Kinetic Metallization™

Polymer Composite Materials

AeroMat 2011 Session 4 - Emerging Materials and Processes

25 May, 2011

Ralph Tapphorn, J. Henness, and H. Gabel

SBIR DATA RIGHTS

Contract No.: NSF IIP-0724502

Contractor Name: Innovative Technology, Inc. (dba) Inovati

Contractor Address: PO Box 60007, Santa Barbara, CA 93160

Expiration of SBIR Data Rights Period: 5 years

The Government's rights to use, modify, reproduce, release, perform, display, or disclose technical data or computer software marked with this legend are restricted during the period shown as provided in paragraph (b) (4) of the Rights in Noncommercial Technical Data and Computer Software--Small Business Innovative Research (SBIR) Program clause contained in the above identified contract. No restrictions apply after the expiration date shown above. Any reproduction of technical data, computer software, or portions thereof marked with this legend must also reproduce the markings.

Overview

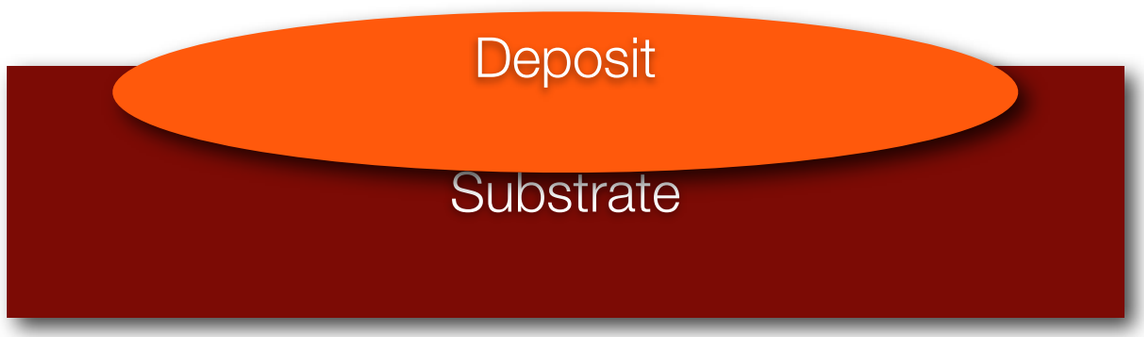
- Kinetic Metallization Process
- KM-Coating Production System (KM-PCS)
- Conformal Antenna and RF Applications
- Polymer Composite Dielectric Applications
- Polymer Coating Repairs & Applications
- Summary

Introduction to Kinetic Metallization™ (KM)

Substrate

Introduction to Kinetic Metallization™ (KM)

- Metal deposition through particle impact
- Low-temperature << melting point
- **Sonic Mach 1 Nozzle**
  - High particle velocity > 750 m/s
  - Pressure < 1 MPa (150 psig)
  - Temperatures to 450 ℃
  - Powder preheater & mixer
  - Powder injection at nozzle inlet
  - Low noise < 75 dBa @ 1 m
  - High quality coatings



Kinetic Metallization™ Difference

Powder

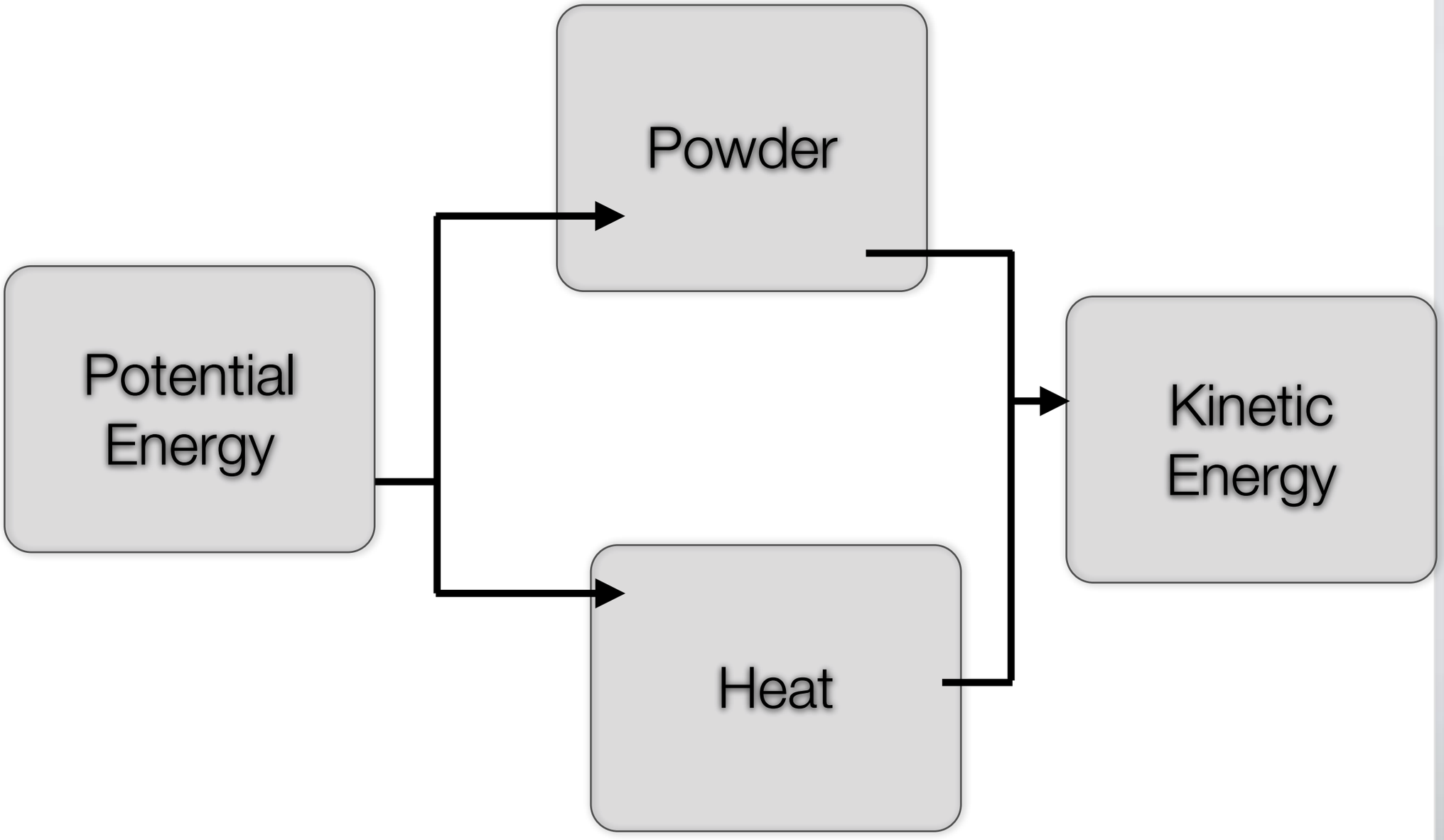
Potential Energy

Kinetic Energy

Heat

Mass Loading ~ 100% gas mass flow

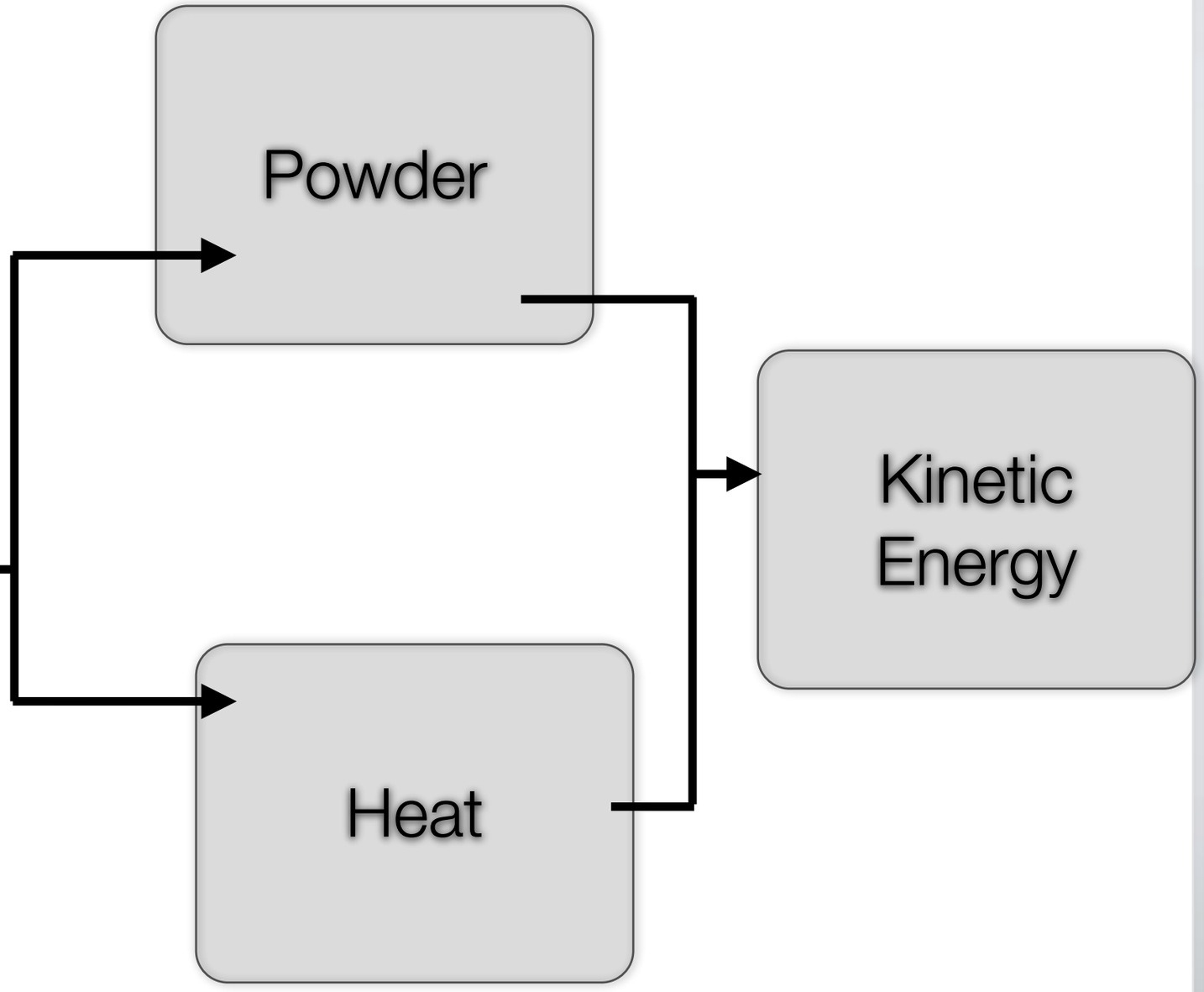
Kinetic Metallization™ Difference



Mass Loading ~ 100% gas mass flow

Kinetic Metallization™ Difference

Gas Storage System



Mass Loading ~ 100% gas mass flow

Kinetic Metallization™ Difference

Gas Storage System

Ultra-fine Powder Fluidizing Unit

Heat

Kinetic Energy

Mass Loading ~ 100% gas mass flow

Kinetic Metallization™ Difference

Gas Storage System

Ultra-fine Powder Fluidizing Unit

2.5 kW Thermal Conditioning Unit
< 150 psig

Kinetic Energy

Mass Loading ~ 100% gas mass flow

Kinetic Metallization™ Difference

Gas Storage System

Ultra-fine Powder Fluidizing Unit

Sonic Deposition Nozzle with Powder Preheater & Mixer

2.5 kW Thermal Conditioning Unit < 150 psig

INOVATI

Mass Loading ~ 100% gas mass flow

INOVATI

Kinetic Metallization Systems

- Low temperature & Pressure (< 150 psig)
- KM-CDS, KM-PCS, & KM-MCS
- Customers Worldwide (US, Japan, Australia, China)

KM Coatings

- RF traces (Cu & Ni) on polymers & ceramics
- Deposition of polymer coatings (e.g.,PEEK, PTFE)
- Wear resistant coatings (WC-Co, WC-CoCr)
- Corrosion resistant coatings (Al-Trans®)
- Refractory bonds (Nb) for HT composites

INOVATI

INOVATI

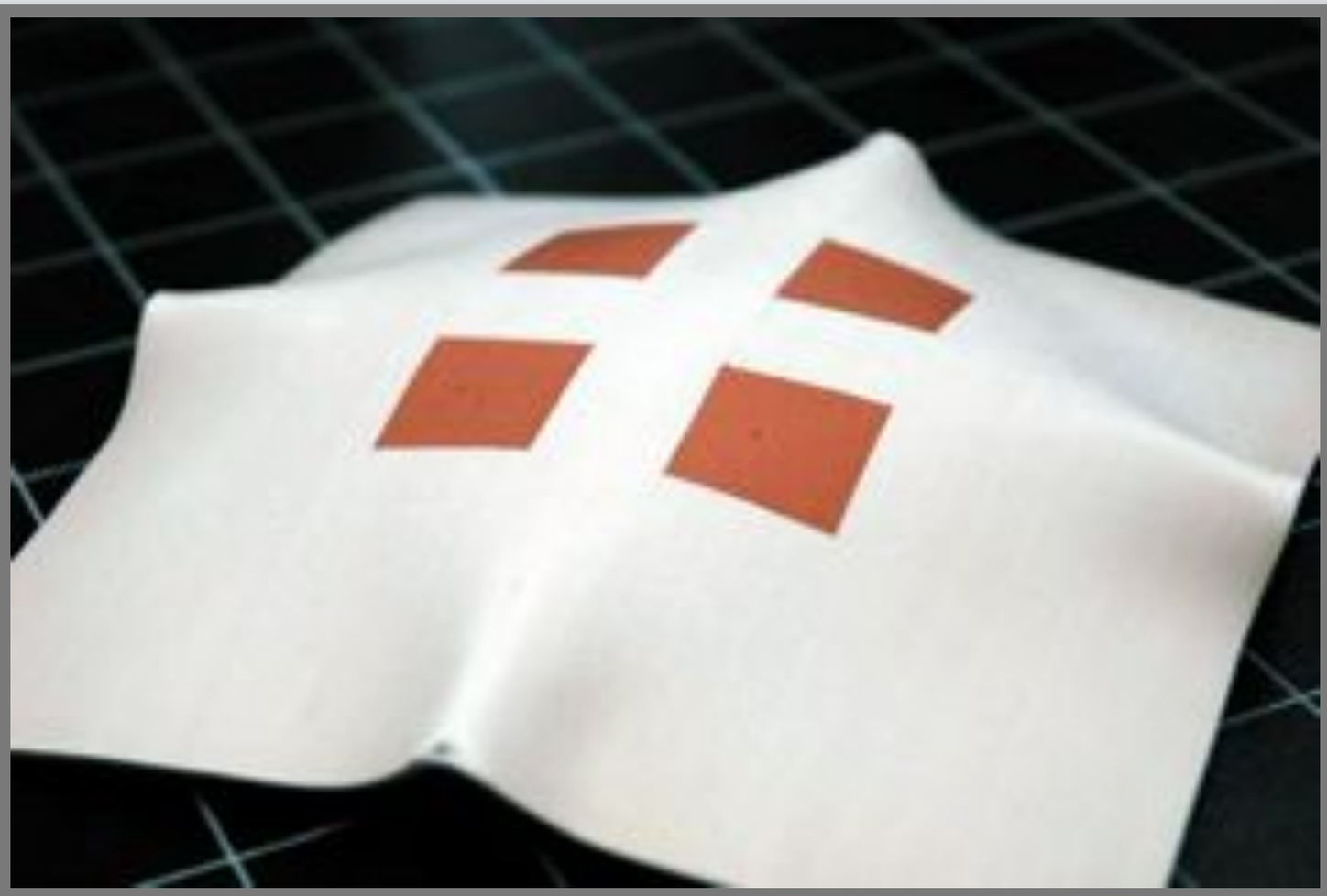
KM-Coating Production System

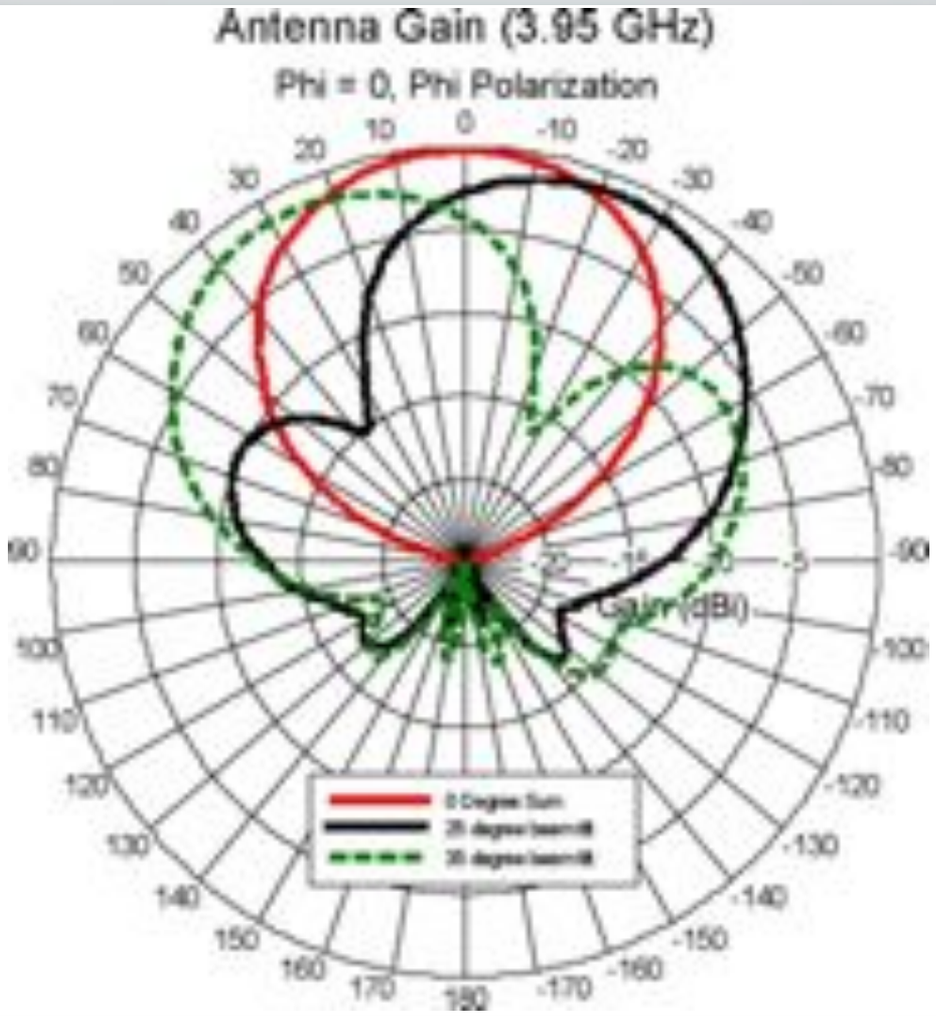
Direct Write Applications-Part I

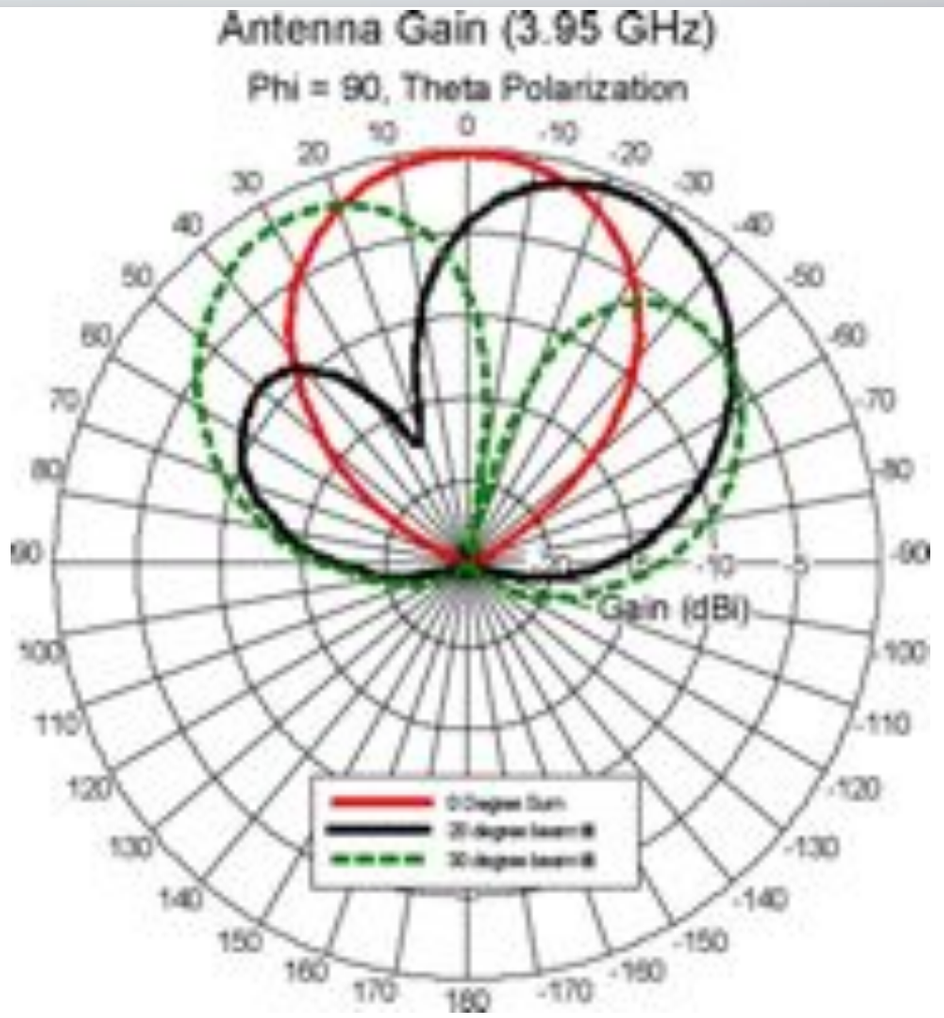
Conformal Antenna & RF Devices

Military Global SatCom Grid

KM Direct Write of Cu Patches on Doubly Curved Dielectrics

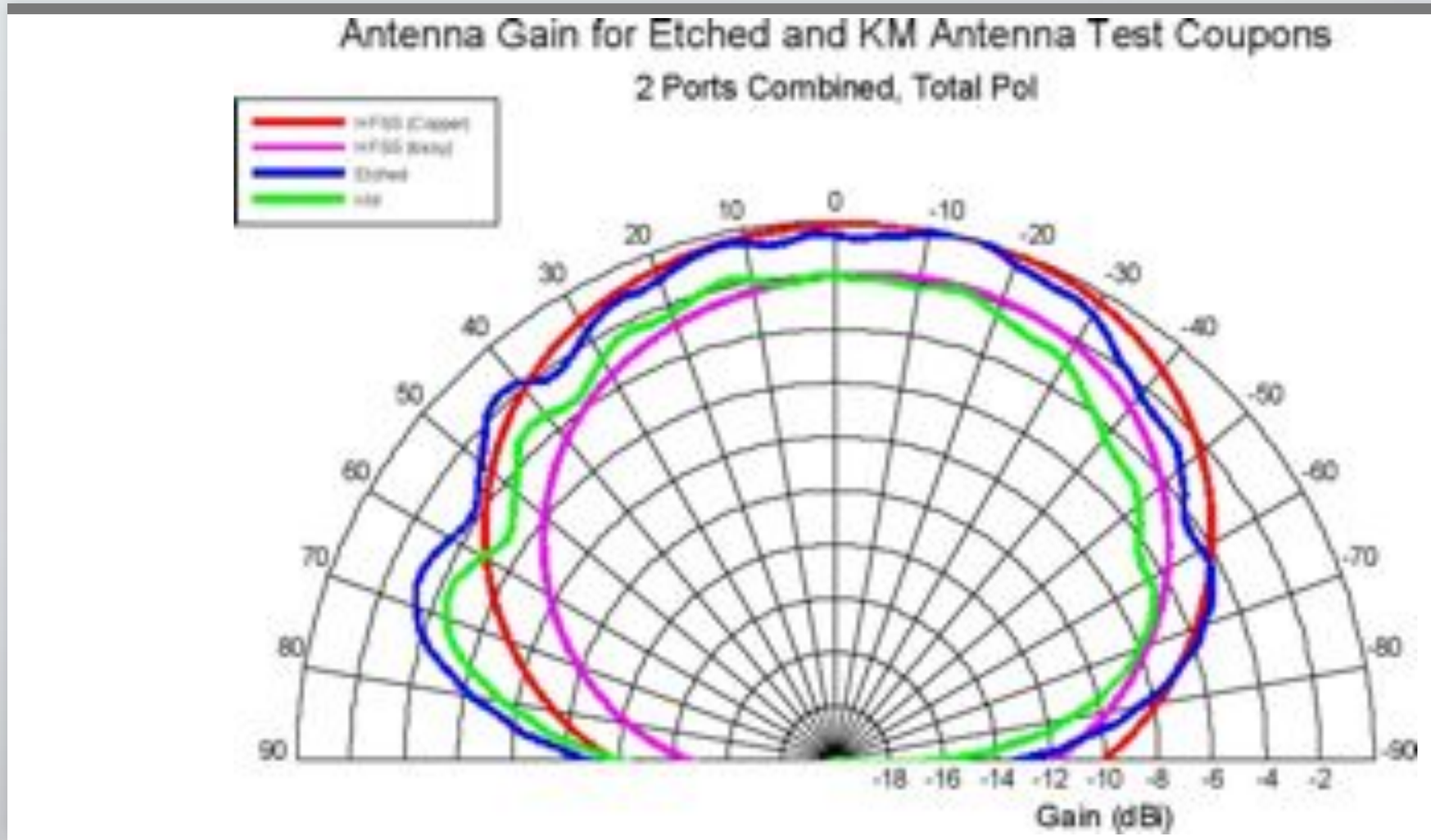


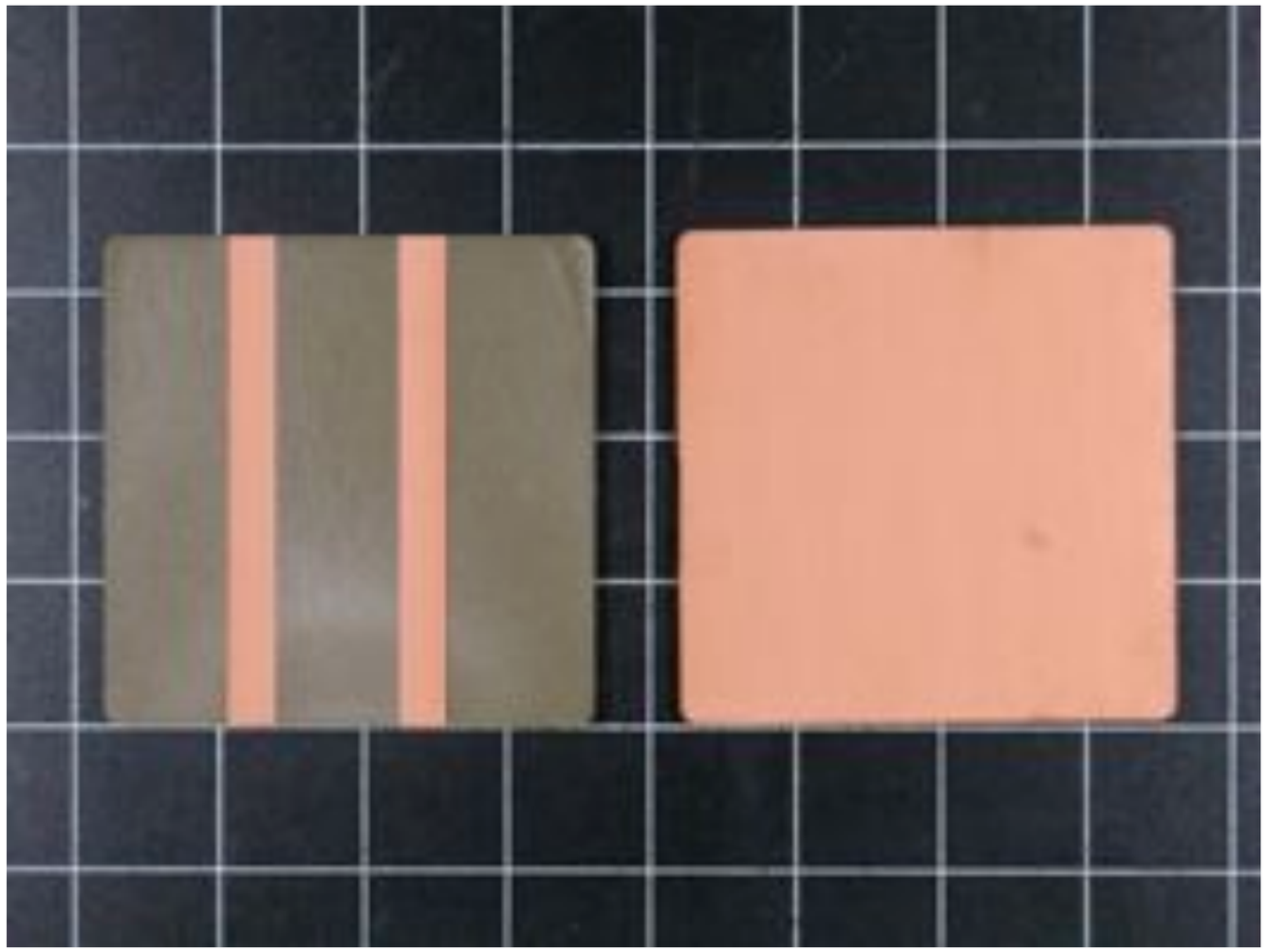




Antenna Beam Steering with 4-element Time Delays

Antenna Gain
KM Cu on RO-3003



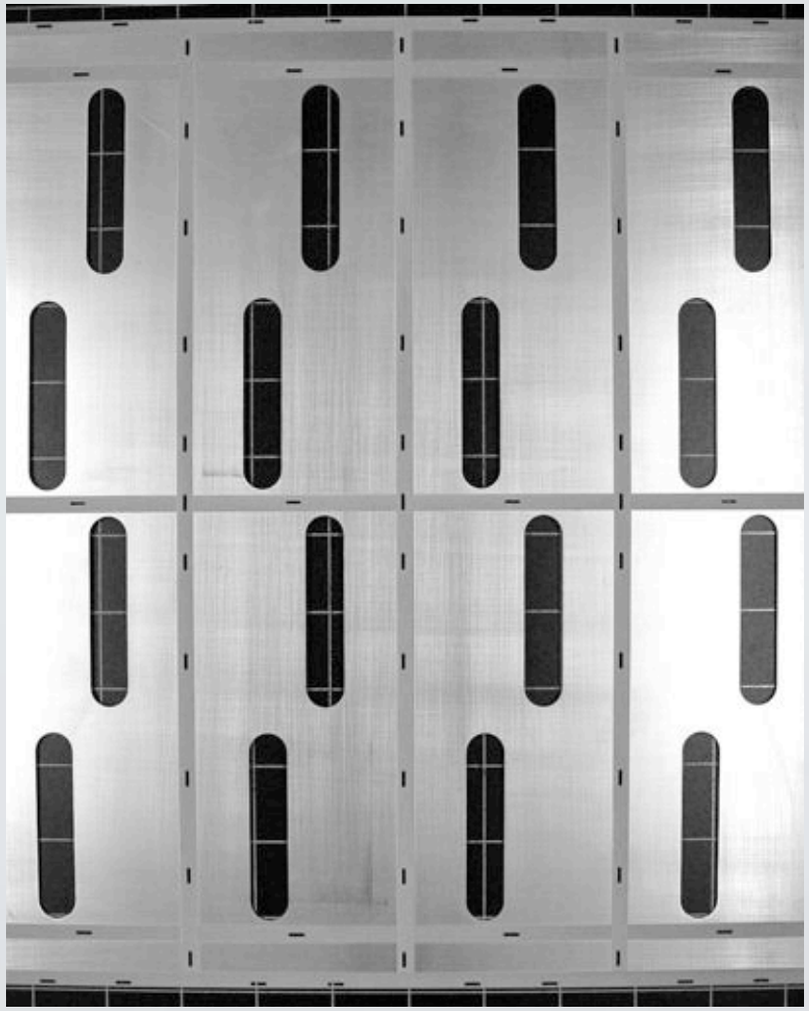


Microstrip Transmission Lines
KM Cu on Ultem-6202 Plastic

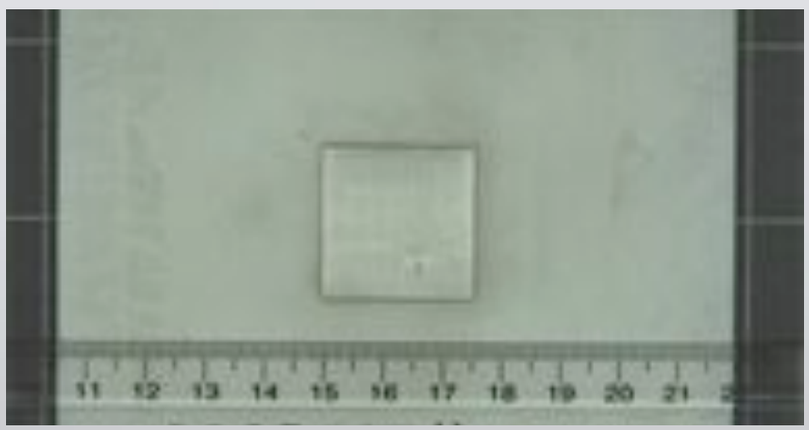
Micrograph of
KM Cu on Ultem Plastic

RF Copper Stripline Performance Characteristics

	Dielectric Material	Microstrip Coating	Dielectric Constant	Loss Tangent	Q @ ~1GHz	Dielectric Attenuation Factor (dB/m)	Conductor Attenuation Factor (dB/m)
Commercial Products	RO-3003	Cu-Clad	3.0	0.0013	340	0.16	0.25
	RO-3003	KM-Cu	3.0	0.0013	300	0.15	0.33



Brazing of Slotted Antenna Waveguides



Silver Antenna Patches on Ceramic Dielectrics

Other RF Electronic Applications

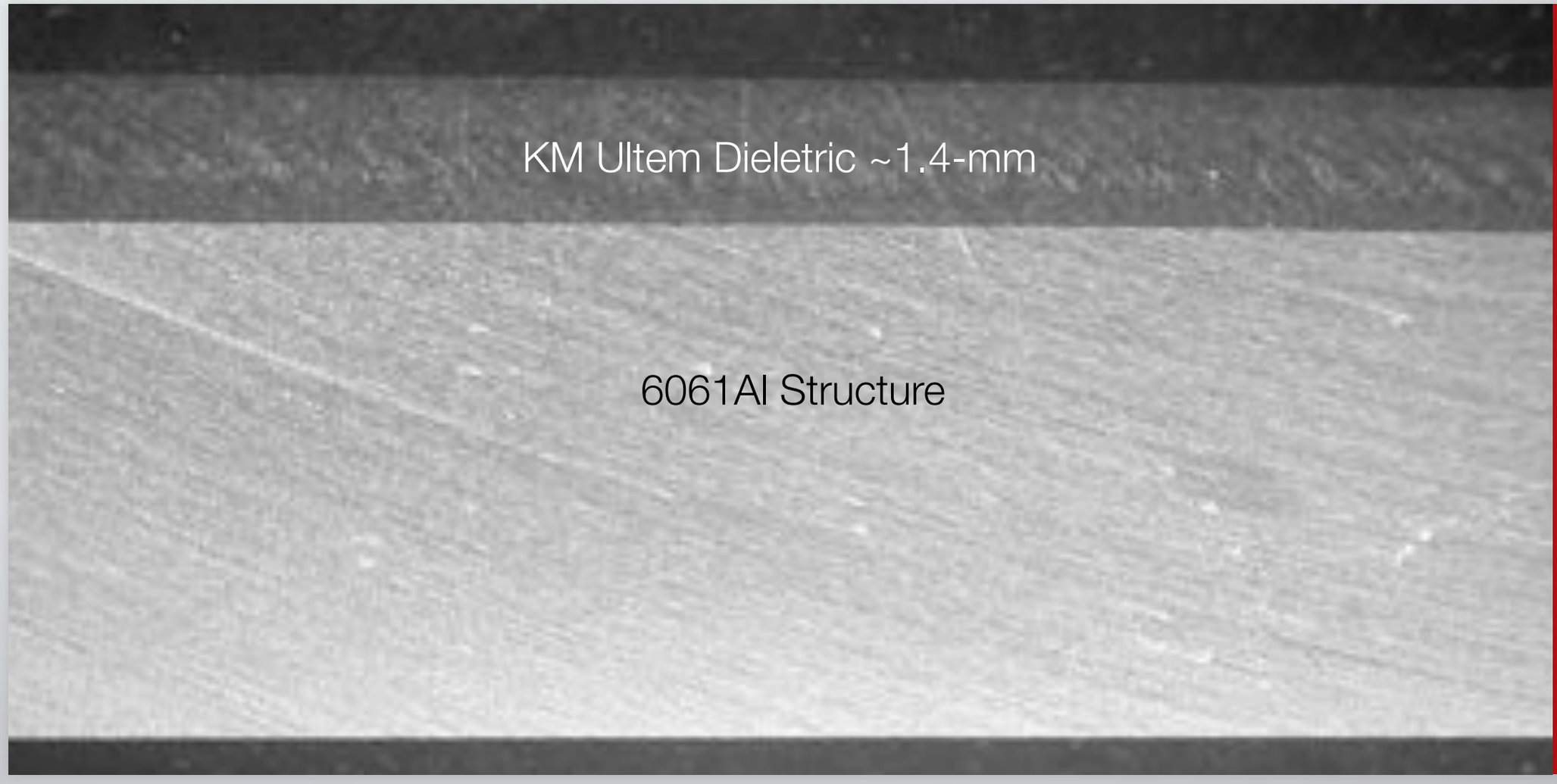
- High Temperature Antenna Materials (missiles & munitions)
- EMI Shielding of Polymer Structures
- RF Electronic Packaging
  - Brazing RF slot antenna systems

Direct Write Applications-Part II

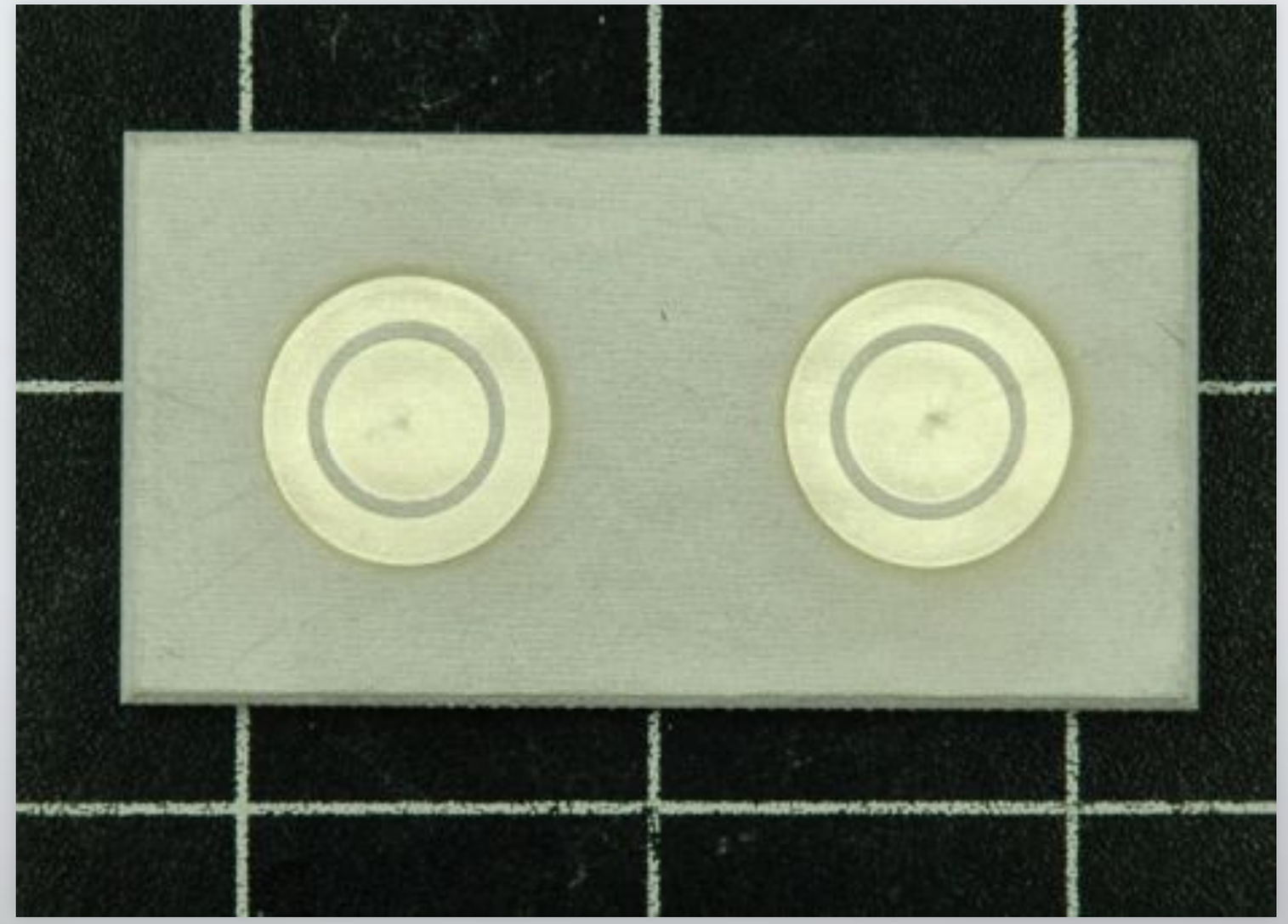
KM Polymer Dielectric Composites

- **Thermoplastic Polymer-Based Composites**
  - Polyetherimides (Ultem) & Polyamides (Nylon)
  - Fluoroplastics - (PTFE, PVDF)
  - PolyEtherEtherKetone (PEEK)
  - Polycarbonates (Lexan) & Acrylic
- **Ceramic 2nd Phase Materials**
  - Alumina, SiC, $BaTiO_3$, Z_2O
  - Ferroelectric & multiferroic materials (e.g. BaTiO3, PZT)

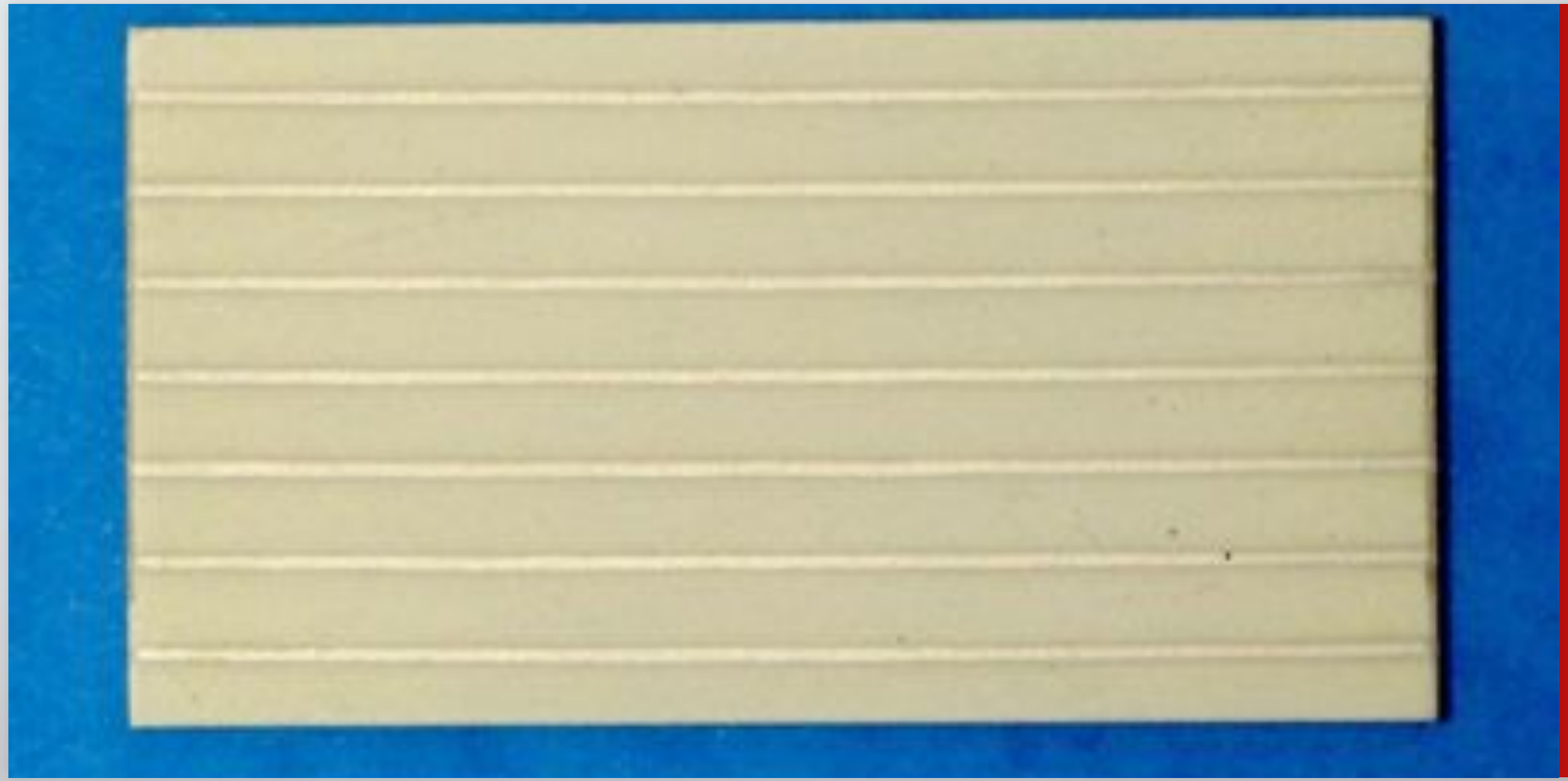
KM Dielectric Micrograph of Polymer Composite on 6061Al



KM Direct Write of Ag Electrodes on KM-PEEK Dielectric Composite

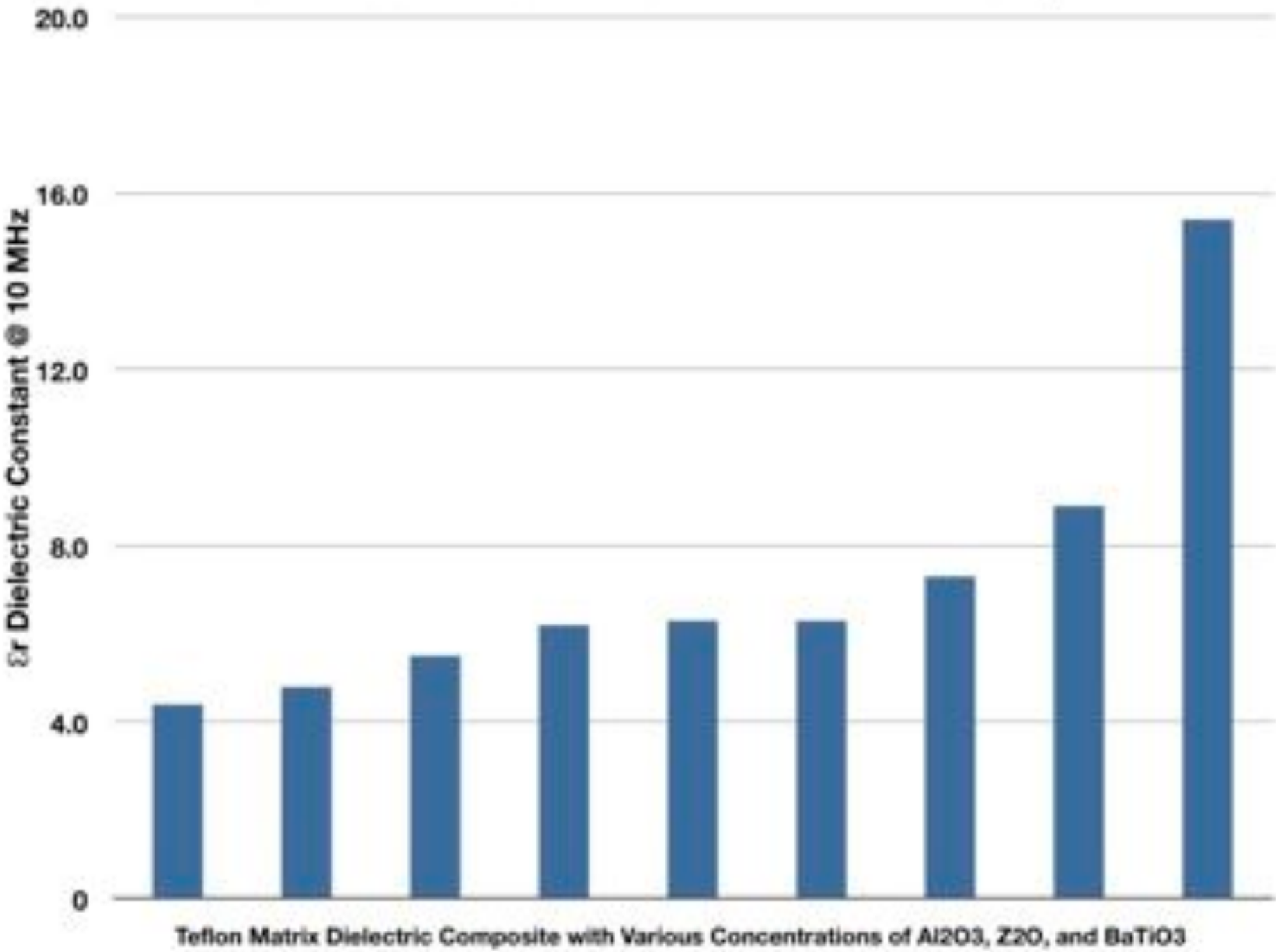


KM Silver Traces ~ 1-mm Width on PEEK Dielectric Composite



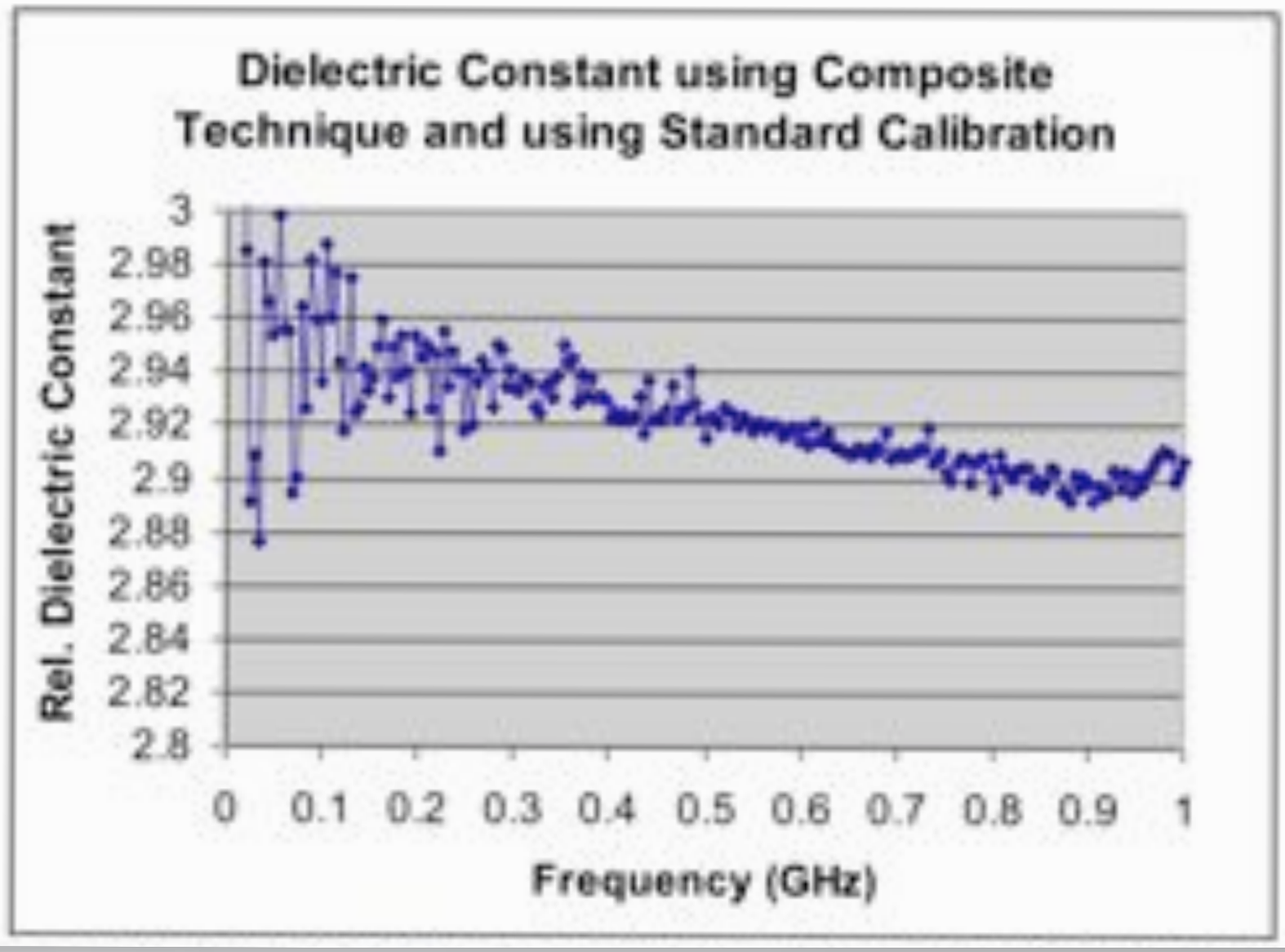
INOVATI

Variable Dielectric Constants with Teflon Matrix Composite



INOVATI

Frequency Response of KM Dielectric Composite



Direct Write-Future Applications

KM Variable Dielectric & Multiferroic

- RF & Antenna Devices
  - Micro-strip stepped impedance filters
  - Phase shifting filters
  - Magnetic tunable dielectric materials
  - Low profile & wide bandwidth antenna (30 MHz - 5 GHz)
    - Tunable dielectric ground planes
  - Piezoelectric embedded sensors

KM Polymer Composites

General Coating Applications

- Field repairs of powder coating (no post curing)
- Corrosion protection & sealants of metallic surfaces
- Wear resistance of polymer surfaces
- Bond coats for polymer and ceramic composites
- Repairs of fiber-reinforced composites
  - Leading edge of helicopter blades

Summary

- **KM Polymer-Base Coatings**
  - Conformal antenna systems
  - Tunable dielectrics for RF devices
  - Piezoelectric sensors
  - Corrosion protection & bond coats
- **KM of Polymer Composites & Metallic Electrodes**
  - Direct write of antenna and RF elements & devices
  - Polymer coating applications with no post-curing