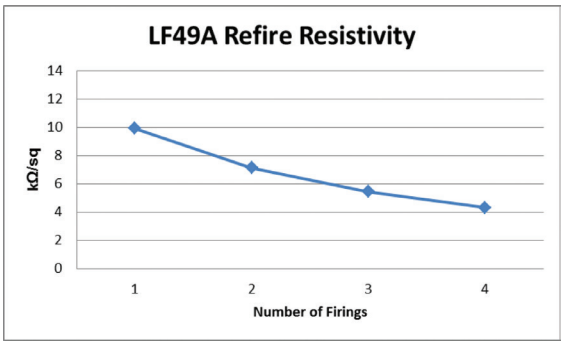


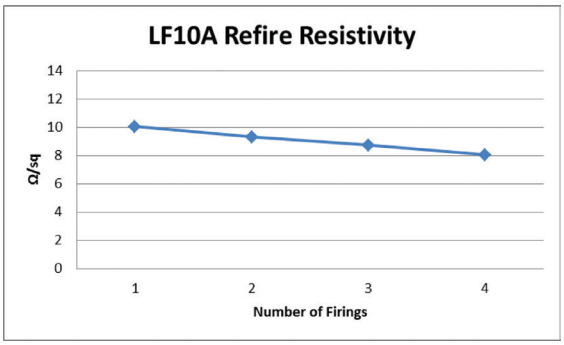


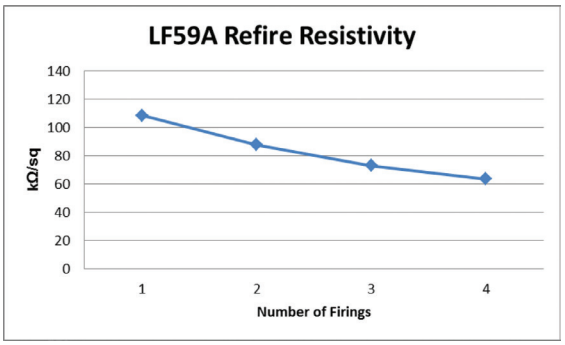
Refire Behavior

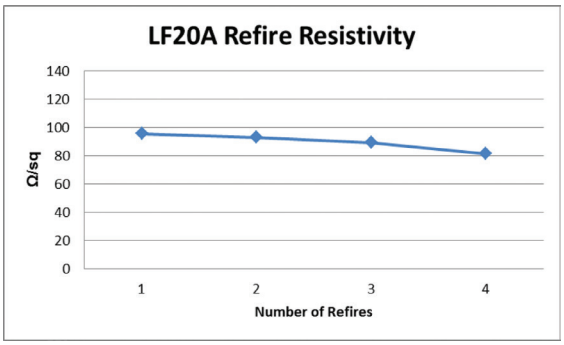
Data measured on 1.0x1.0 mm resistors on LF171 Ag/Pt Pb-free conductor terminations

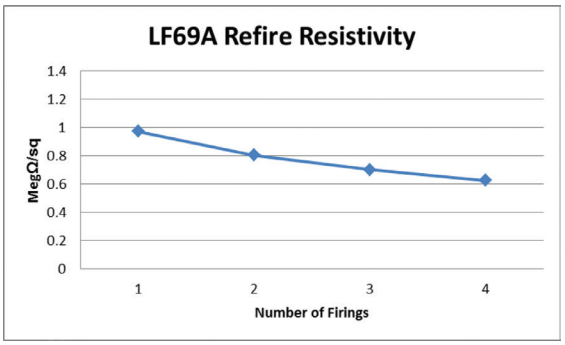


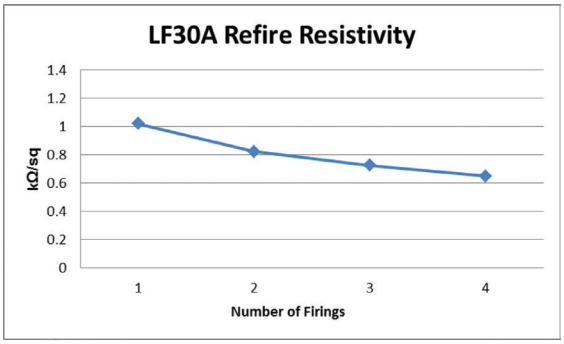


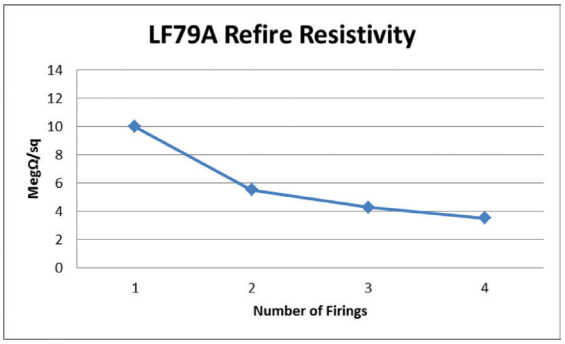


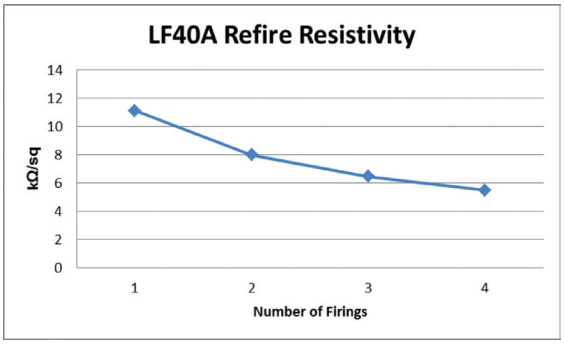






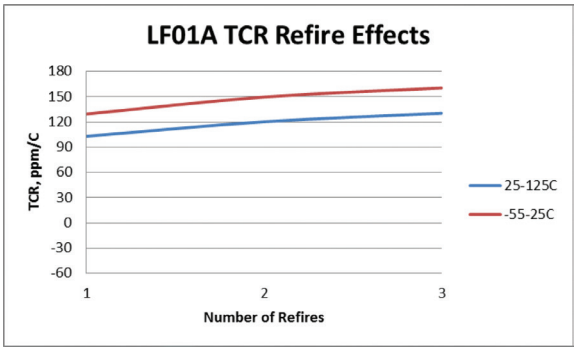


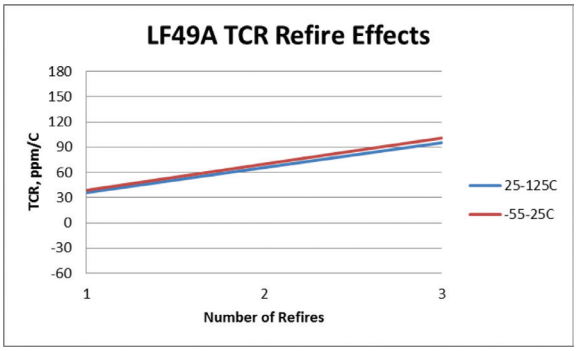


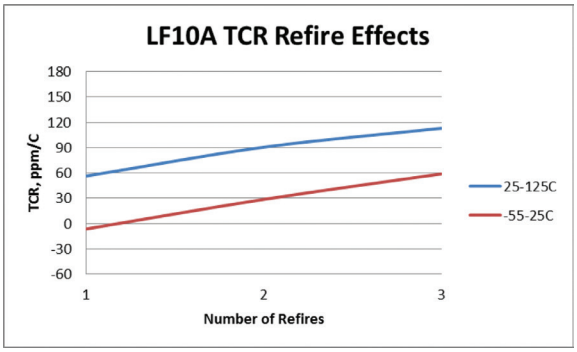


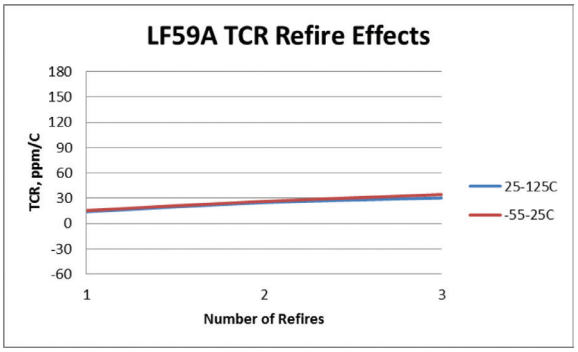
TCR Refire Effects

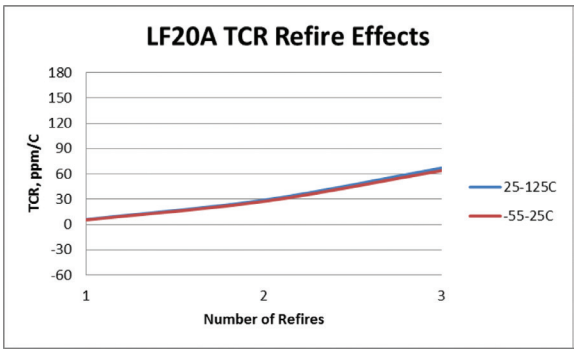
Data measured on 1.0x1.0 mm resistors with Pb-free LF171 Ag/Pt terminations

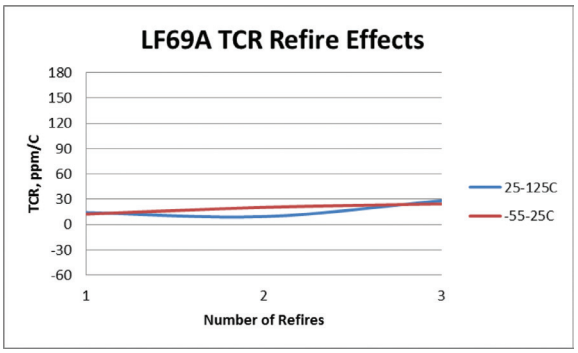


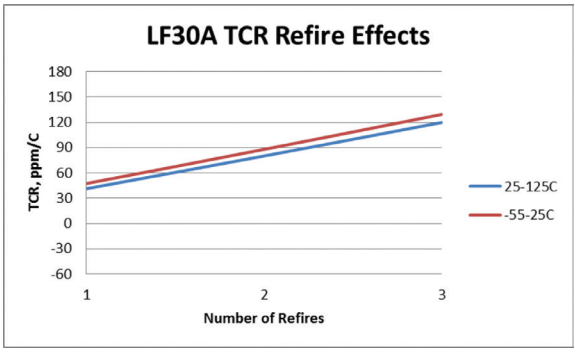


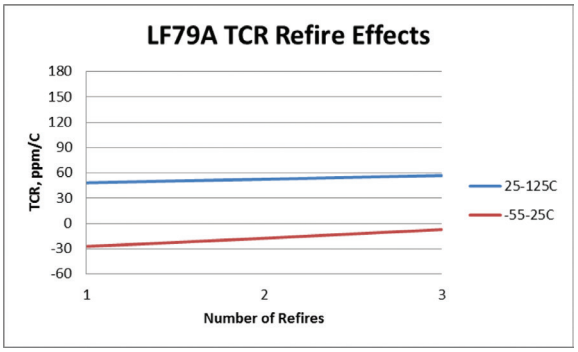


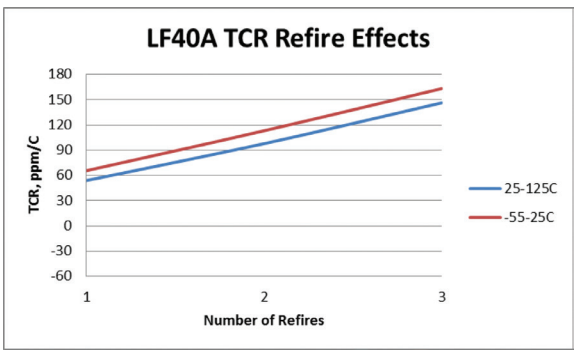






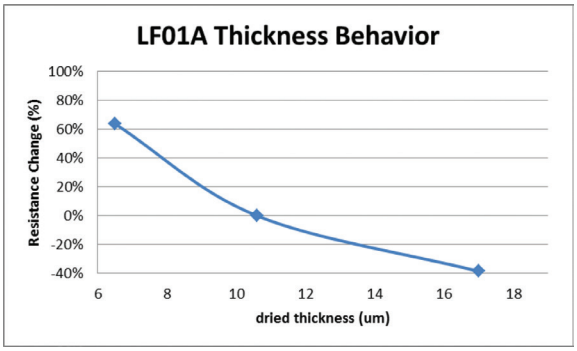


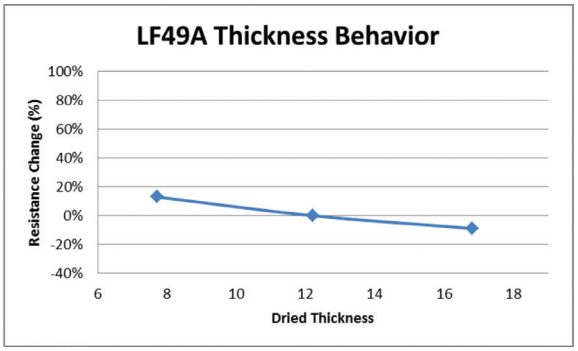


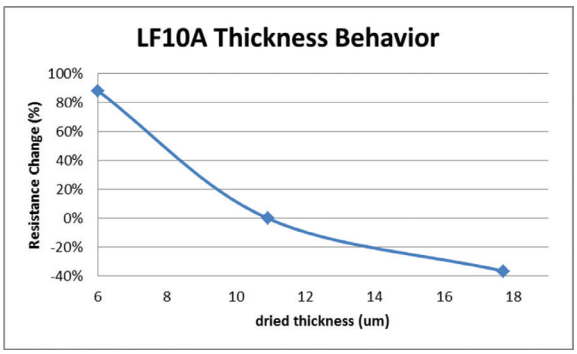


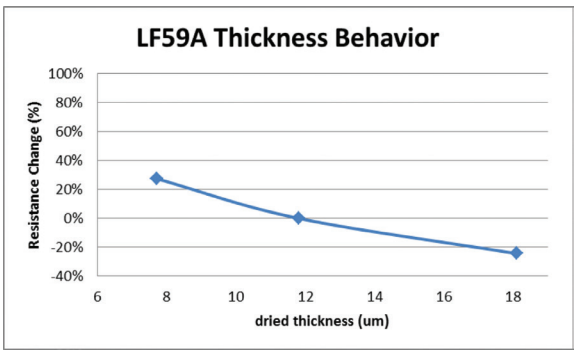
Thickness Behavior – Resistivity

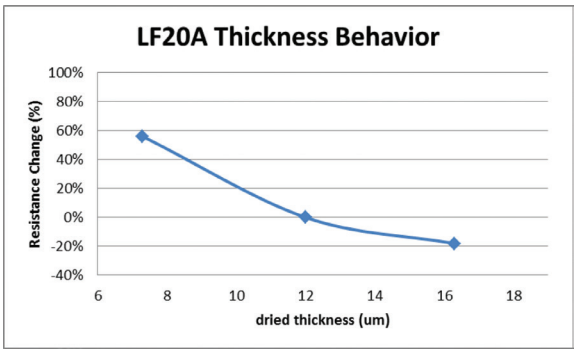
Data measured on 1.5x1.5 mm resistors with Pb-free Ag/Pt terminations

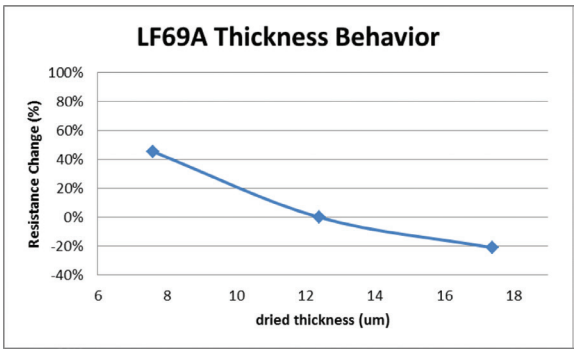


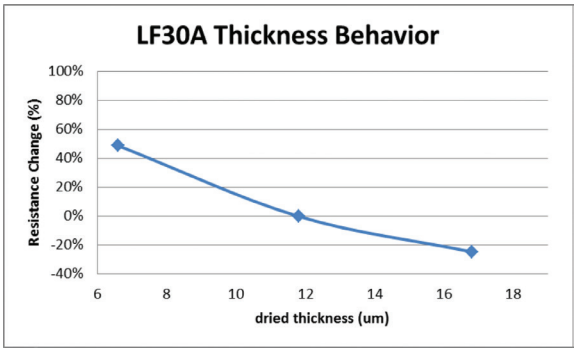


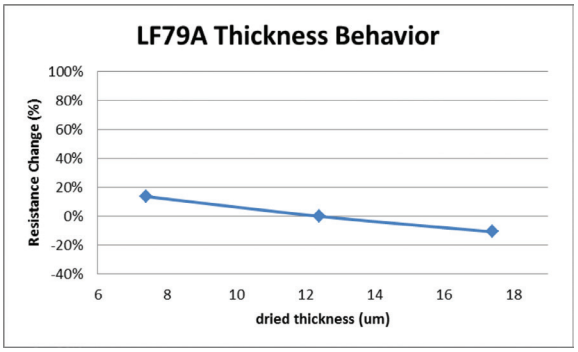


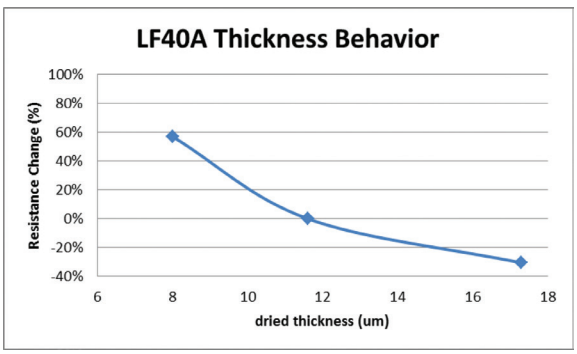






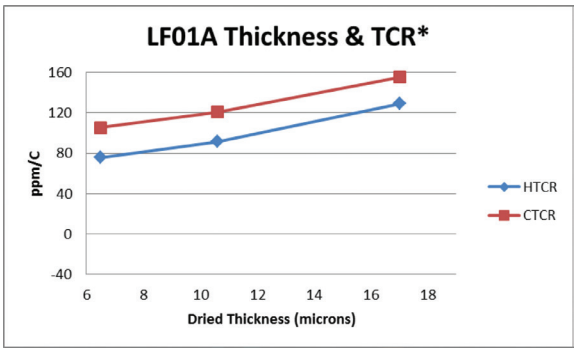


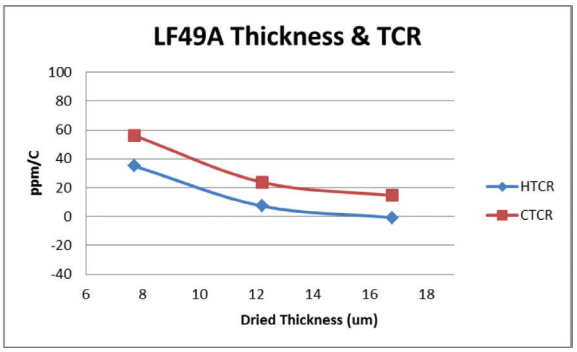


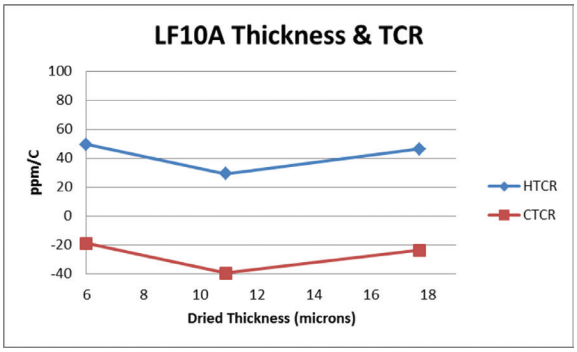


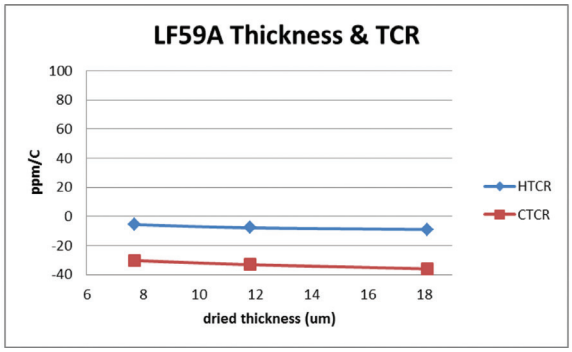
Thickness Behavior – TCR

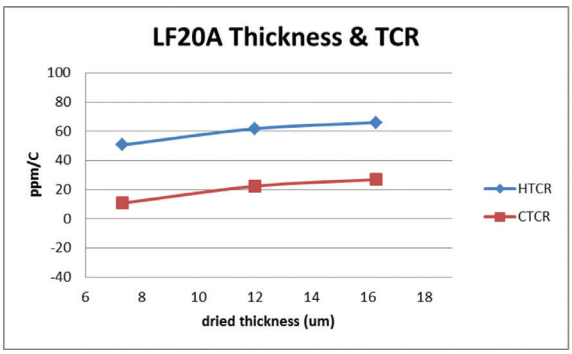
Data measured on 1.5x1.5 mm resistors with Pb-free Ag/Pt terminations

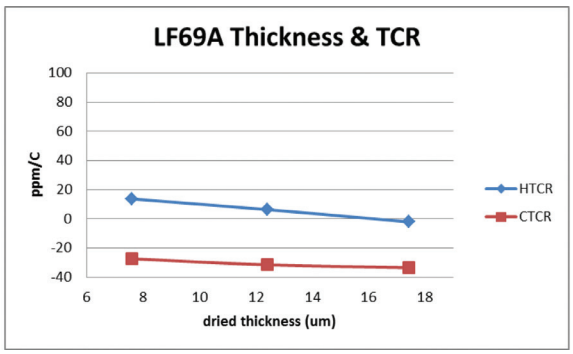


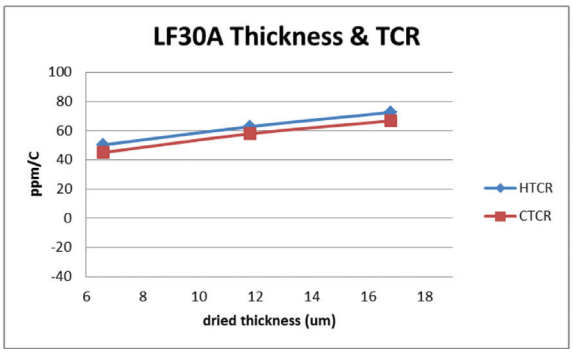


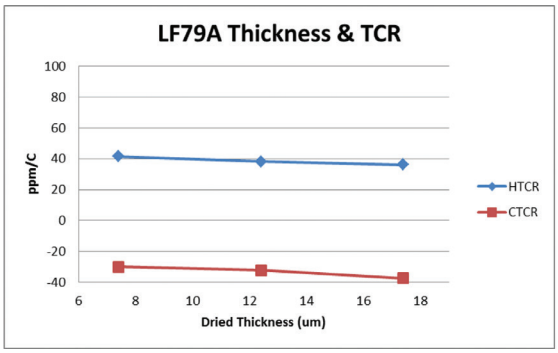


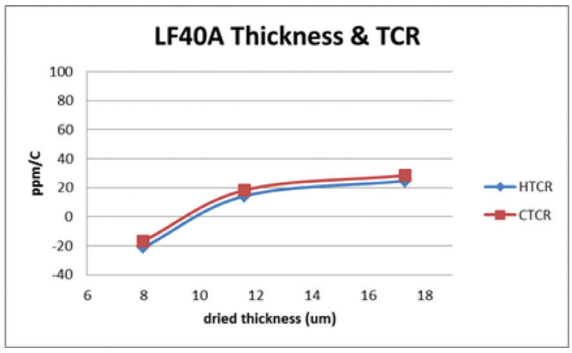










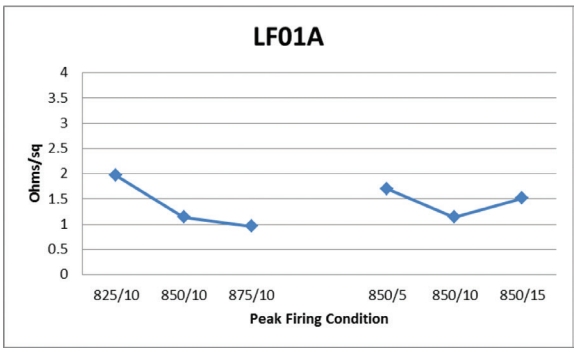


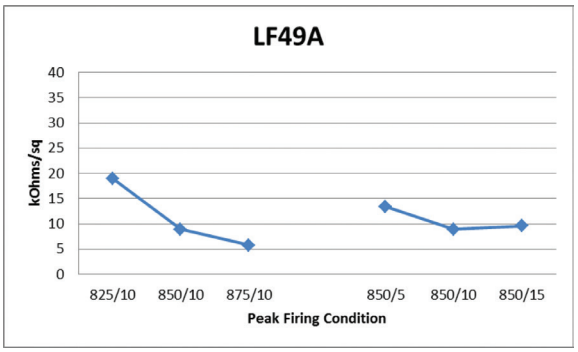
*LF01A charted data measured using 1 square resistor. QC is tested using 8 squares pattern to compensate for termination influence.

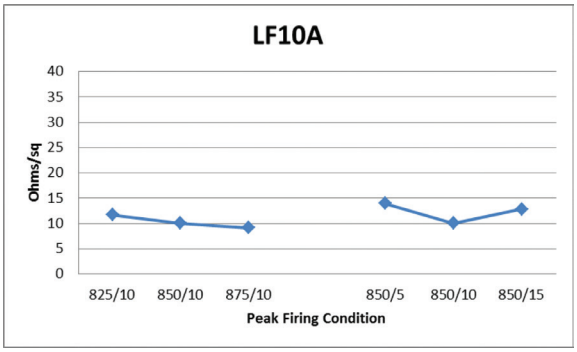
Sensitivity to Firing Conditions

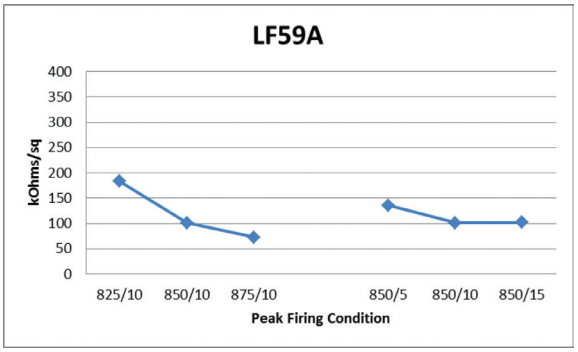
(Resistivity VS Peak Temperature and Time at Peak)

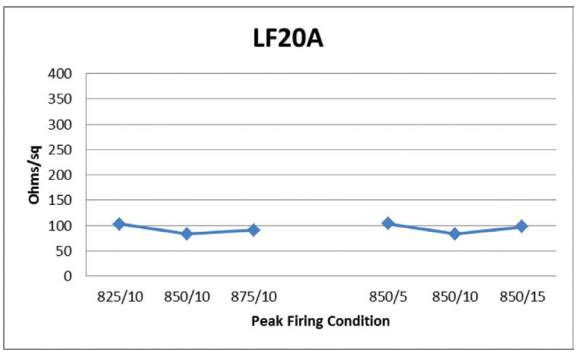
Data based on 1.0x1.0 mm resistors with Pb-free LF171 Ag/Pt terminations

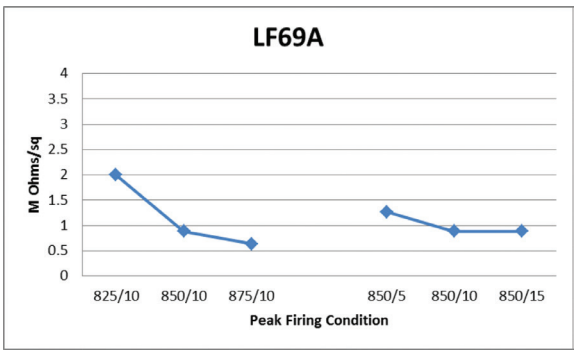


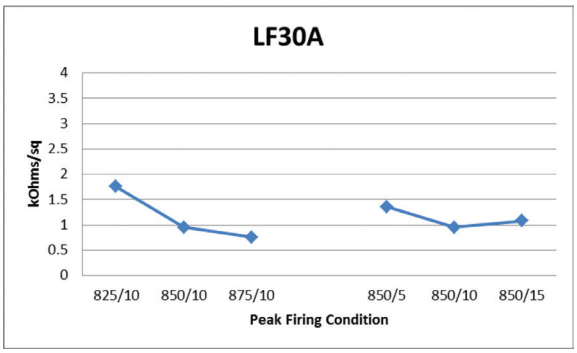


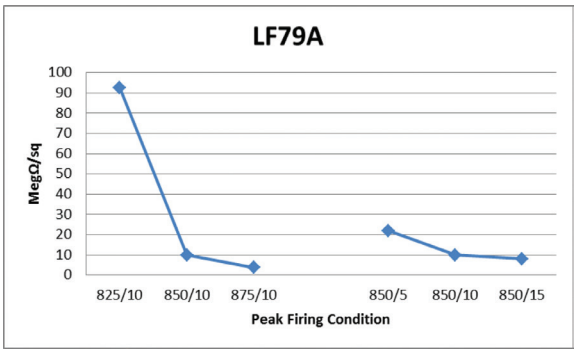


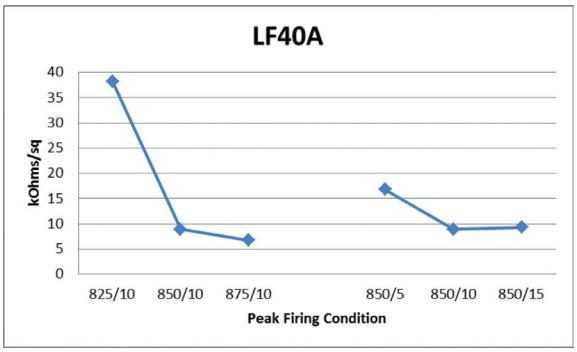








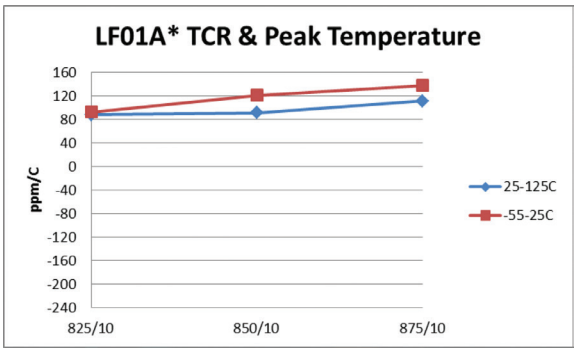


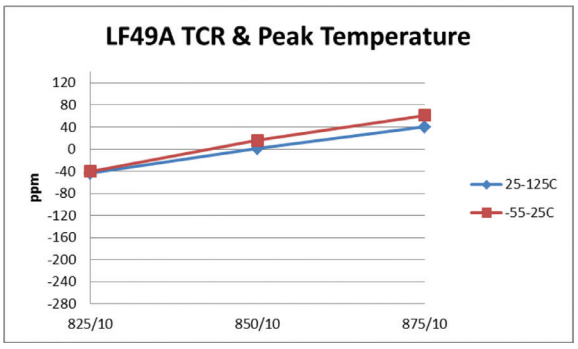


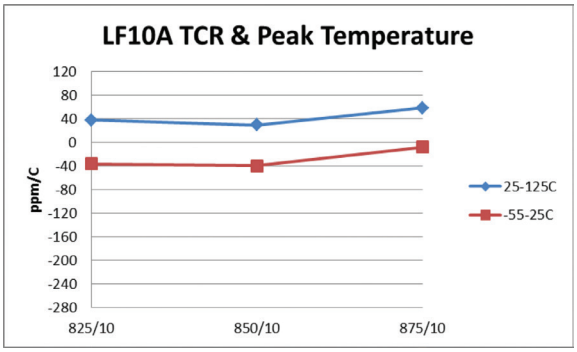
TCR Sensitivity to Firing Conditions

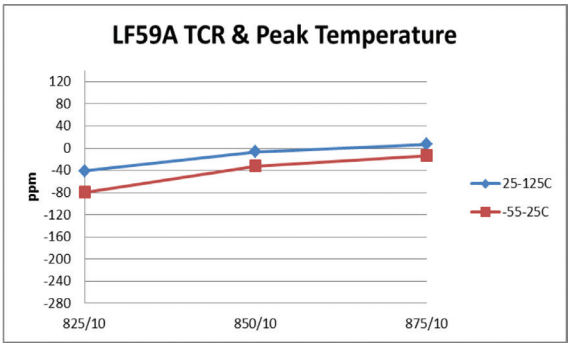
(Peak Temperature)

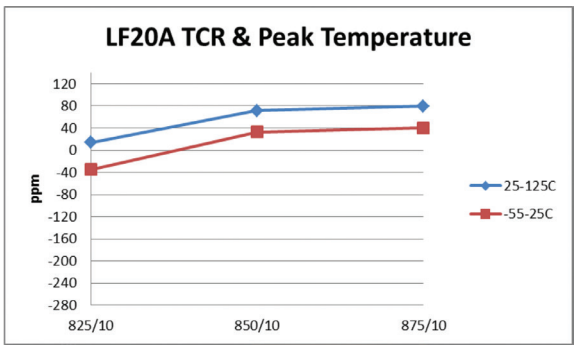
Data based on 1.0x1.0 mm resistors with Pb-free LF171 Ag/Pt terminations.

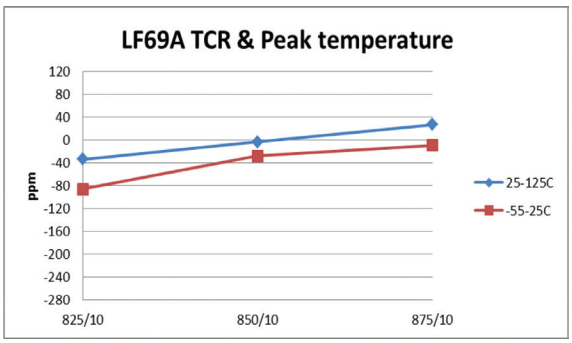


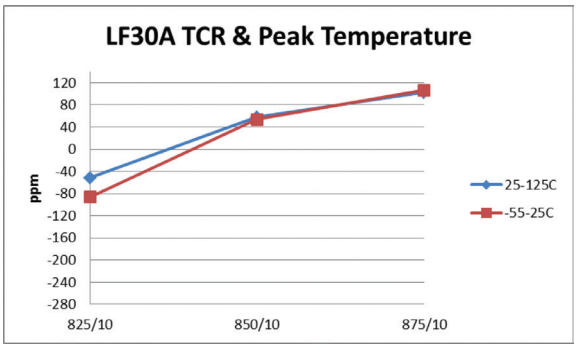


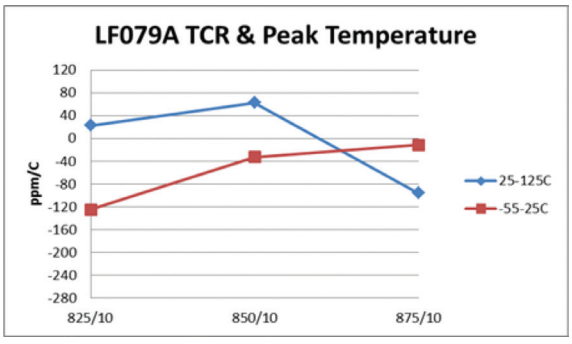




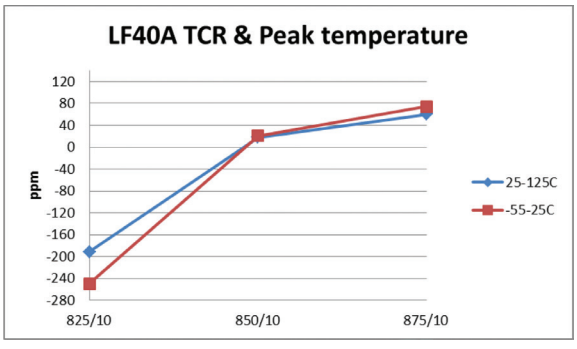








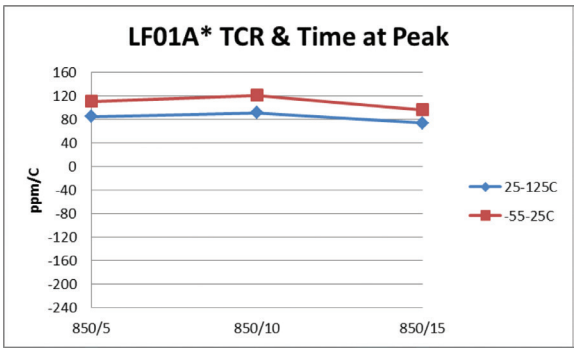
*LF01A data based on 1mm x 1mm resistor.

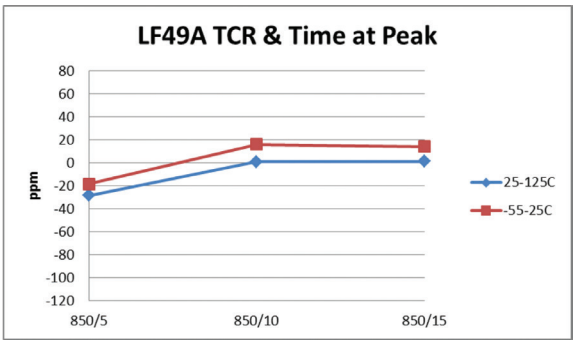


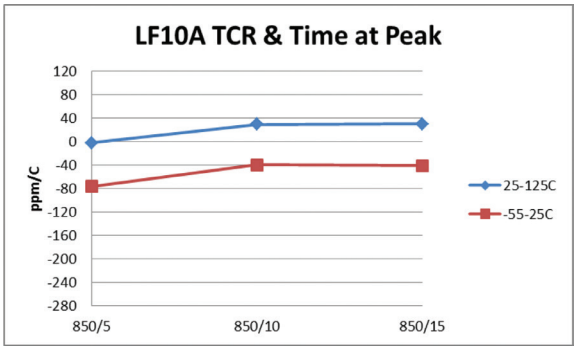
TCR Sensitivity to Firing Conditions

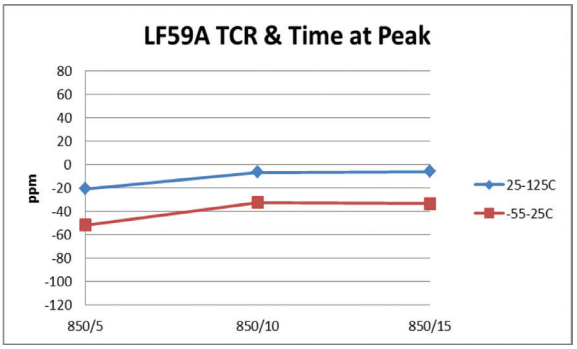
(Time at Peak)

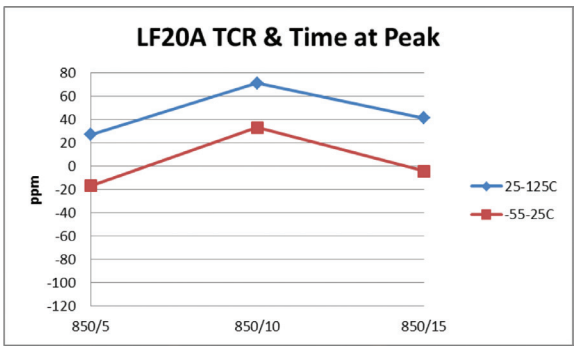
Data based on 1.0x1.0 mm resistors with Pb-free LF171 Ag/Pt terminations.

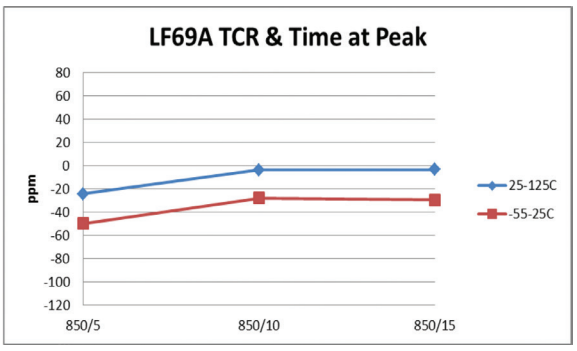


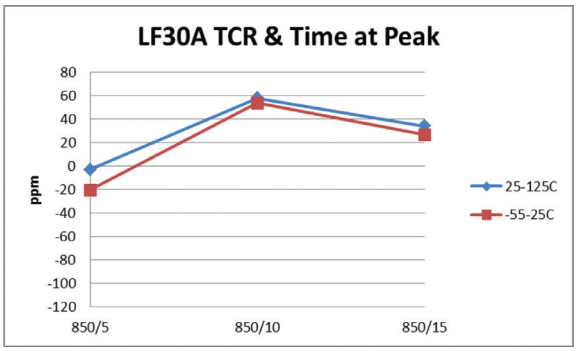


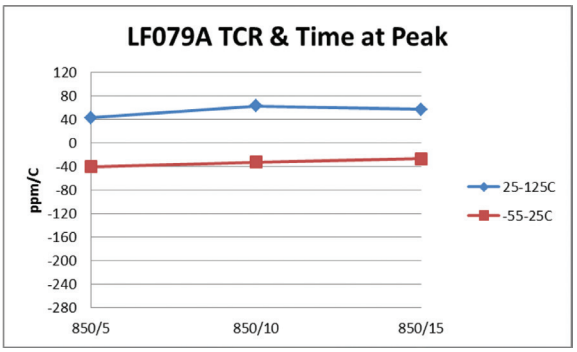




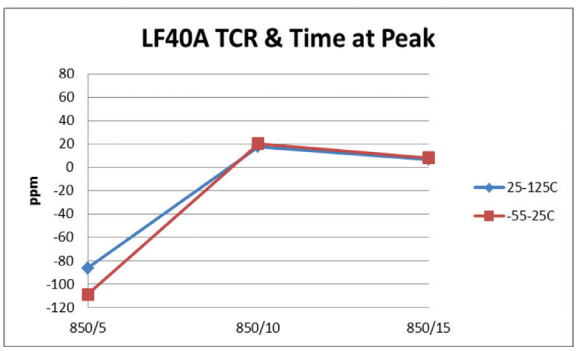






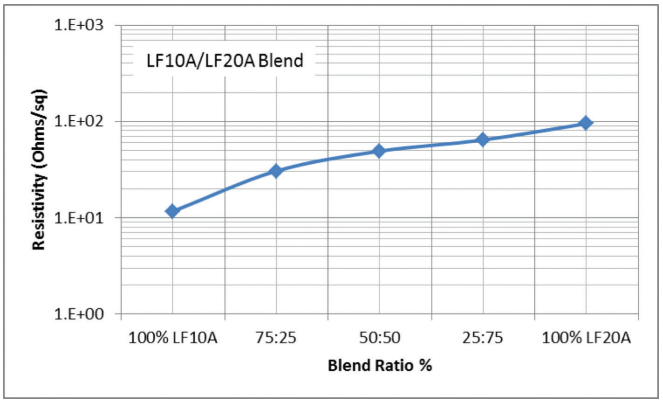


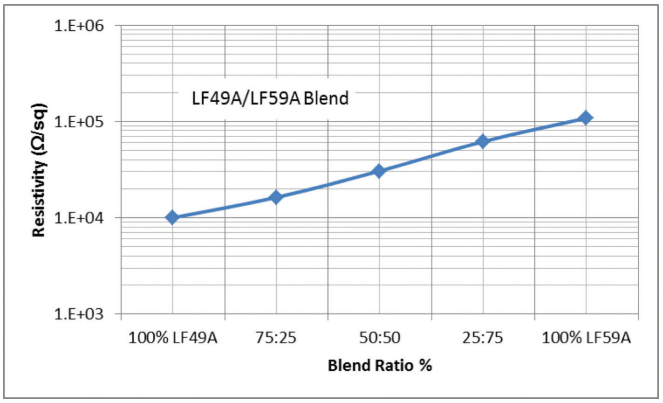
*LF01A data based on 1mm x 1mm resistor.

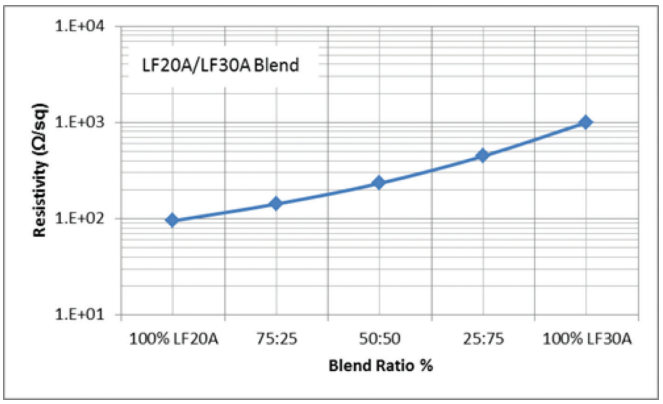


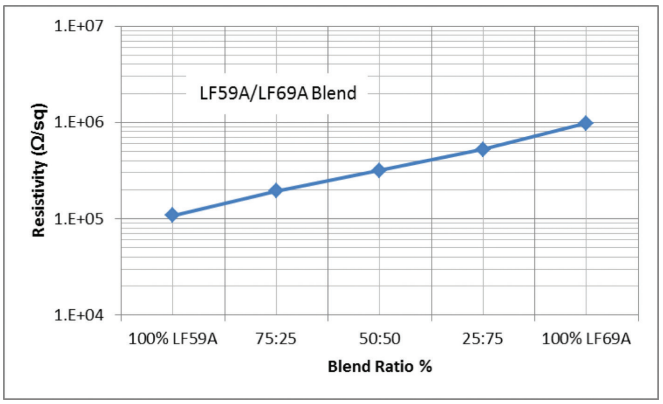
Blend Behavior – Resistivity

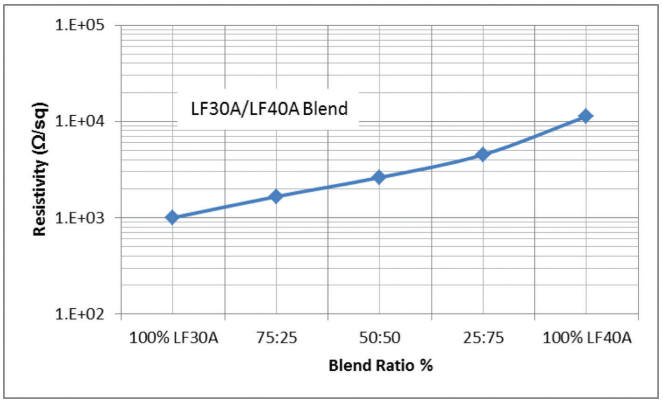
Data based on 1.0x1.0 mm resistors with Pb-free LF171 Ag/Pt terminations









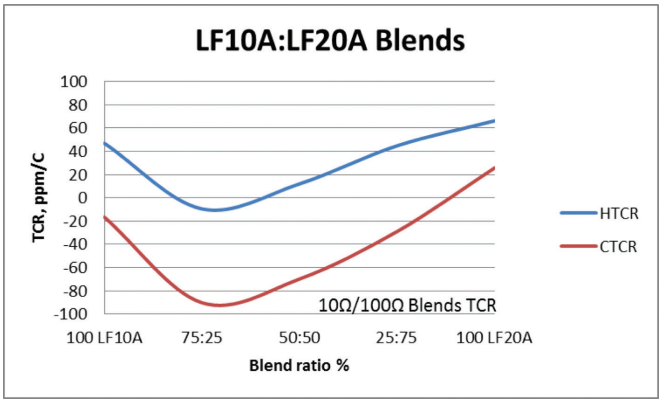


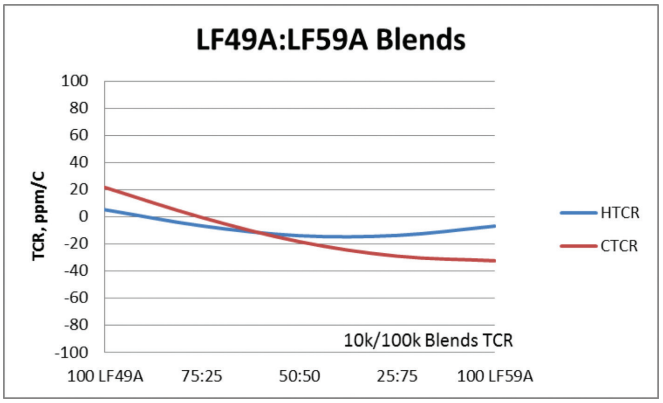
Blend Behavior – TCR

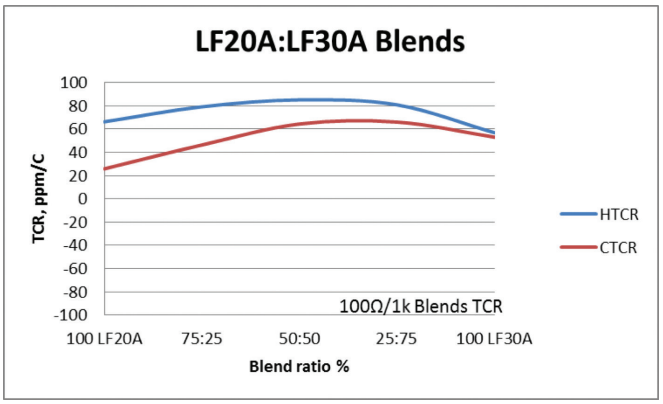
Data based on 1.0x1.0 mm

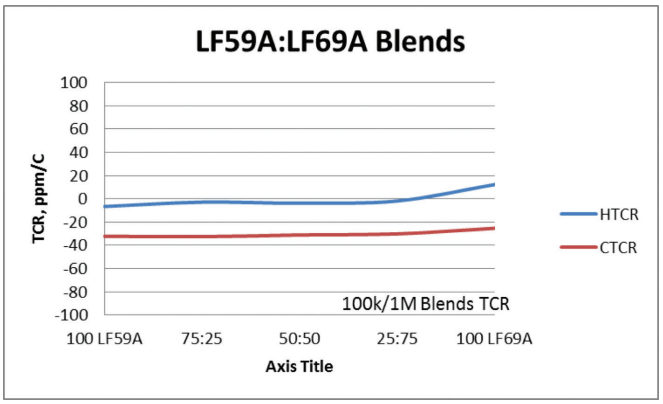
HTCR = 25°C - 125°C, CTCR = –55°C - 25°C

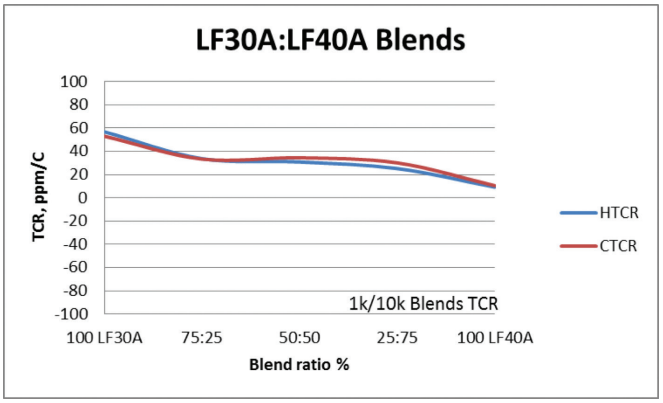
Data based on 1.0x1.0 mm resistors with Pb-free LF171 Ag/Pt terminations







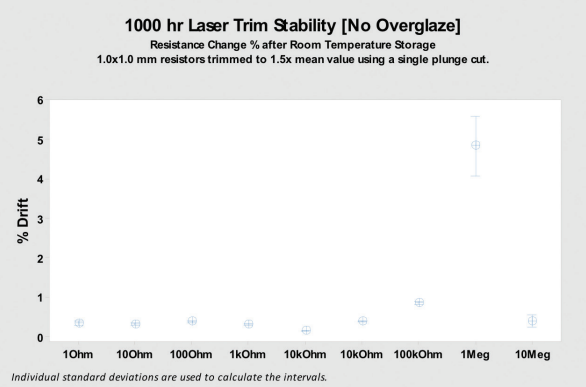


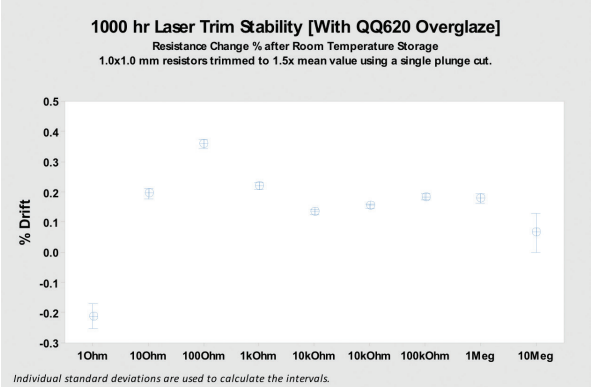


Laser Trim Stability – 1000 hours

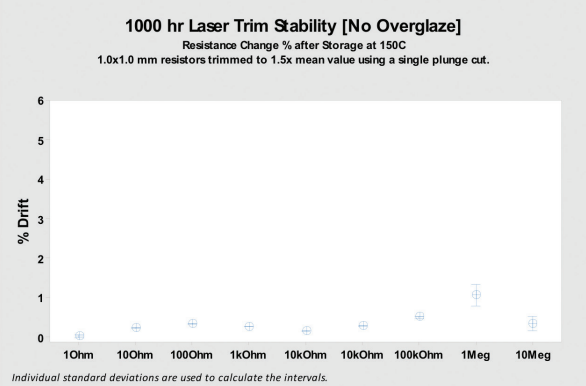
Unglazed **VS** **Glazed with QQ620**

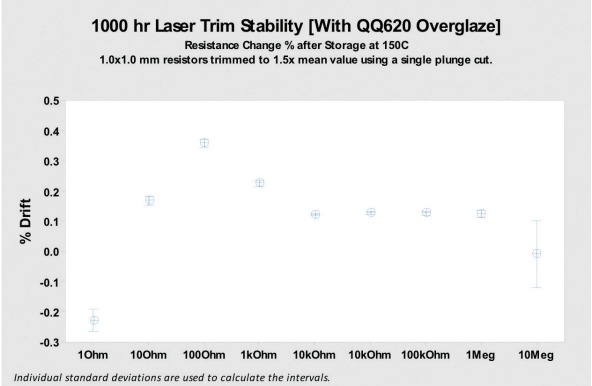
Room Temperature Storage



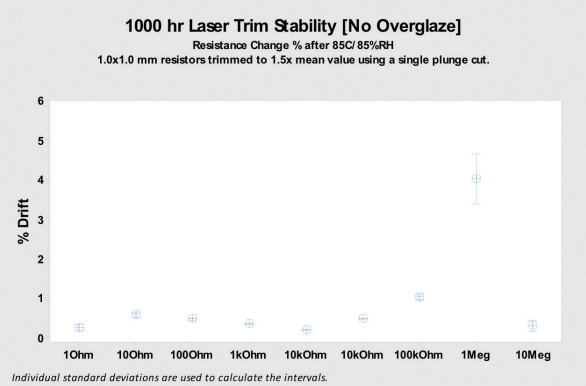


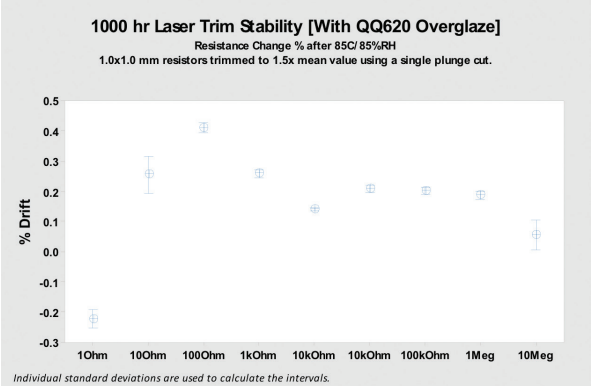
Storage at 150°C



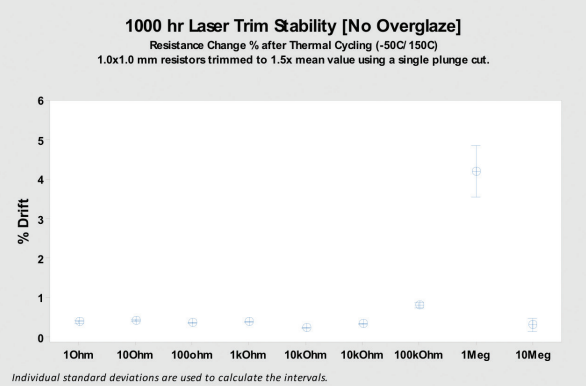


Storage at 85°C/85%RH





After Thermal Cycling –50°C/150°C



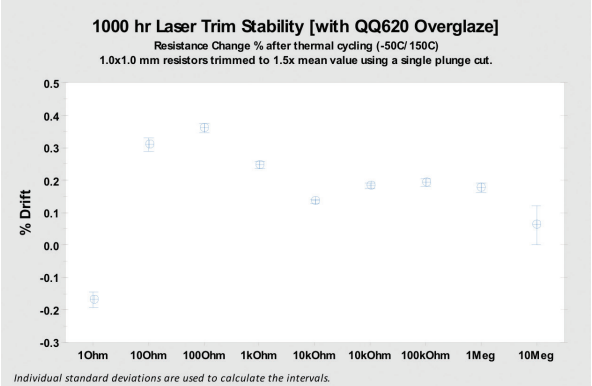
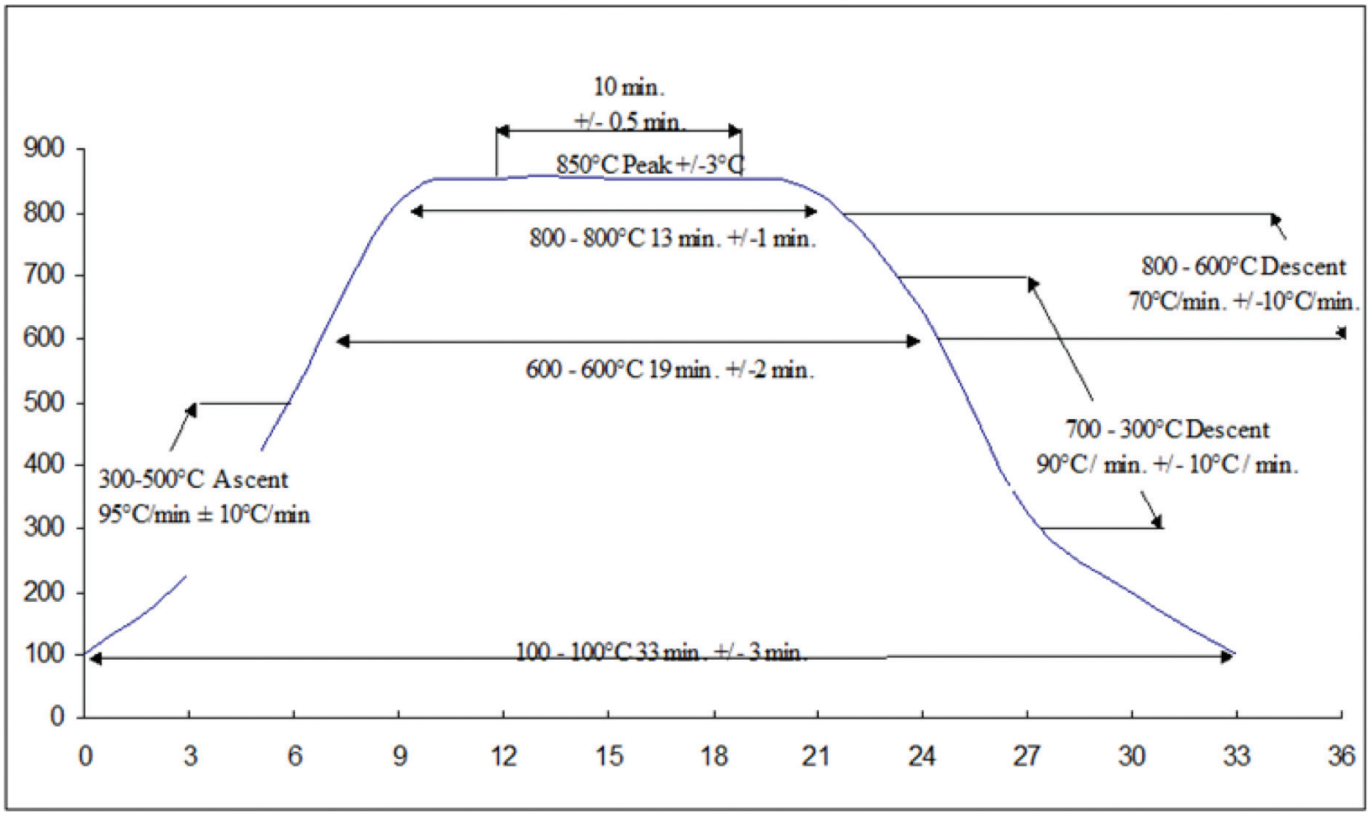


Figure 1 – Typical 30 minute Furnace Profile



DUPONT™ LFX0A SERIES

For more information, please contact your local representative:

Americas
DuPont Microcircuit Materials
14 TW Alexander Drive
Research Triangle Park, NC 27709
USA
Tel +1 800 284 3382 (calls within USA)
Tel +1 919 248 5188 (calls outside USA)

Europe, Middle East & Africa
Du Pont (UK) Ltd
Coldharbour Lane
Bristol BS16 1QD
UK
Tel +44 117 931 3191

Asia
Du Pont Kubushiki Kaisha
MCM Technical Lab
DuPont Electronics Center
KSP R&D B213, 2-1,
Sakado 3-chome, Takatsu-ku,
Kawasaki-shi, Kanagawa, 213-0012
Japan
Tel +81 44 820 7575

DuPont Taiwan Ltd
45, Hsing-Pont Road
Taoyuan, 330
Taiwan
Tel +886 3 377 3616

DuPont China Holding Company Ltd
Bldg. 11, 399 Keyuan Road
Zhangjiang Hi-Tech Park
Pudong New District
Shanghai 201203
Tel +86 21 3862 2888

DuPont Korea Inc.
3-5th Floor, Asia tower #726
Yeoksam-dong, Gangnam-gu
Seoul 135-719, Korea
Tel +82 2 2222 5275

E.I. DuPont India Private Limited
7th Floor, Tower C, DLF Cyber Greens
Sector-25A, DLF City, Phase-III
Gurgaon 122 002 Haryana, India
Tel +91 124 409 1818

Du Pont Company (Singapore) Pte Ltd
1 HarbourFront Place, #11-01
HarbourFront Tower One
Singapore 098633
Tel +65 6586 3022

mcm.dupont.com

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