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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)
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 °C
- Powder preheater & mixer
- Powder injection at nozzle inlet
- Low noise < 75 dBA @ 1 m
- High quality coatings
Mass Loading ~ 100% gas mass flow

Kinetic Metallization™ Difference

- Potential Energy
- Powder
- Heat
- Kinetic Energy
Kinetic Metallization™ Difference

Potential Energy → Powder → Heat → Kinetic Energy

Mass Loading ~ 100% gas mass flow

Friday, June 3, 2011
Kinetic Metallization™ Difference

Gas Storage System

Powder

Heat

Kinetic Energy

Mass Loading ~ 100% gas mass flow

Friday, June 3, 2011
Kinetic Metallization™ Difference

Gas Storage System

Ultra-fine Powder Fluidizing Unit

Heat

Kinetic Energy

Mass Loading ~ 100% gas mass flow

Friday, June 3, 2011
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

Friday, June 3, 2011
Kinetic Metallization™ Difference

Gas Storage System

Ultra-fine Powder Fluidizing Unit

2.5 kW Thermal Conditioning Unit < 150 psig

Sonic Deposition Nozzle with Powder Preheater & Mixer

Mass Loading ~ 100% gas mass flow
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
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

<table>
<thead>
<tr>
<th>Dielectric Material</th>
<th>Microstrip Coating</th>
<th>Dielectric Constant</th>
<th>Loss Tangent</th>
<th>Q @ ~1GHz</th>
<th>Dielectric Attenuation Factor (dB/m)</th>
<th>Conductor Attenuation Factor (dB/m)</th>
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</thead>
<tbody>
<tr>
<td>RO-3003</td>
<td>Cu-Clad</td>
<td>3.0</td>
<td>0.0013</td>
<td>340</td>
<td>0.16</td>
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<tr>
<td>RO-3003</td>
<td>KM-Cu</td>
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<td>0.0013</td>
<td>300</td>
<td>0.15</td>
<td>0.33</td>
</tr>
</tbody>
</table>
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$_2$O
  - Ferroelectric & multiferroic materials (e.g. BaTiO$_3$, PZT)
KM Dielectric Micrograph of Polymer Composite on 6061Al

KM Ultem Dielectric ~1.4-mm

6061Al Structure
KM Direct Write of Ag Electrodes on KM-PEEK Dielectric Composite
KM Silver Traces ~ 1-mm Width on PEEK Dielectric Composite
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