Embedded Thin-Film NiP Resistor Technology Recent Developments in Lead-Free and Microwave Applications

By

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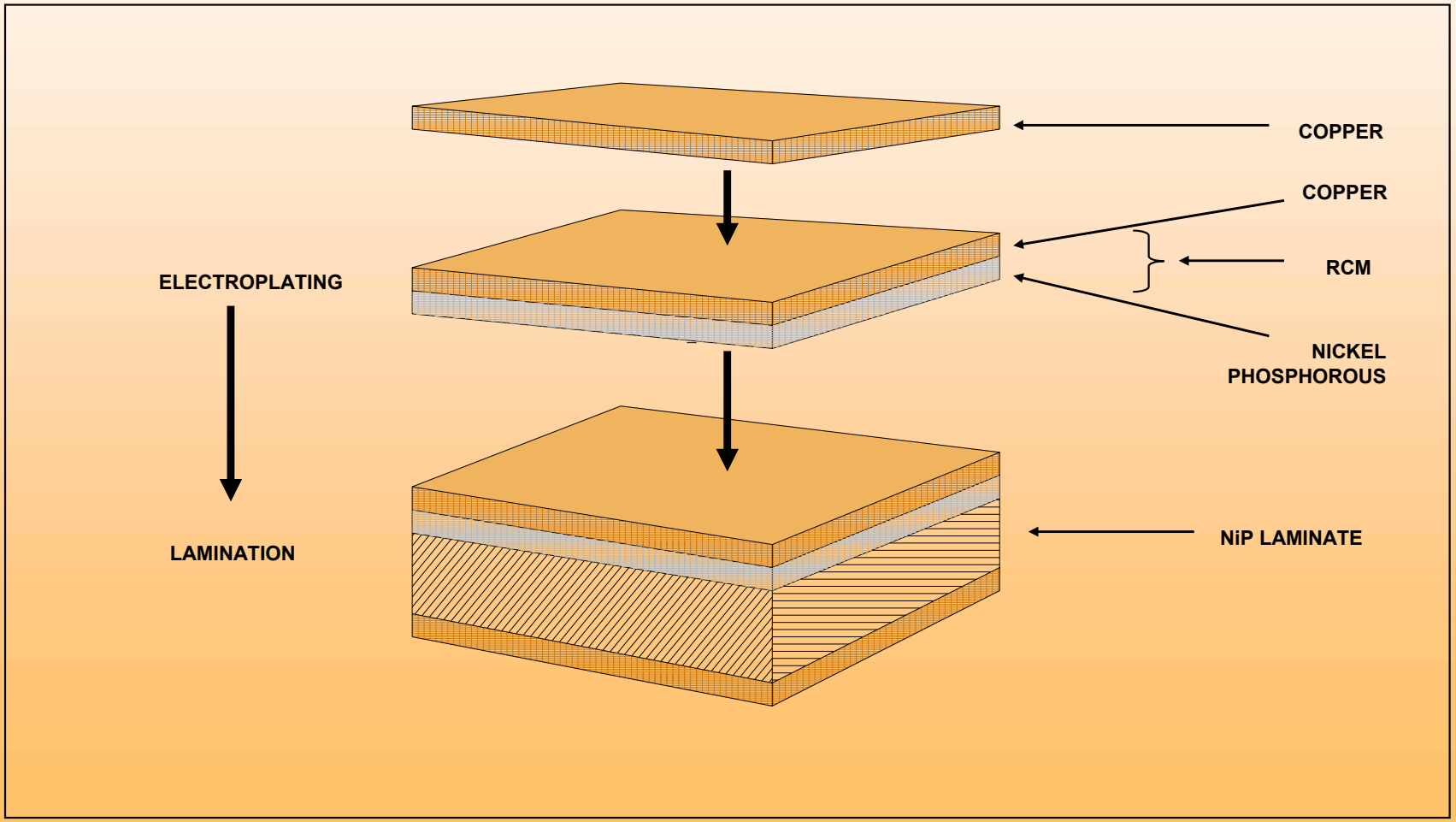
NiP Resistor Manufacturing Overview

Thin film **NiP** resistive alloy material is made by electrodepositing of the NiP alloy onto copper foil (RESISTOR-CONDUCTOR MATERIAL) which is then laminated to a dielectric material and subtractively processed to produce planar resistors. Because of its thin film nature, it can be buried within layers without increasing the thickness of the board or occupying any surface space like discrete resistors.



Recommended Copper Type for Various Dielectric Materials

PT

Hi T_g Epoxy

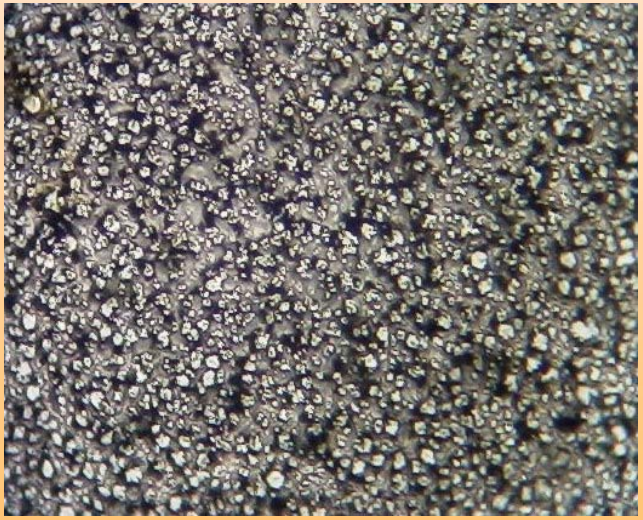
Polyimide

Lead-Free

Rogers 4003

Ceramic-Filled

LCP (Rogers Ultralam 3850)



1R25 with PT COPPER FOIL at 200X

TOCIII

PTFE

Rogers Duroid®

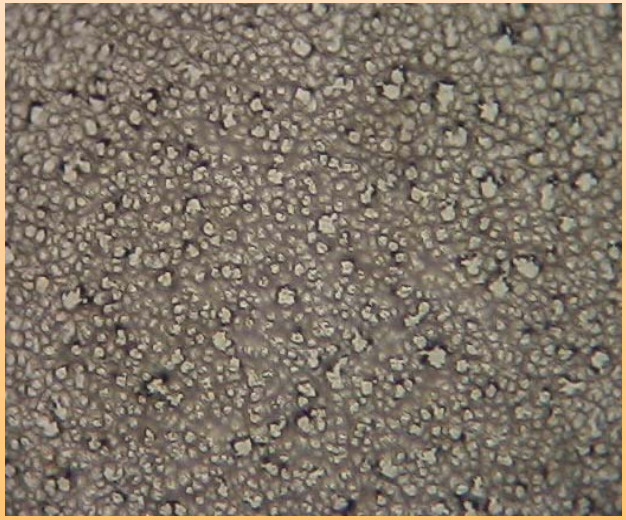
Arlon CLTE

Ohmega/Faradflex ®

BC24

BC16

Flex



1R25 with TOCIII COPPER FOIL at 200X

DFF

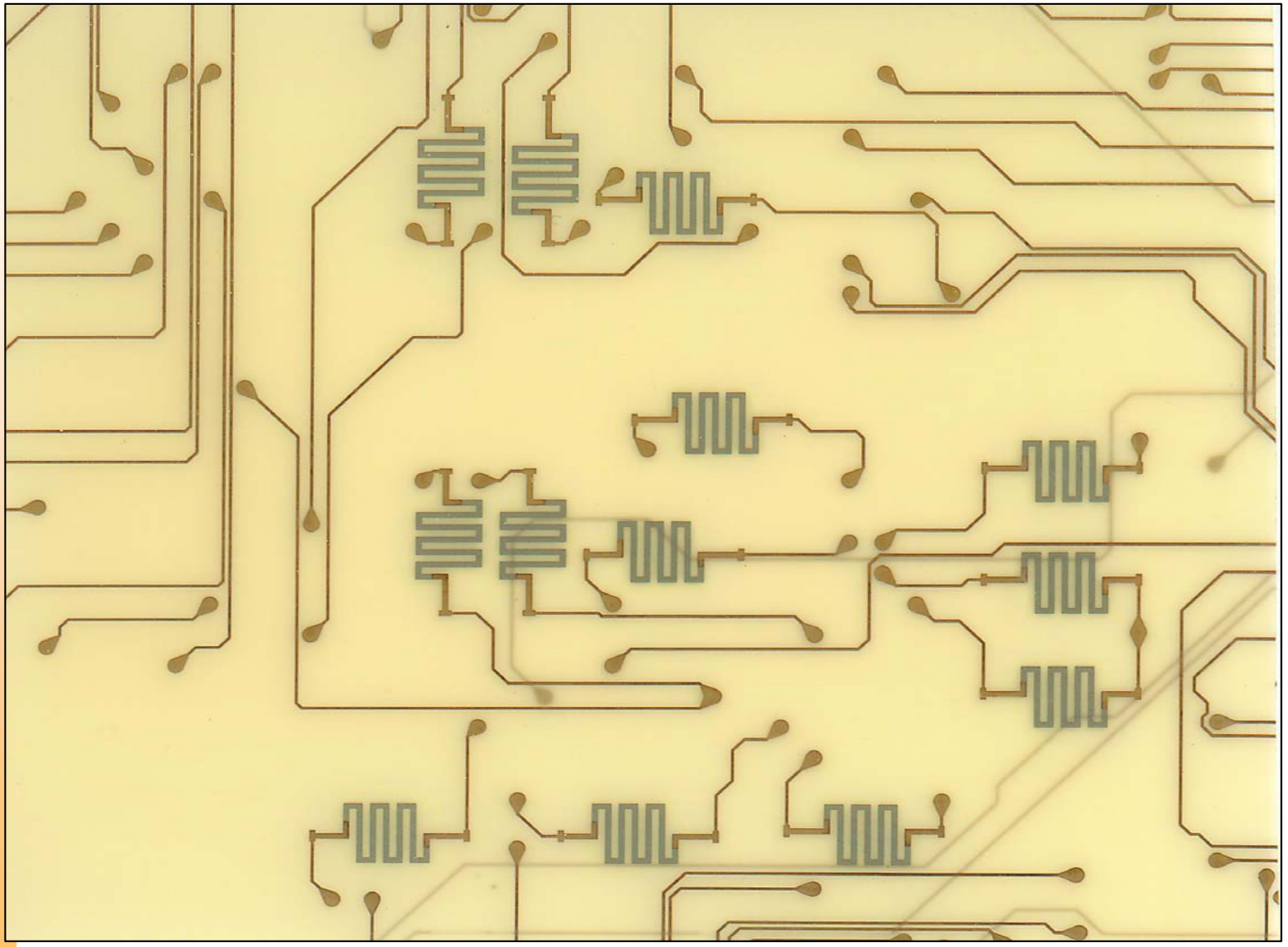
Ohmega/Faradflex ®

BC12

BC8

1R25 with DFF COPPER FOIL at 200X

Application of NiP Resistors Using PT Copper



▲ *Pull-up resistors in an avionic application – Polyimide Dielectric*

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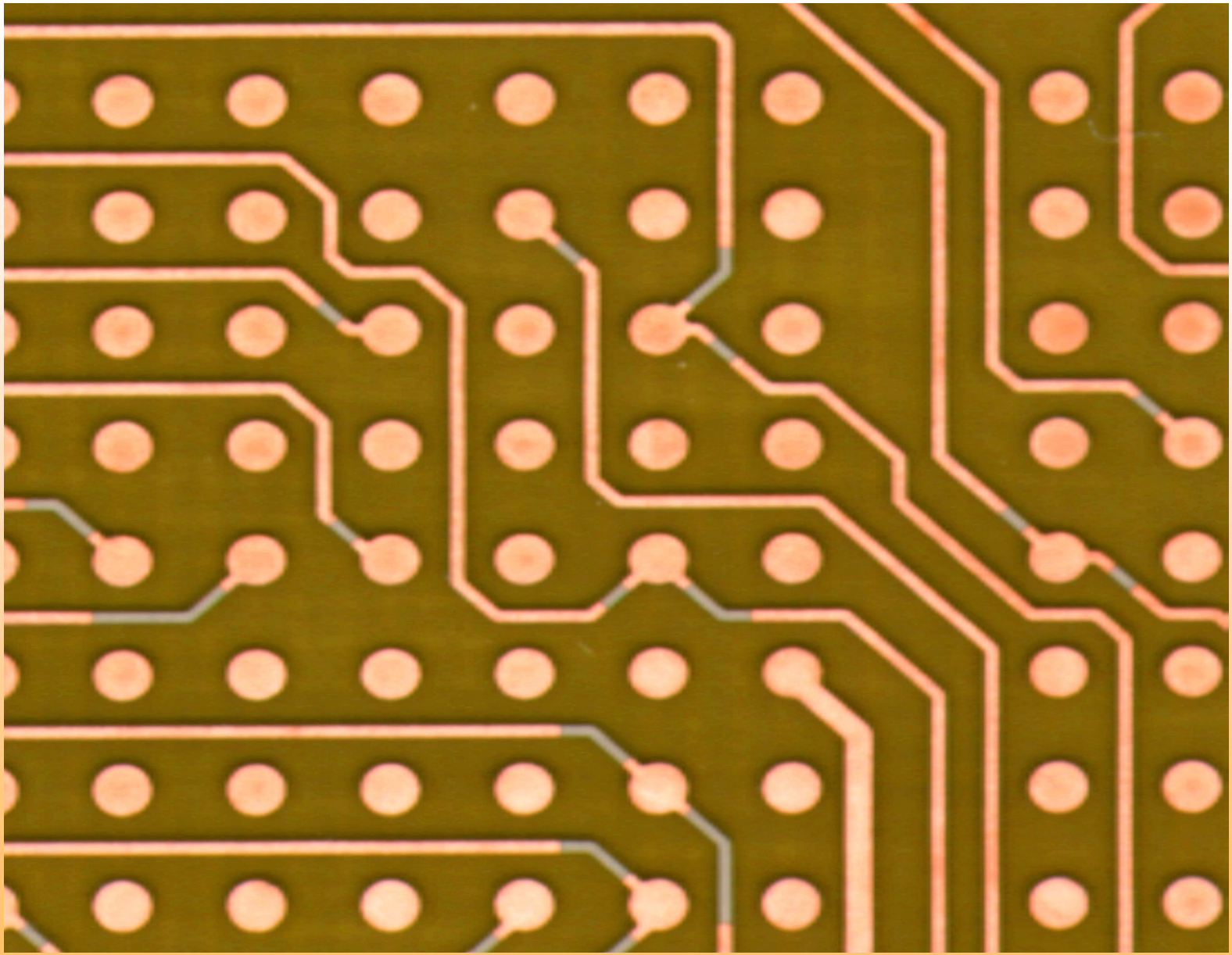
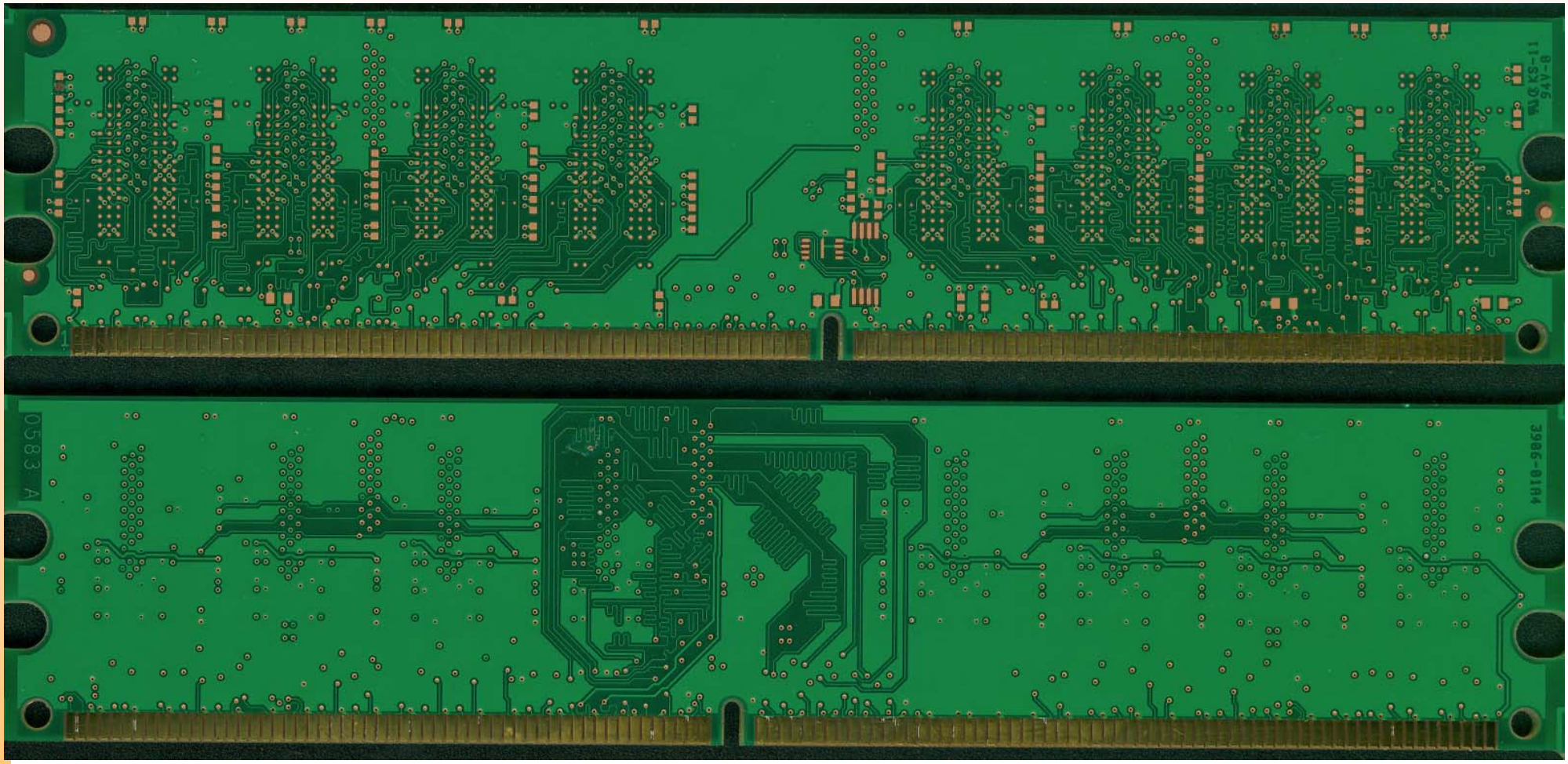


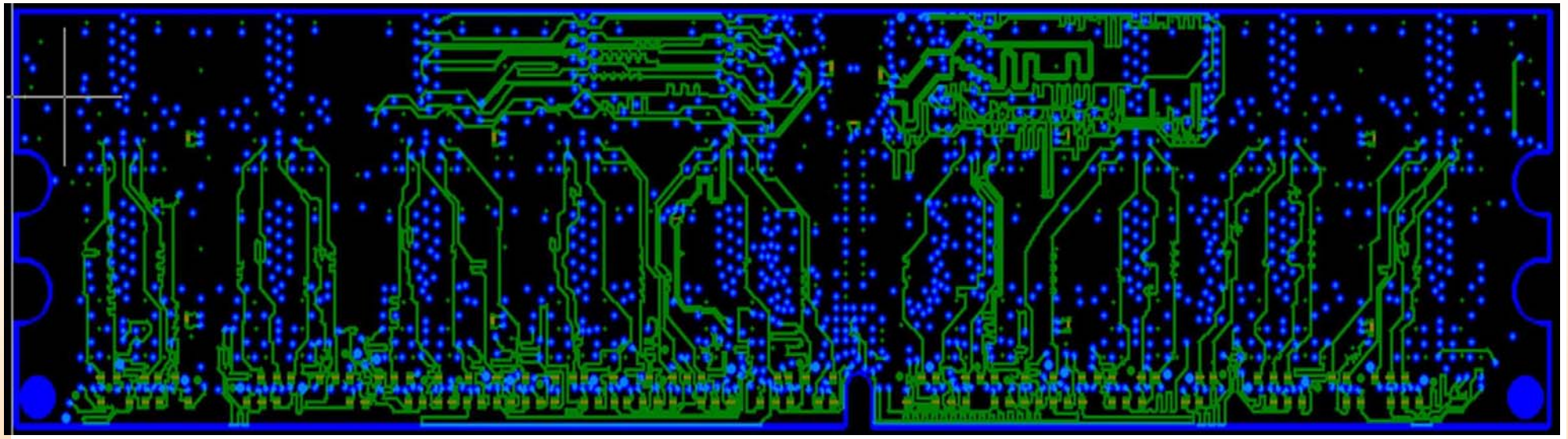
▲ Ohmega Resistor Built in Trace (ORBIT)® *as series terminating resistors.*

Application of NiP Resistors Using PT Copper

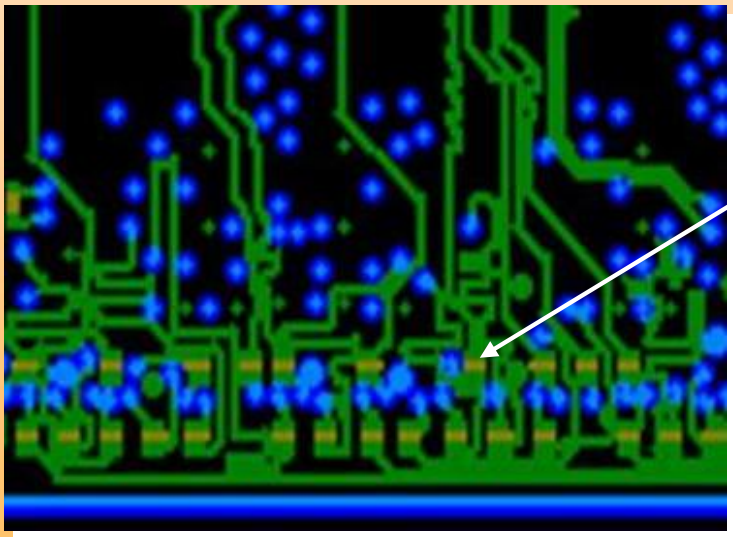


▲ *NiP Resistors Embedded in DRAM PCB – FR4 Dielectric for Lead-Free Assembly*

Application of NiP Using PT Copper



▲ *NiP Resistors on Inner Layer of DRAM Design*



▲ *Enlargement of Above Design*

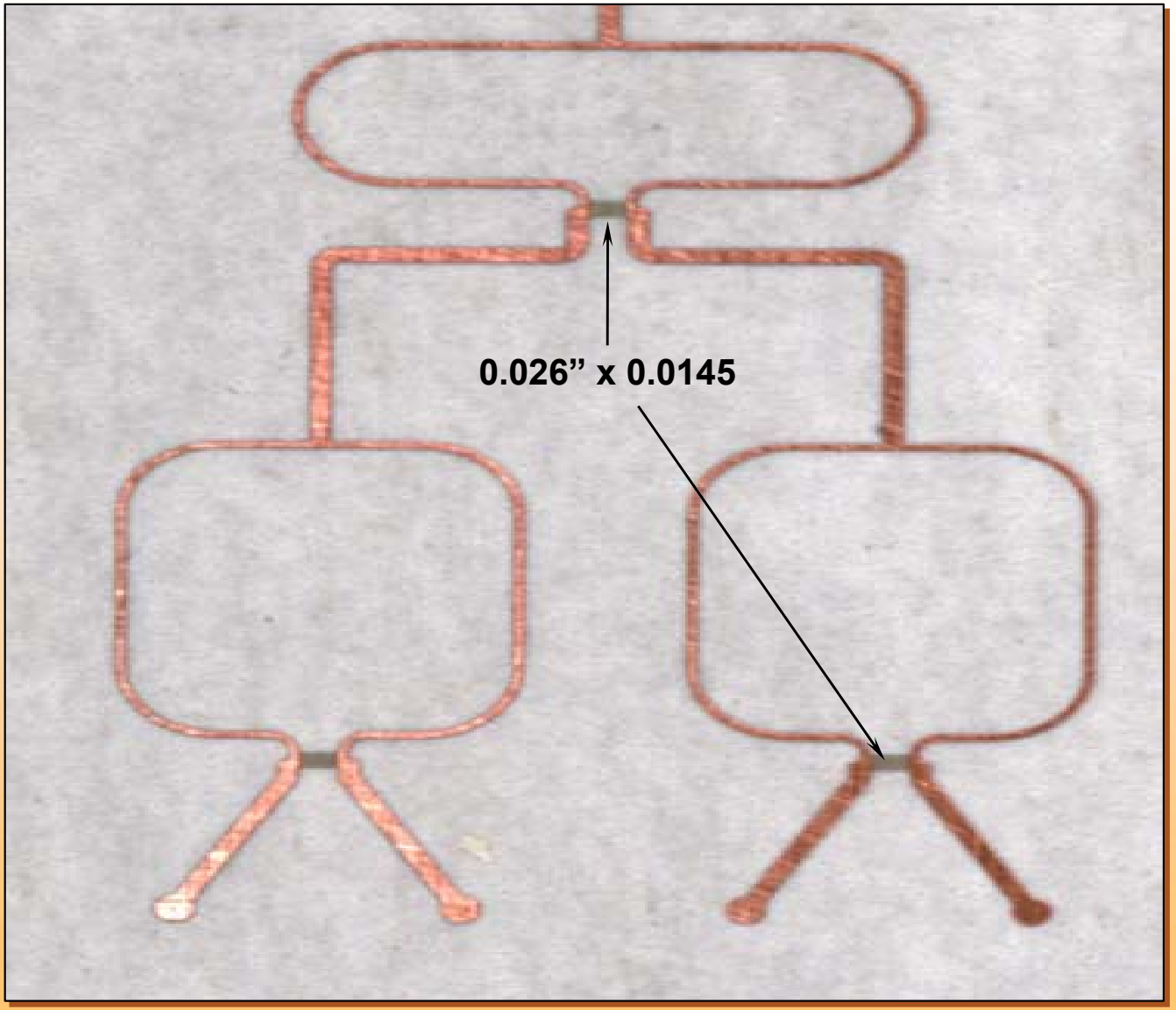
NiP Material Using PT Copper

Results of Lead-Free Assembly Simulation

SUBSTRATE	% ΔR AT 1 CYCLE	% ΔR AT 2 CYCLE	% ΔR AT 5 CYCLE	% ΔR AT 10 CYCLE	% ΔR AT 15 CYCLE	% ΔR AT 20 CYCLE	% ΔR AT 25 CYCLE	TEST METHOD	CONDITION
FR-4	-0.36	-0.47	-0.47					T260. 20 sec	no bake
Lead Free	-0.57	-0.58	-0.62	-0.54	-0.24	-0.13	-0.08	T288, 10 sec	5 hr bake
Lead Free	-0.27	-0.37	-0.46	-0.27	-0.16	0.17	0.26	T288, 10 sec	no bake
FR-4	-1.39	open						T288, 10 sec	5 hr bake
FR-4	-1.25	open						T288, 10 sec	no bake

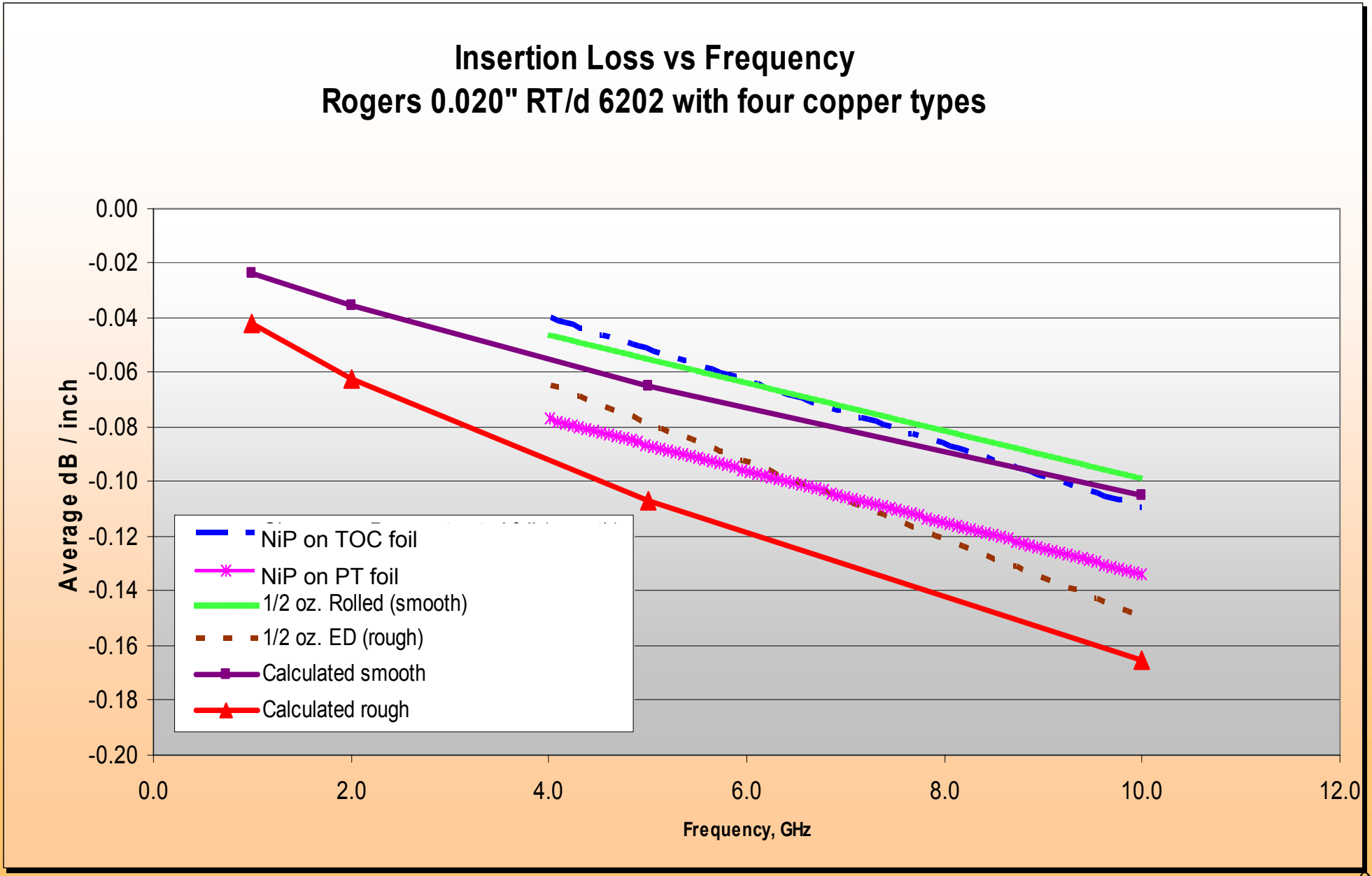
Memory board, 10 layers with one layer of 22 ohm resistors, 23 mils x 10 mils.
Built using Double Treat 1/2A50ohm NiP laminate.
The FR-4 PCB used a standard multifunctional epoxy laminate.
The "lead-free" PCB used a phenolic-cured laminate.
Testing per IPC-TM-650, Method 2.4.13.1, baking was performed at 125 dC.

Application of NiP Resistors Using TOC Copper in Microwave Applications



▲ *Enlargement of a four-up array 16-way power divider with 50 Ω/sq NiP resistors*

Comparison of Various Copper Types of NiP Material in Microwave Applications



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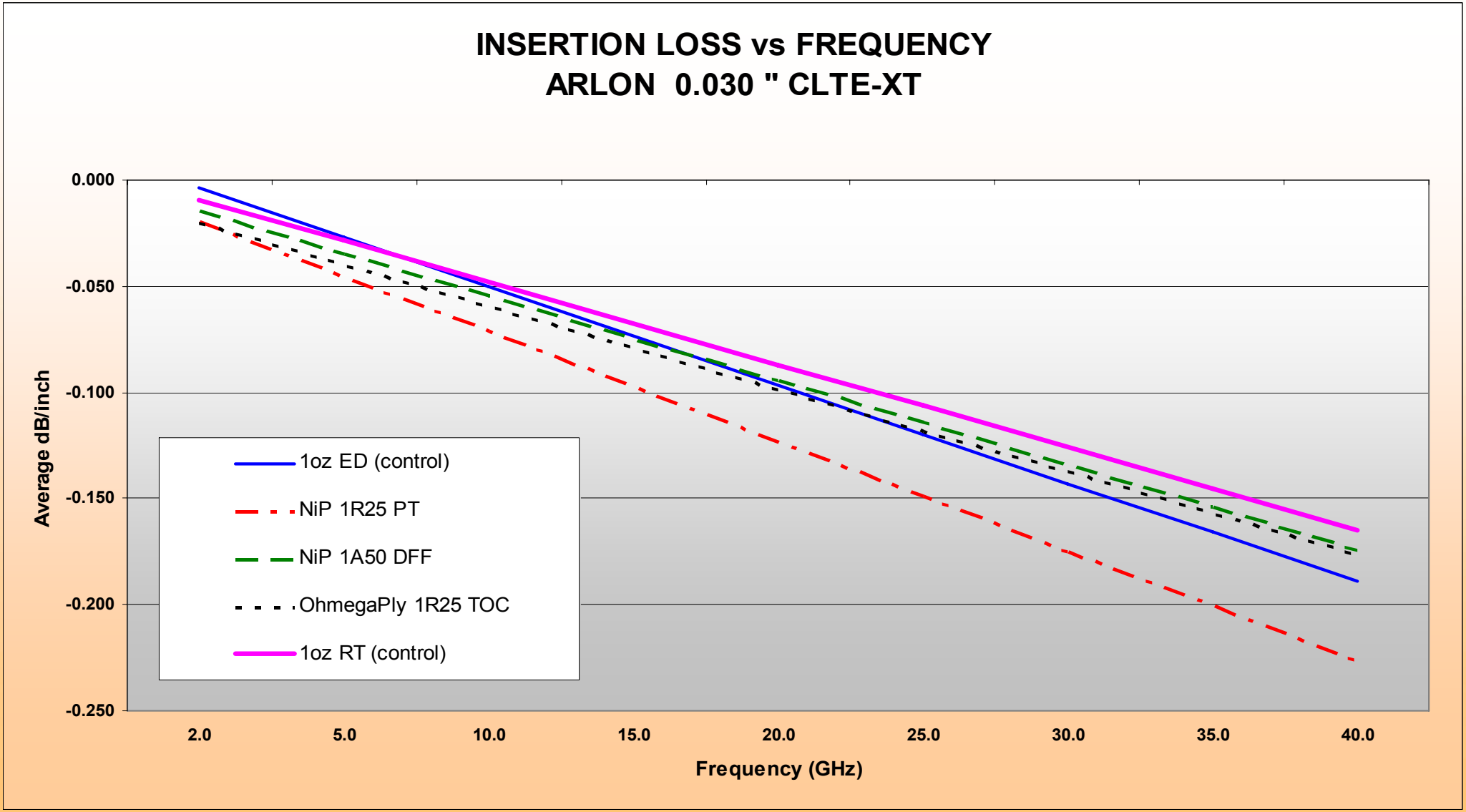
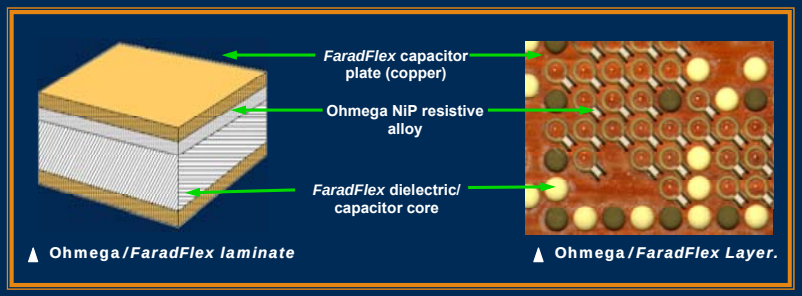


Application of NiP Resistors with DFF Copper Embedded Resistor/Capacitor Core

Ohmega®/*FaradFlex*®

EMBEDDED RESISTANCE-CAPACITANCE TECHNOLOGY

Ohmega®/*FaradFlex*® is a combined product of the OhmegaPly® thin film resistive-conductive material (RCM) laminated to a *FaradFlex*® dielectric material and subtractively processed to produce embedded RC Networks.



- Combined Laminate Product.
- Resistance and Capacitance in the same core.
- Developed to accommodate high density designs.
- Embedded Resistor and Capacitor Networks
- Improved signal integrity by better impedance matching.
- Improved signal to noise ratios.
- Standard PCB Subtractive Processing.
- Greater cost effectiveness than separate BR and BC cores.

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Application of NiP Resistors Using DFF Copper

SPECIFICATIONS AND PROPERTIES for 1R25 / BC24

1-Capacitor Layer Properties

Properties	Ohmega/FaradFlex Core	Remarks and Conditions
Copper Weight, µm	35	Nominal
Sheet Resistivity, ohms / square	25	Nominal
Dielectric Thickness, µm	24	Nominal
Cp@ 1MHz, nF/in2(pF/cm2)	1.0 (155)	IPC-TM 650 2.5.5.3
Dk @1MHz	4.4	IPC-TM 650 2.5.5.3
Loss Tangent @ 1MHz	0.015	IPC-TM 650 2.5.5.3
Peel Strength, lbs/in	5.0	IPC-TM 650 2.4.9
Dielectric Strength, kV/mil	5.3	IPC-TM 650 2.5.6.3
Tensile Strength, Mpa(kpsi)	152(22.0)	ASTM D-882 A
Elongation, %	18.5	ASTM D-882 A

Synergistic Effect!

2-NiP Resistor Properties

Properties	Ohmega/FaradFlex Core	Ohmega Core FR-4 (control)	Remarks and Conditions
Sheet Resistivities (ohm/square)	25	25	Nominal
Material Tolerance	+/-5%	+/-5 %	
Load Life Cycling Test Resistor Size: 0.500" X 0.050" Loaded: (Δ R%) @ 150mW Unloaded: (Δ R%)	 1.6 1.2	 <5	MIL-STD-202-108I Ambient Temp: 70C On Cycle: 1.5 hrs Off Cycle: 1.5 hrs Length Of Test: 10000 hrs
Current Noise Index in dB	<-23	<-15	MIL-STD-202-308 Voltage Applied: 5.6 Volts
Humidity Test (Δ R%)	0.5	0.5	MIL-STD-202-103A Temp: 40 °C Relative Humidity: 95% Time: 240 hrs
Characteristic (RTC) PPM/°C	-6.0	50	MIL-STD-202-304 Hot Cycle: 25°, 50°,75° 125°C Cold Cycle: 25°, 0°,-25°, -55°C
Thermal Shock (Δ R%)	0.2	-0.5	MIL-STD-202-107B No of Cycles: 25 Hot Cycle Temp: 125 °C Cold Cycle Temp: -65 °C
Solder Float (Δ R%) After 1 Cycle After 5 cycles	 -0.4 -0.6	 0.5	MIL-STD-202-210D Temp: 260°C Immersion: 20 Second
Power Density (mW/mil ^{2}) derated at 50%	0.45	0.15	Step-up Power Test Resistor Size: 0.020" X 0.035"

Ohmega®/*FaradFlex*® Material Availability

OhmegaPly® Sheet Resistivities (Ohm/square)	FaradFlex® Products					
	BC24	BC16	BC12	BC8	BC12TM	BC16T
10	x	x	o	o	o	o
25	x	x	x	x	o	o
50	x	x	x	x	o	o
100	x	x	o	o	o	o
250	x	x	o	o	o	o
Cp @ 1MHz/1GHz (pF/cm^2)	180/160	250/225	300/270	480/430	700/600	1700/1450

X- Currently Available

O- Available 2008

Conclusion

- Embedded Thin-Film NiP resistors on advanced dielectric materials require modifications of the substrate topography.
- This paper has shown the successful implementation of these modifications.