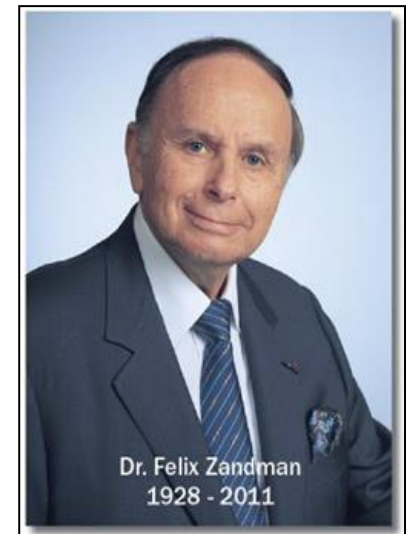


Ultra High Precision Resistors



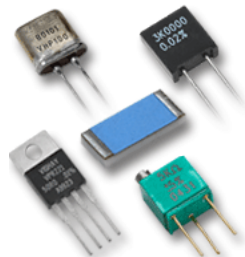
Vishay Foil Resistors - Overview

- More than five decades after its invention by physicist, Dr. Felix Zandman in 1962 , Bulk Metal® Foil (BMF) technology still outperforms all other resistor technologies available today for applications that require precision, stability, and reliability.
- Used in the highest quality instruments for which the resistor performance (TCR, stability) is the most important requirement.
- Develop and manufacture, military-established-reliability components (EEE-INST-002, DSCC, CECC, ESA, ER, QPL, etc).
- Customized chip resistor networks and resistor arrays can also be manufactured.



VPG Brands

VPG Foil Resistors



VPG Micro Measurements



VPG Load Cells



VPG Process Weighing



VPG On-board Weighing



**VISHAY FOIL
RESISTORS**
A VPG Brand

AE Alpha Electronics
A VPG Brand

POWERTRON
A VPG Brand

Typical Applications

- Measurement systems
- Current sensing
- High-precision amplifiers
- Weighing systems
- Force balance scales
- Differential amplifiers
- Switching power supplies
- Electron microscopes
- Gyro navigation controls
- Pressure sensors
- Motor speed controls
- Telecommunications
- Bridge networks
- Standard Box & Decade
- **Tailored solutions per customer specifications**



Tailored Solutions

The Foil resistors can be provided even with better specification than written in the standard datasheets. There are specific cases where some parameters can be maximized/ Improved beyond the standard performances to suit the customer requirements.

- Examples of such parameters are:
 - Total Error Budget (TEB) or End Of Life (EOL)
 - Long term stability
 - Ultra precision
 - Matched resistors
 - Resistance Value
 - Tolerance - Absolute and matched
 - TCR - Absolute and tracking



CSNG



PRND



VCS1610



HTHA



Network



CAL4

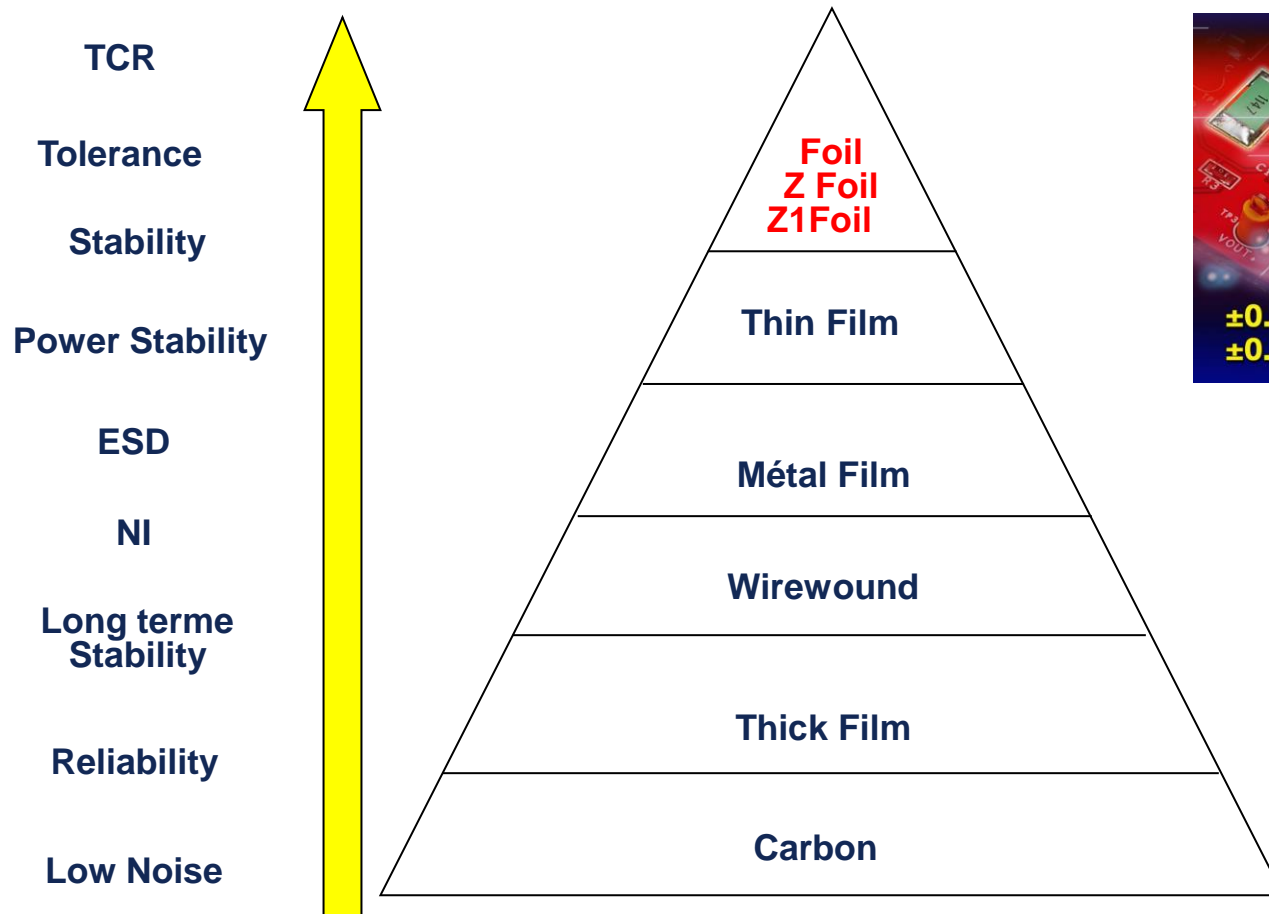
For more information please contact Application Engineering department: foil@vishaypg.com

Diversified Customer Base

Distributors/EMS	AMS	Medical	Precision Instrumentation	Industrial
                	              	           	                   	               

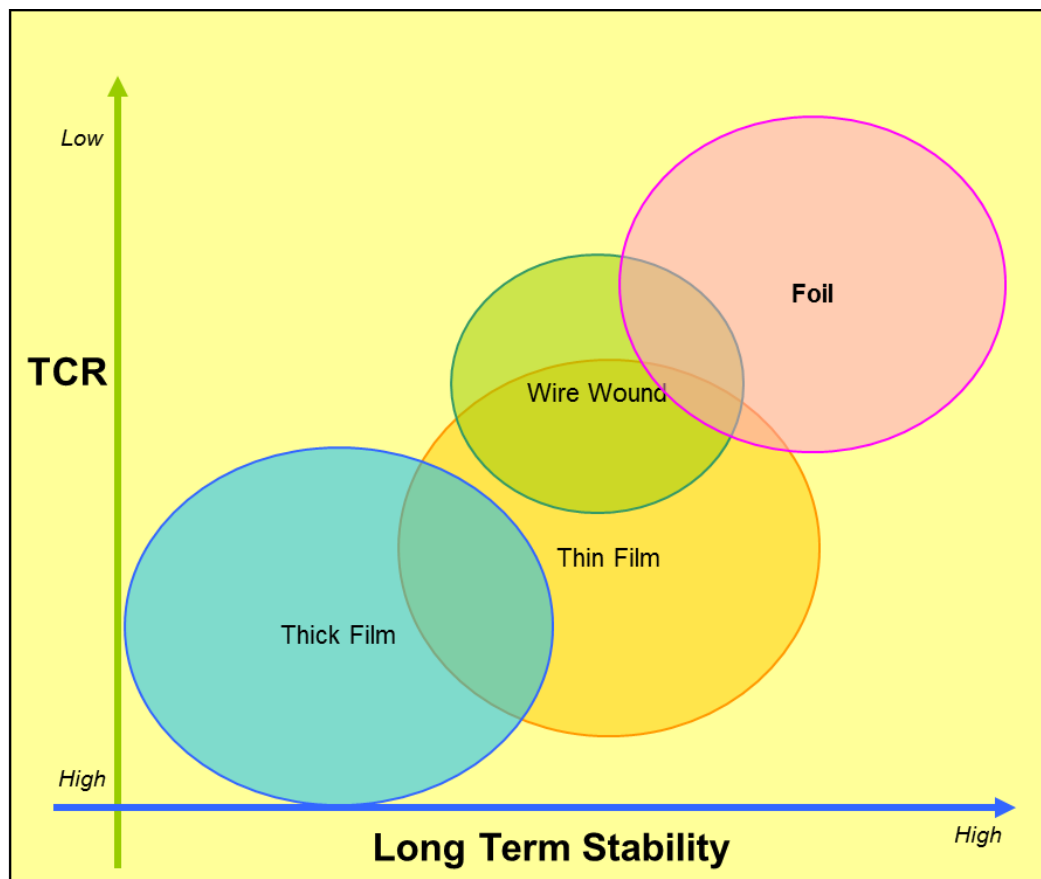
What Factors Do Design Engineers Look For When Choosing Resistors?

Resistors Evolution



MOQ: 1
RV: 1K1234
Tol.: 0.001%
TCR: 0.2ppm/°C
ESD: >25KV
High Temp.: 240°C
Samples in 5 days

Comparison of Resistor Technologies



Comparison of Resistor Technologies

Technology	Temperature Coefficient of Resistance (TCR) -55°C to +125°C, +25°C ref.	Initial Tolerance	End of Life Tolerance	Load Life Stability at +70°C, Rated Power 2000 Hours and 10,000 Hours	ESD (V)	Thermal Stabilization	Noise (dB)
Bulk Metal® Foil	±0.2 ppm/°C	From 0.001%	<0.05%	0.005% (50 ppm) 0.01% (100 ppm)	25,000	<1 second	-42
High-Precision Thin Film	±5 ppm/°C	From 0.05%	<0.4%	0.05% (500 ppm) 0.15% (1500 ppm)	2500	>few minutes	-20
Precision Thick Film	±50 ppm/°C	From 0.5%	<5%	0.5% (5000 ppm) 2% (20,000 ppm)	2000	>few minutes	+20
Wirewound	±3 ppm/°C	From 0.005%	<0.5%	0.05% (500 ppm) 0.15% (1500 ppm)	25,000	>few minutes	-35

Resistor Technologies

Thick Film

Screen Printed
Conducting Paste
+
Laser Trimming

Thin Film

Sputtering
+
Laser Trimming

Precision Thin Film

Sputtering
+
Photo Etching
+
Laser Trimming

Bulk Metal Foil

Metal Rolling
+
Photo Etching
+
Laser
Trimming
or
Manual Trimming

Typical TCR Range
100 to 400ppm/K

Typical TCR Range
50 to 200ppm/K

Typical TCR Range
5 to 25ppm/K

**Typical TCR Range
0.2 to 5ppm/K**



Why Bulk Metal Foil Resistor?

Stability

- Time=The Lowest Long Term Stability (2 ppm/year for 6 years)
- Temperature=The Lowest TCR (0 ± 0.05 ppm/°C)

Reliability

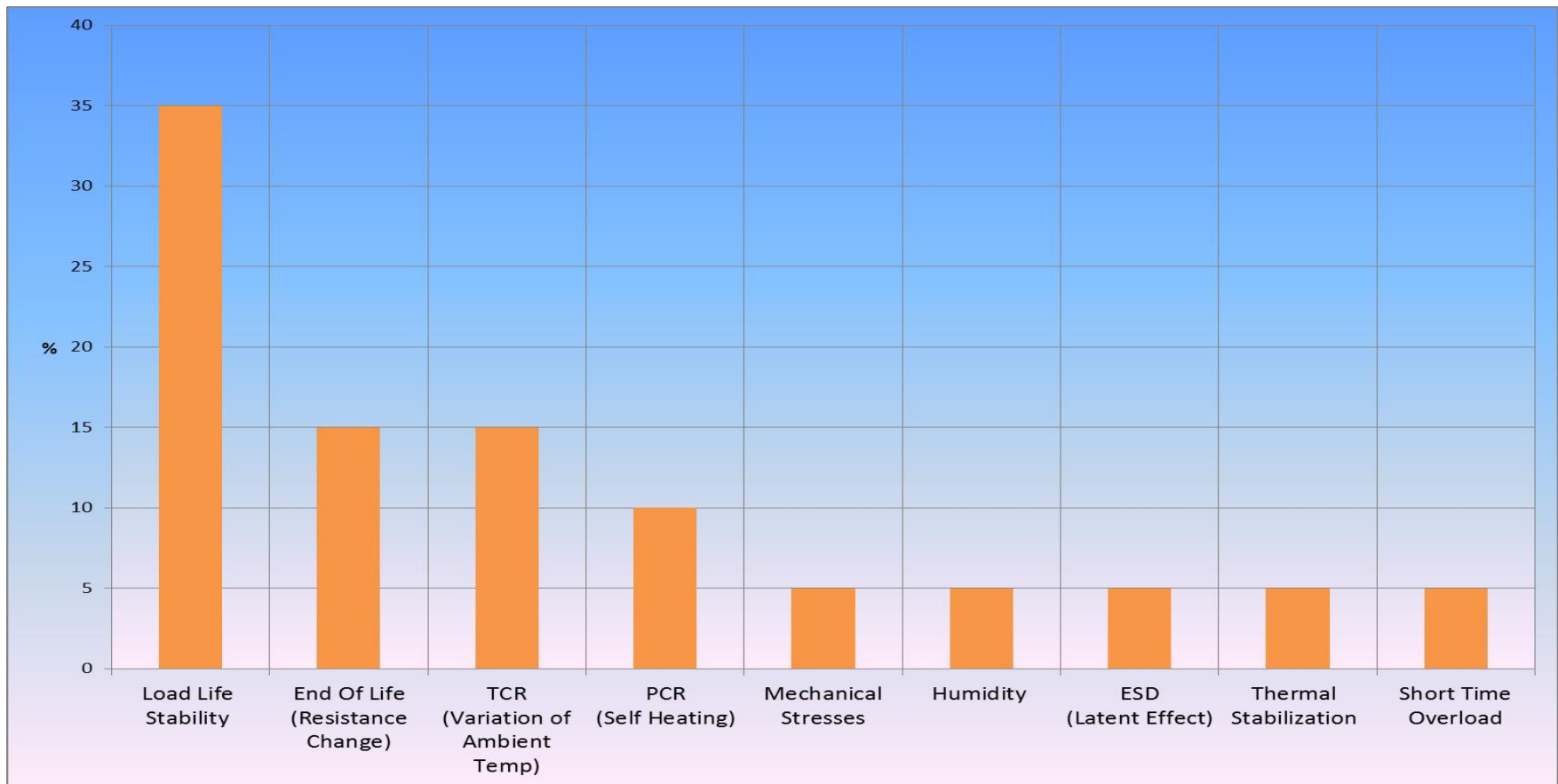
- Reliability Tests= According to MIL-PRF-55182/9
& MIL-PRF-55342

Accuracy

- The Tightest Tolerance ($\pm 0.001\%$)

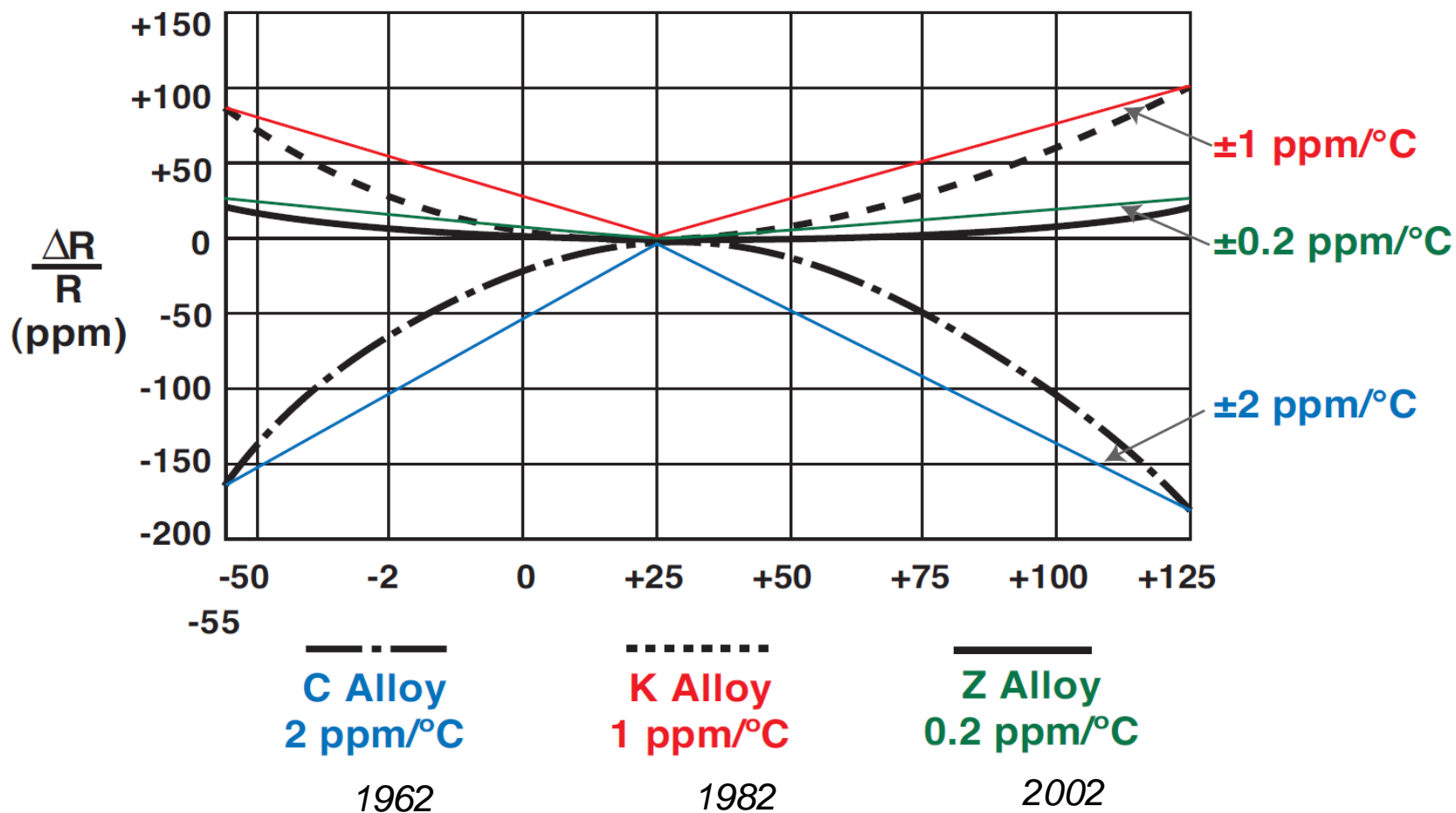


Main reasons for selecting Foil as a precision resistor



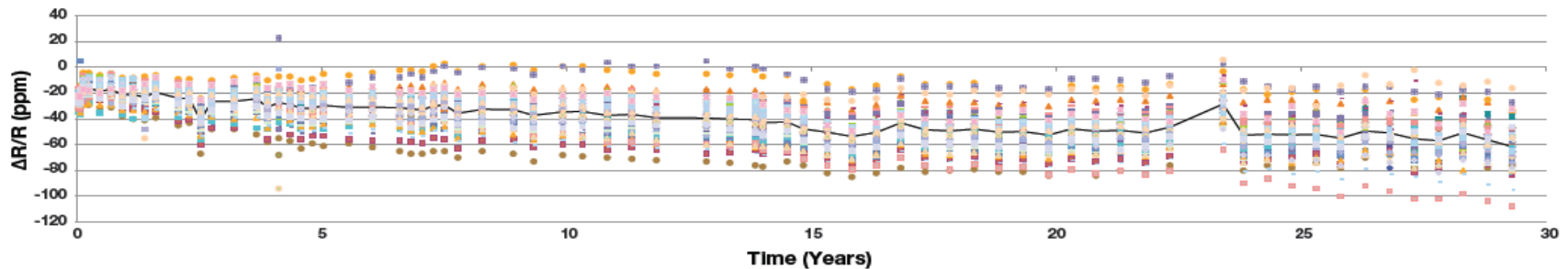
* VPG Foil Resistors estimates

The Foil development over the years

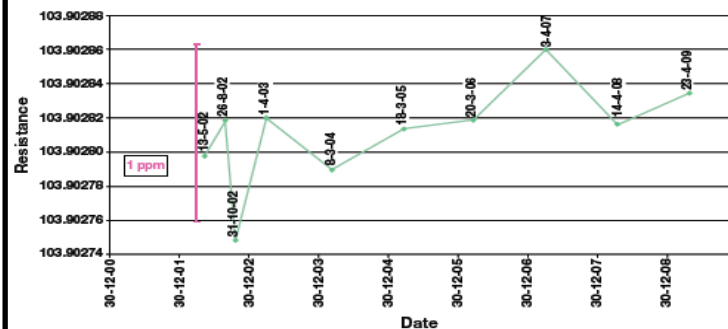


Vishay Foil Resistors Unique Stability

Long –Term Stability over 30 years (0.1 W at 70 ° C 50 samples (S102C, 10K Ω))



Shelf Life test results of hermetically sealed VHP 101 Foil Resistors over 10 years

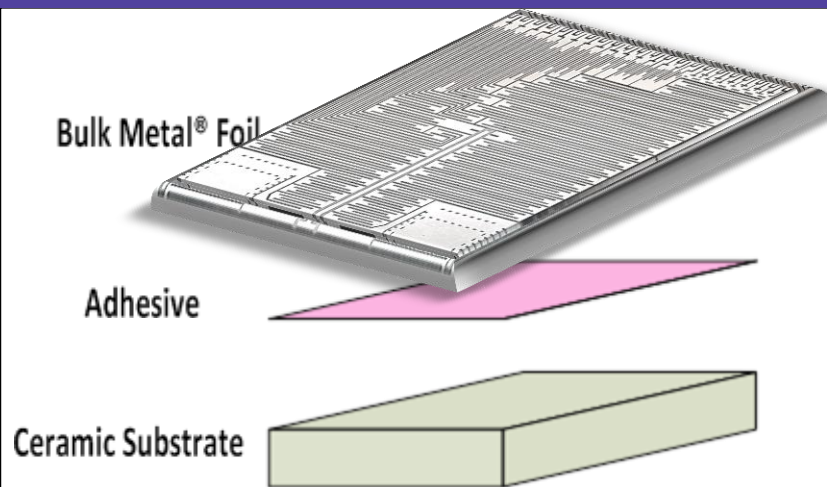


What is Behind The Foil Technology

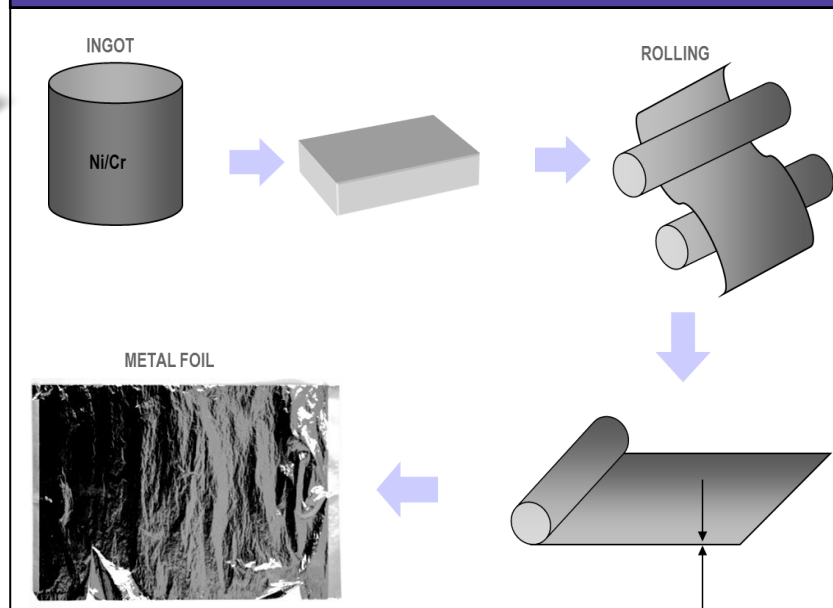
Company's Key Technology

The Bulk Metal® Foil resistor is based on a special concept where a proprietary bulk metal cold-rolled Foil is cemented to a ceramic substrate.

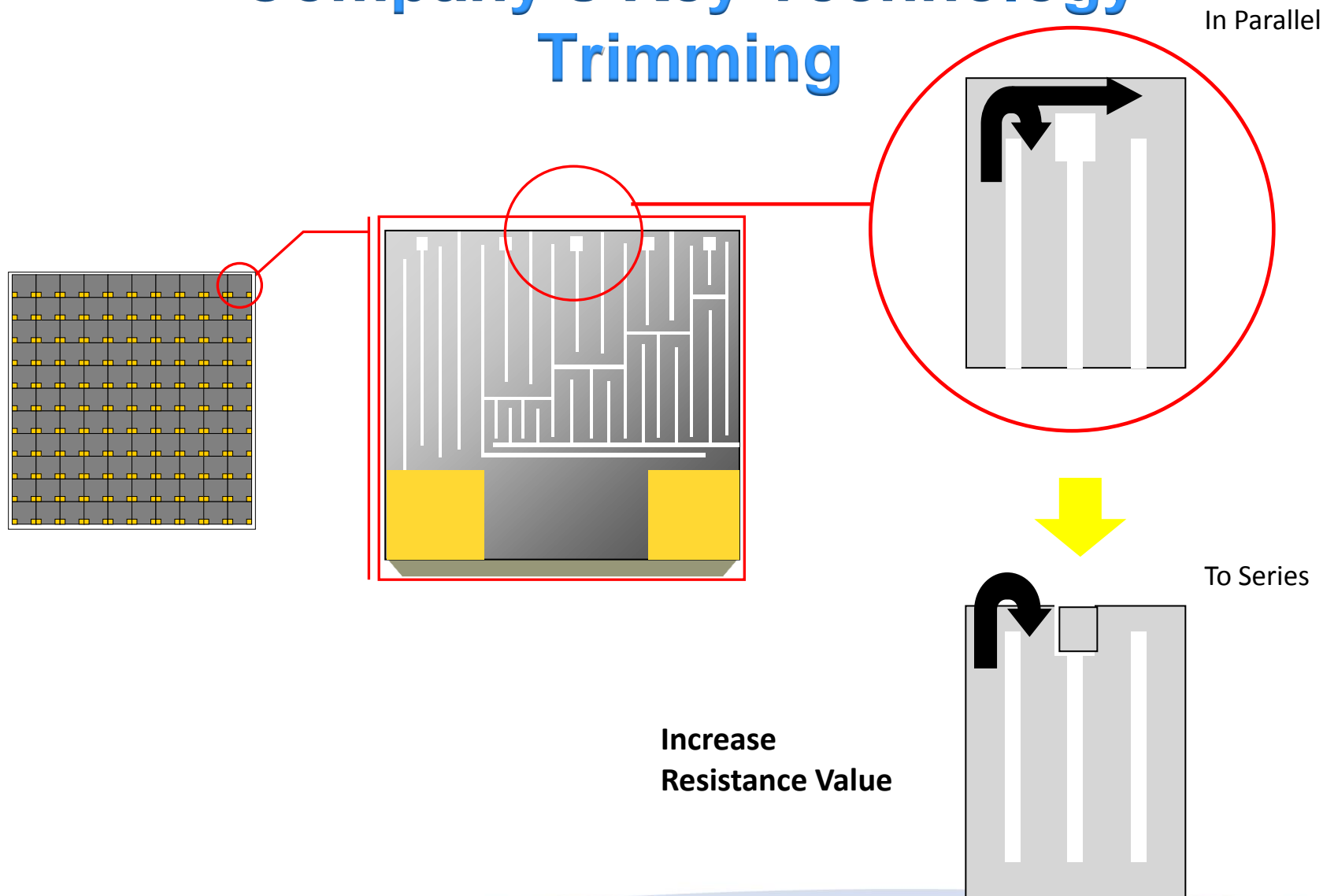
Special Layer Construction



The Bulk Metal® Foil Production

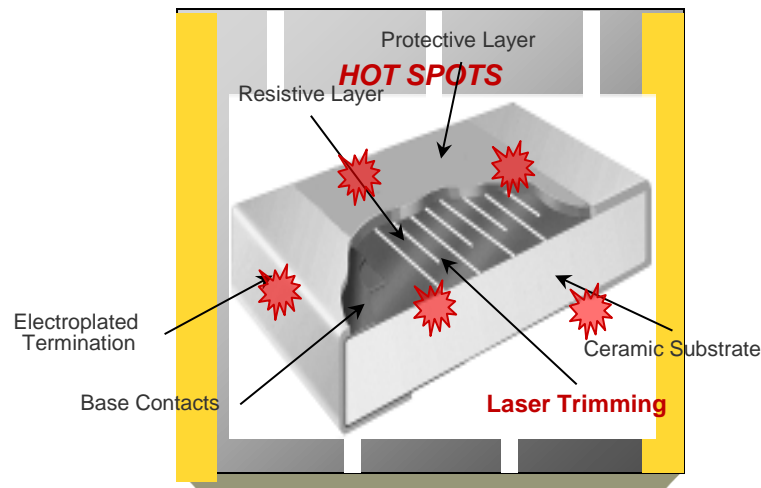
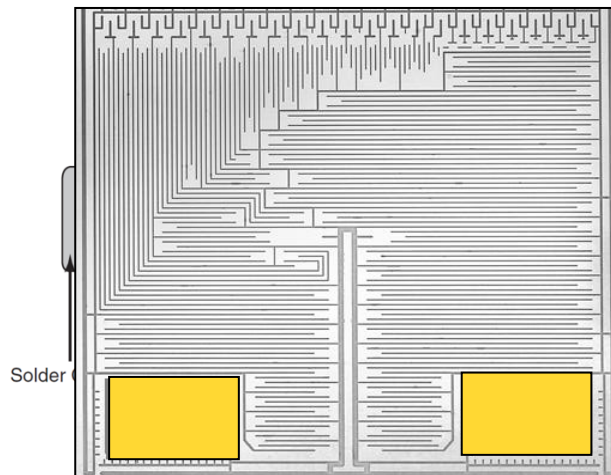


Company's Key Technology Trimming

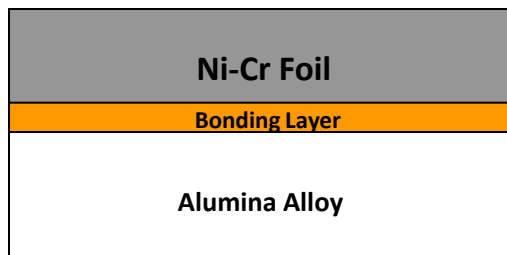


Technology Comparison

Bulk Metal Foil vs. Thin Film Resistor



25,000Å (2.5μm)



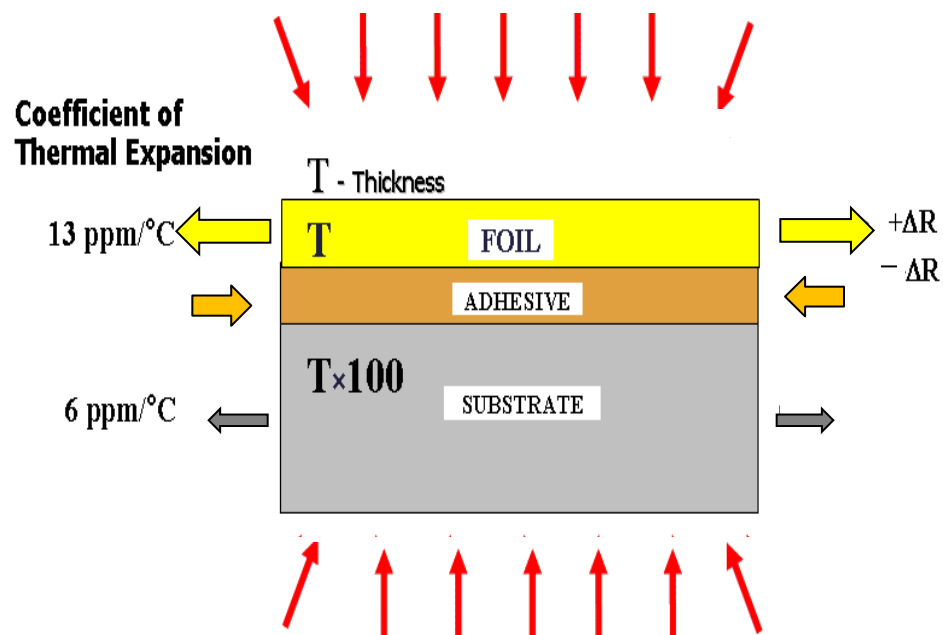
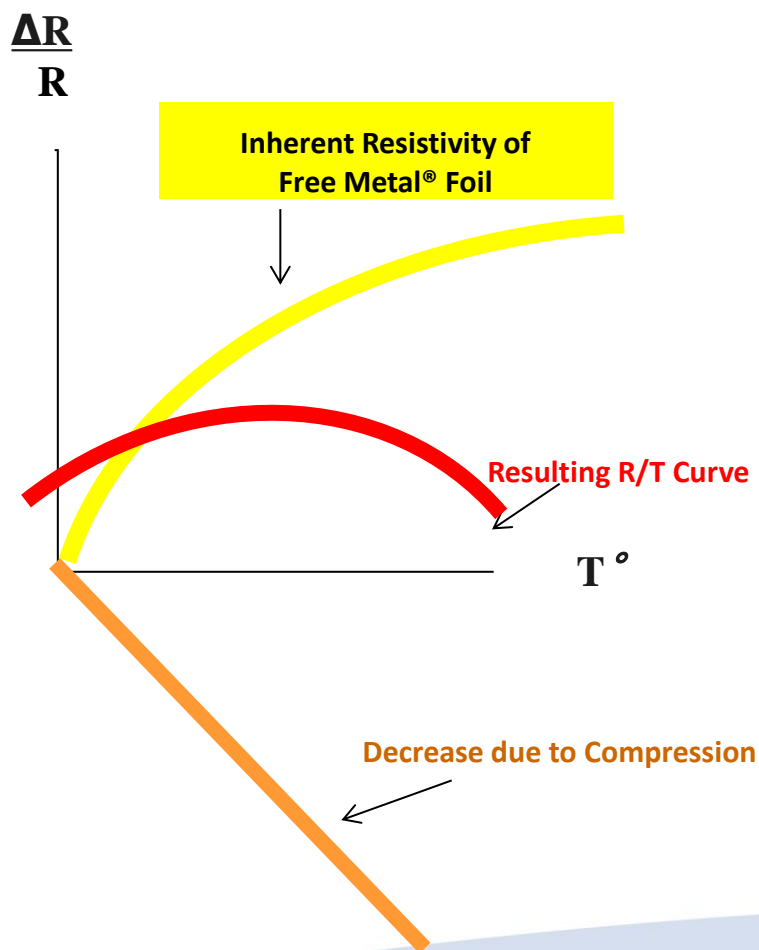
250Å

Ni-Cr Film



Company's Key Technology

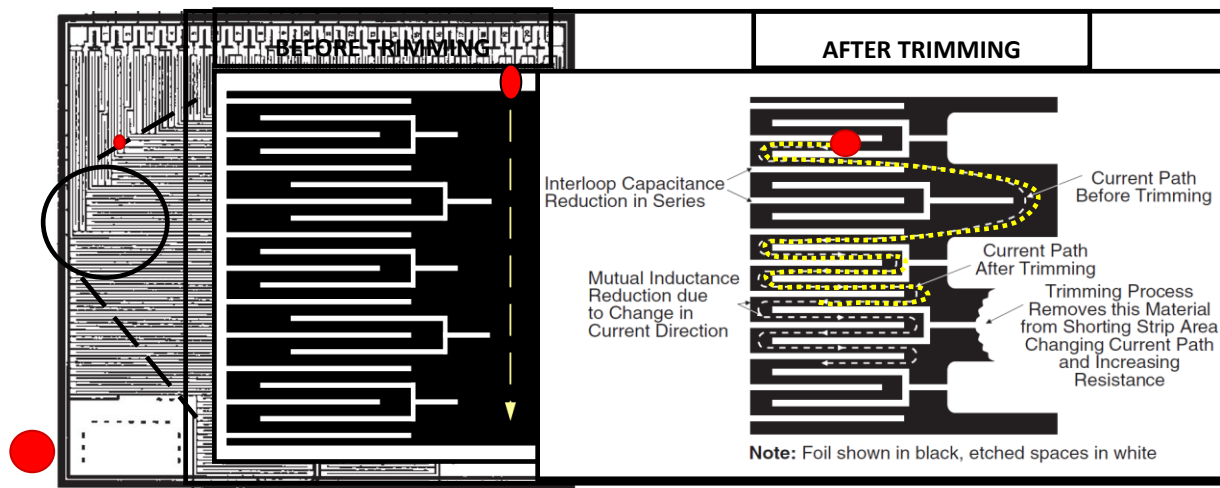
TCR & PCR



Unique Trimming Method

The Bulk Metal® Foil is photo etched into a resistive pattern (no mechanical stress introduced). Later, it is laser (or manually) adjusted to any desired value and tolerance.

Because the resistive metal used is not drawn, wound or mechanically stressed in any way during manufacturing process, the Bulk Metal Foil resistor maintains all its design, physical and electrical characteristics while winding of wire, or sputtering of Thin Films, or thick film glazing do not.



Capacitance & Inductance

- In spiraled and wire wound resistors, the Capacitance and Inductance are created by the loops and spaces formed by the spirals or turns of wire (Fig A).
- In planar resistors such as the Bulk Metal® Foil resistors, the geometry of the lines of the resistor patterns is intentionally designed to counteract these reactance's.
- Figure B shows a typical serpentine pattern of a planar resistor. Opposing current directions in adjacent lines reduces mutual inductance while geometry-related inter-line capacitances in series reduces overall capacitance.
- Both inductance and capacitance produce reactance proportional to the operating frequency and it changes the effective resistance and the phase between the current and voltage in the circuit.

Fig A- Capacitance and Inductance in a Wound or Spiraled Resistor

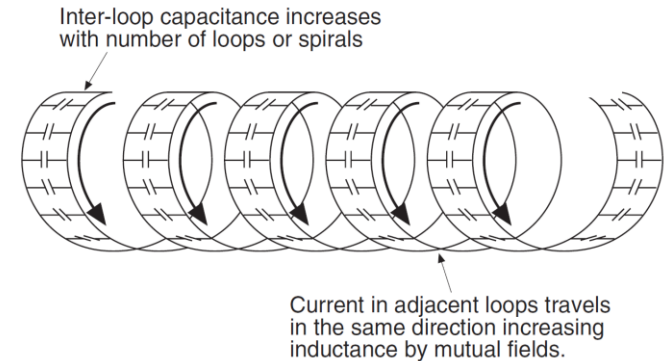
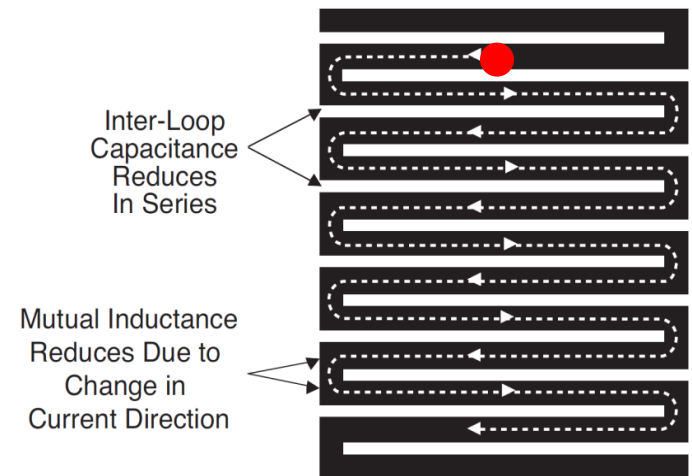
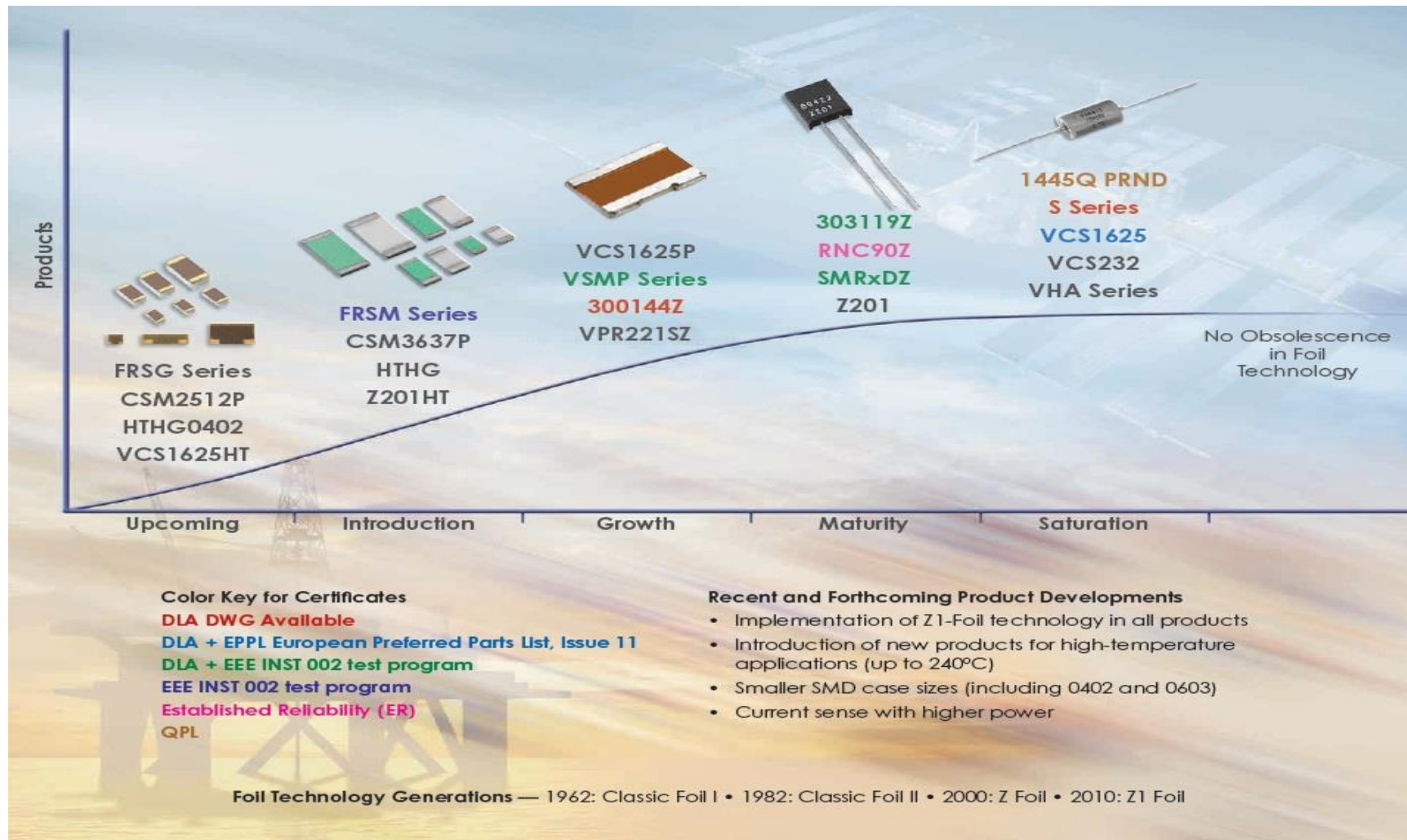


Fig B- Bulk Metal® Foil Planar Design



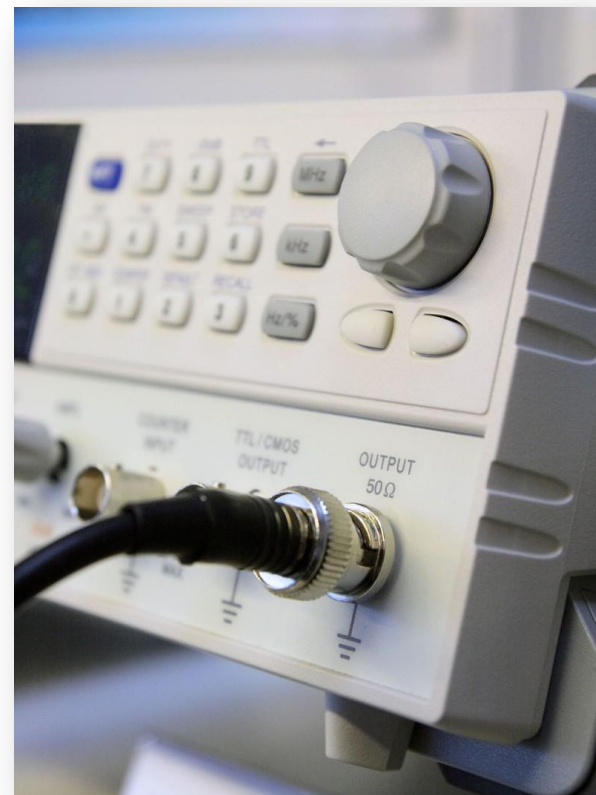
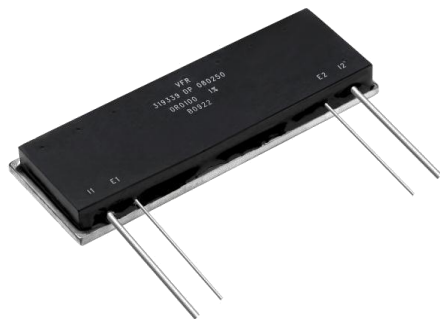
Product Life Cycle



Bulk Metal® Foil Resistors in Precision Instrumentation

*New Generation Custom Designed Current Sensor is used in
High End Voltage/Current Calibrator*

Value: 10mΩ, TCR <1 ppm/°C

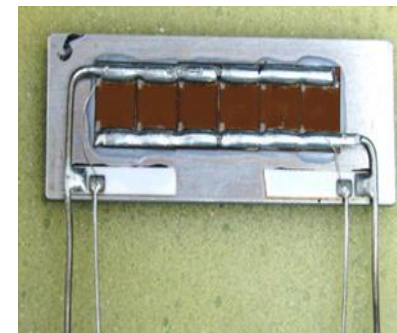
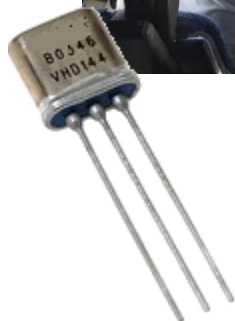
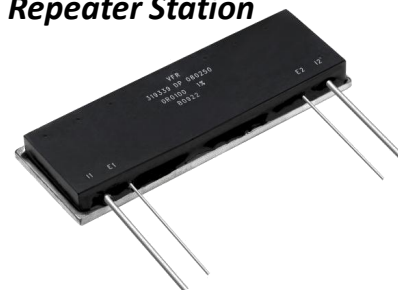


Bulk Metal® Foil Resistors in AMS and High-Reliability Applications

*VHD200 for high temperature up to +200°C is used in
Brakes Control System of Commercial Airplanes*



*New Generation Current sensor is used to enable
handling of 40A and accuracy of 0.005% in
Submarine Repeater Station*

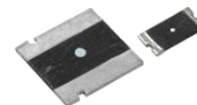


Bulk Metal® Foil Resistors in Space Application



Space Level Resistor per EEE –INST-002

- CSM Series (current sensors)
- VSMP Series (warp around SMD)
- SMR series (Molded SMD)
- PRND
(Hermetically Sealed Networks)



Bulk Metal® Foil Resistors in Precision Instrumentation

*Hermetically sealed Ultra High Precision Z-Foil Technology
Resistors – H-Series for
Electron Beam Microscope*

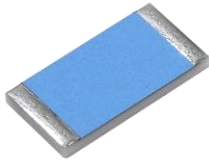


*Ultra high-precision Z-Foil flip chip resistor for
DC Test Instrument*

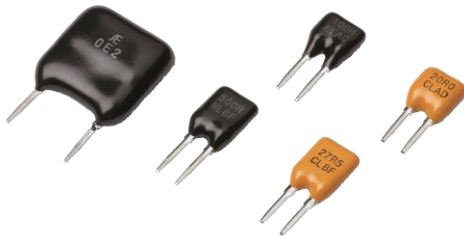


Bulk Metal® Foil Resistors in Precision Weigh Scale

*VFCP2512 are used as current sense resistors
at the new series of
High Performance Laboratory Scales*



*Alpha's thermo sensitive resistors are used as
temp. compensator for load cell of
Weigh Scales*

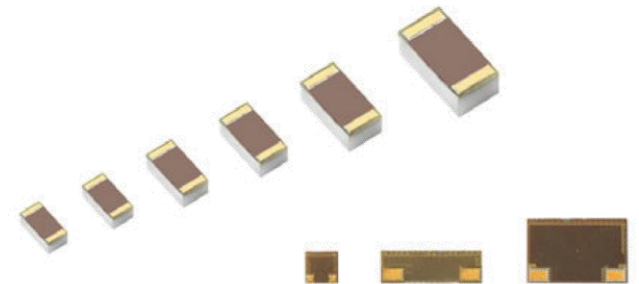


Bulk Metal® Foil Resistors in Down Hole Drilling Tool (High Temperature)



*HTHG series is used for measurement inside of
A Drilling Tool*

*Withstand temperature up to **+270°C***

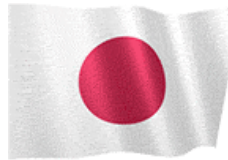


Three Manufacturing Facilities

Israel



Japan



Germany



**VISHAY FOIL
RESISTORS**
A VPG Brand

AE Alpha Electronics
A VPG Brand

POWERTRON
A VPG Brand

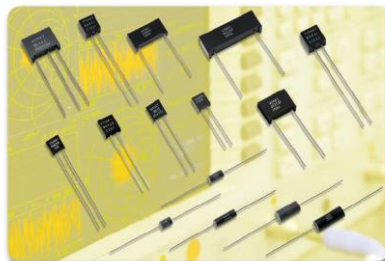
Bulk Metal® Foil Resistors Categories

Vishay Foil Resistors

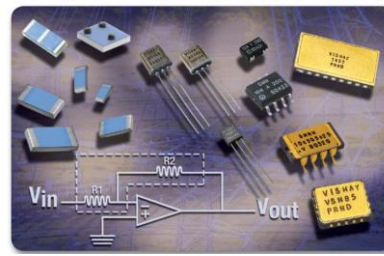
Surface Mount



Through Hole



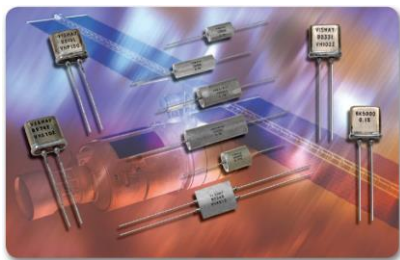
Voltage Dividers and Networks



Power Current Sensors



Hermetically Sealed



Trimmers



Hybrid Chips and PRND



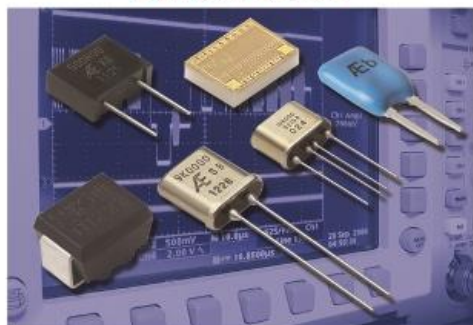
Military and Space



Bulk Metal® Foil Resistors Categories

Alpha

Current Sense



High Precision



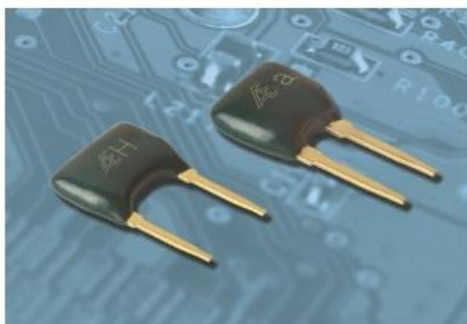
Networks



Thermosensitive



Thin Film

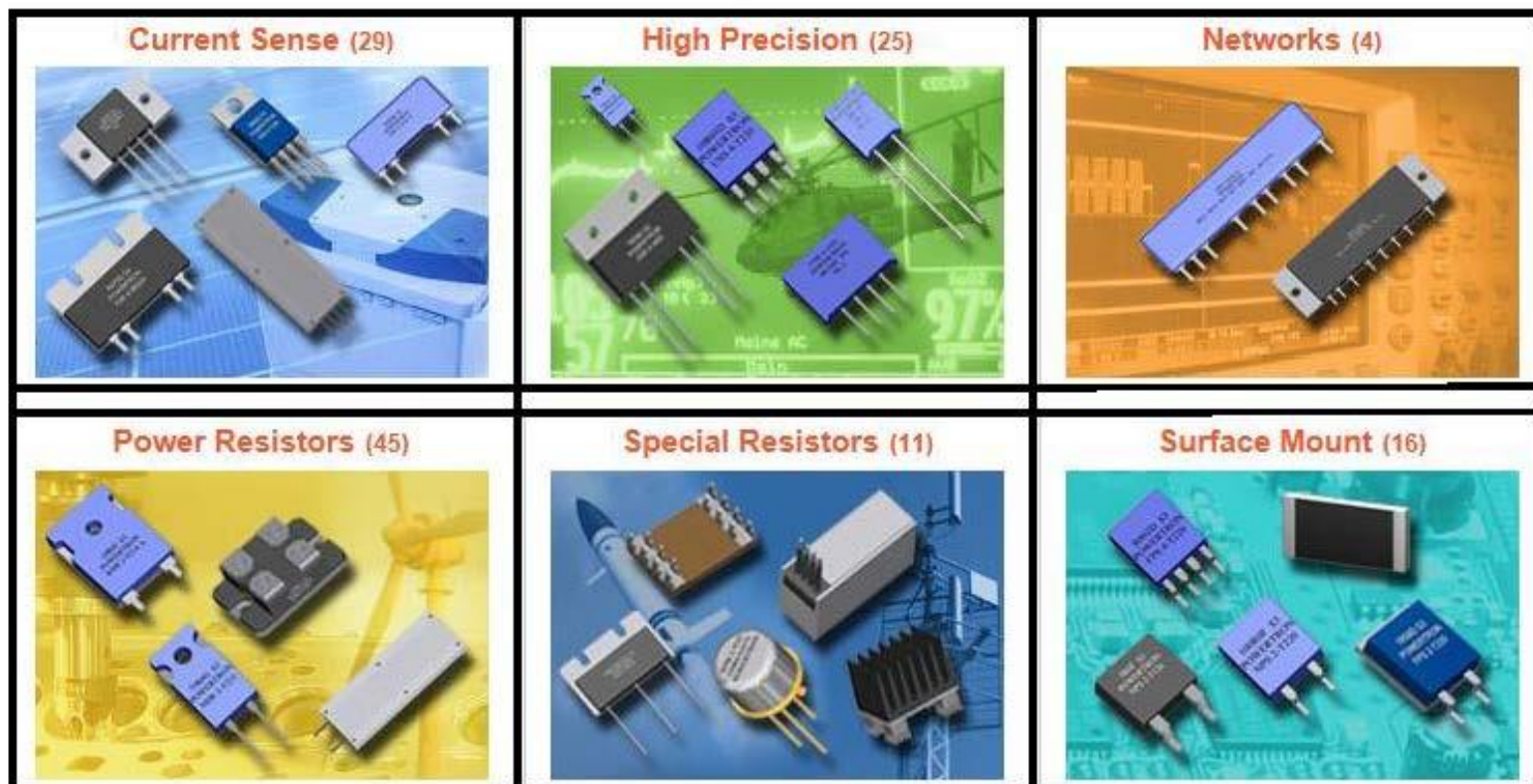


Standard Resistor



Bulk Metal® Foil Resistors Categories

Powertron



Contact us at
foil@VPGsensors.com

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www.VPGFoilResistors.com