

# Kinetic Metallization™ Ceramic Armor Tiles

Military Applications - Session I

24 May, 2012

R. Tapphorn, H. Gabel, L. Premuda, K. Hashimoto, and T. Crowe





# Metallic Encapsulation Ceramic Armor Tiles

- ❖ **Enhance Ballistic Properties**
  - ❖ Multiple hit resistance
  - ❖ Hydrostatic confinement to increase dwell time & mushrooming of projectiles
  - ❖ Improve durability and damage tolerance
  - ❖ Lightweight metals (Al or Ti)
- ❖ **Historical Fabrication Methods**
  - ❖ Powder metallurgy forming
  - ❖ Diffusion bonding - HIPing
  - ❖ Vacuum casting of liquid metal layers



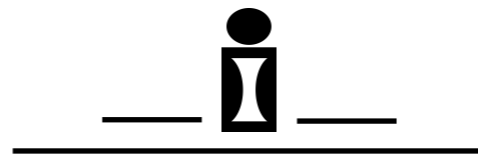
# Kinetic Metallization™ Coating Ceramic Armor Tiles

## ❖ **Spray Deposition Process**

- ❖ Low temperature (< 600 °F)
- ❖ CTE matching with ceramic blended bond coats
- ❖ Enhanced adhesion to SiC and B<sub>4</sub>C tiles

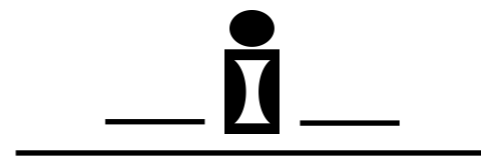
## ❖ **Adaptable & Low Cost Process**

- ❖ Low capital equipment investment
- ❖ Low cost - high deposition efficiency of Al & Ti feedstock
- ❖ Robotic flexibility to accommodate complex shapes



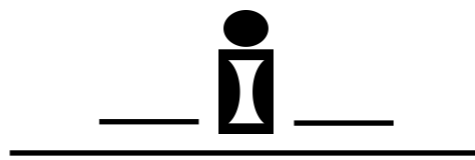
# Kinetic Metallization Process & Equipment





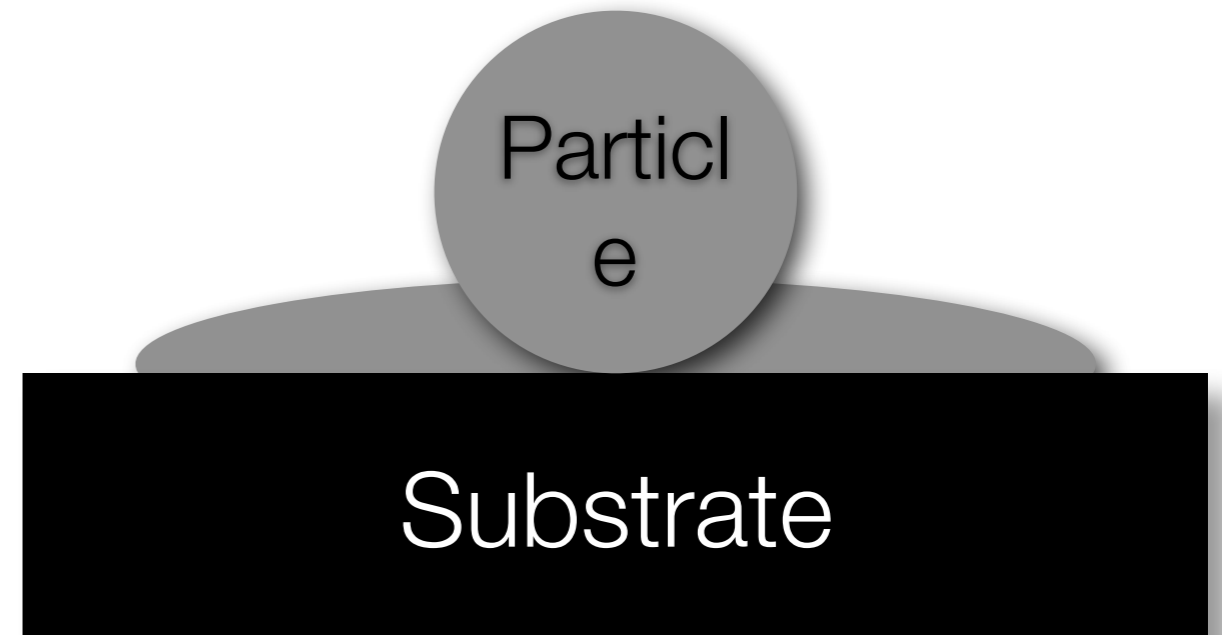
# Introduction to Kinetic Metallization

- ❖ Metal deposition through particle impact
- ❖ Low-temperature  $\ll$  melting point
- ❖ Low noise  $< 75$  dBa @ 1 m
- ❖ Highest quality — Lowest cost



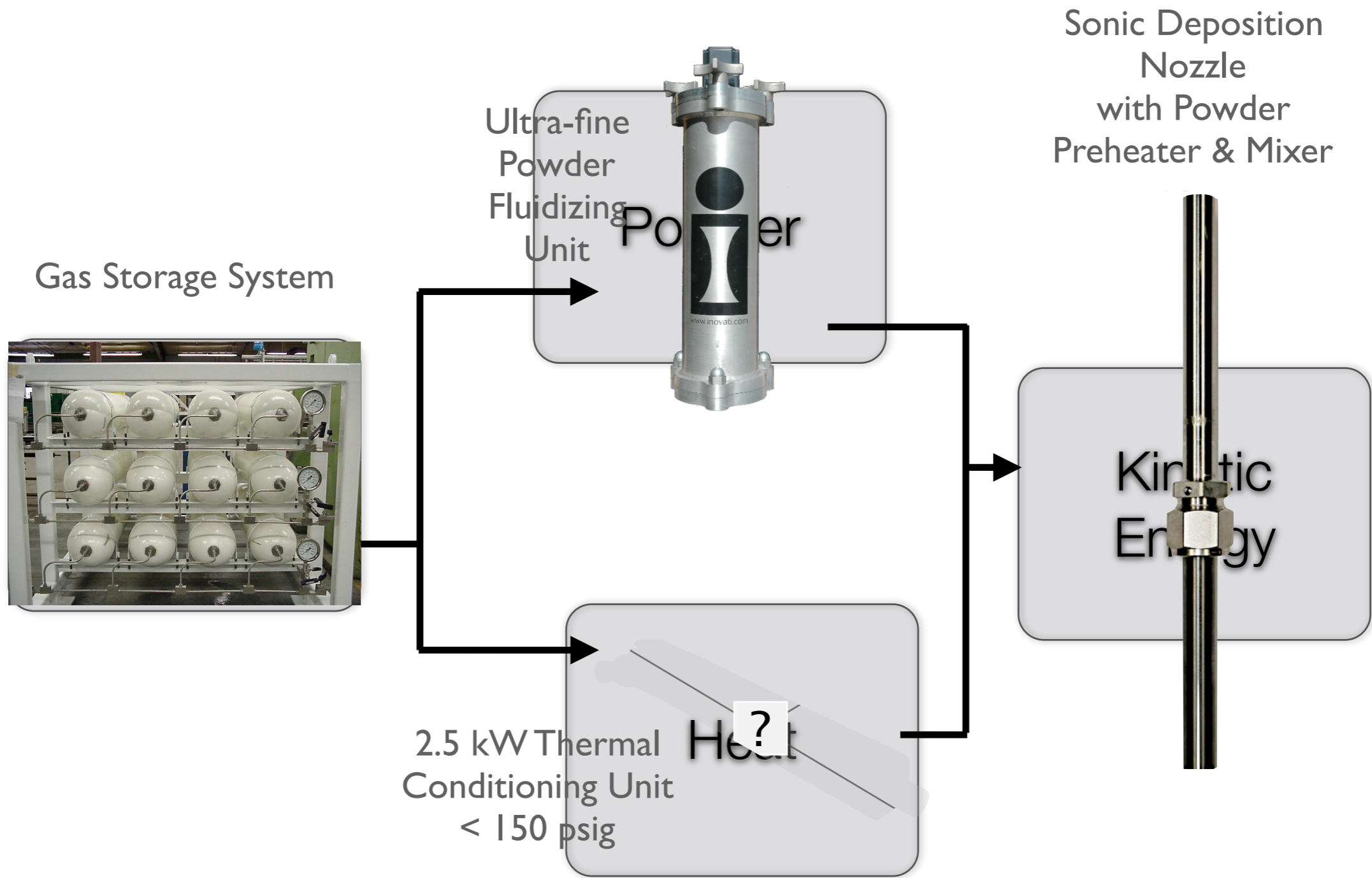
# Sonic Mach 1 Nozzle

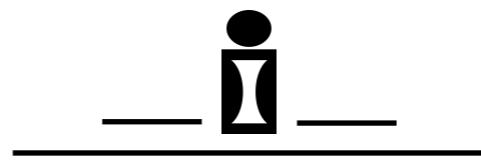
- ❖ High particle velocity  
> 750 m/s
- ❖ Powder injection at  
nozzle inlet
- ❖ Pressure < 1 MPa  
(150 psig)
- ❖ Temperatures to  
1100C
- ❖ Powder preheater &  
mixer





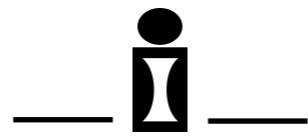
# Kinetic Metallization™ Process





# Latest Development

- ❖ KM-1373
- ❖ Highest temperature available
- ❖ Lowest gas flow available
- ❖ Highest quality coatings
- ❖ Lowest cost coatings



# KM Systems







# KM-1373 System

## ❖ Multiple Types Spray Guns

- ❖ Robotic, ID Gun, & Handheld
- ❖ Gas blending (He & GN2)

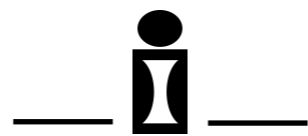
## ❖ Applicable Coatings

- ❖ 1100 °C Helium @ 60-90 psig
- ❖ WC-Co, Ni alloys, Nb, Ta
- ❖ GN2 (Al-Trans® , Cu, Zn, Ni)
- ❖ Polymers (PEEK, PTFE)

## ❖ Powder Loading

- ❖ ~100% gas mass flow

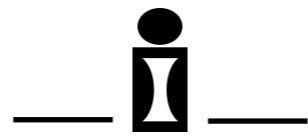




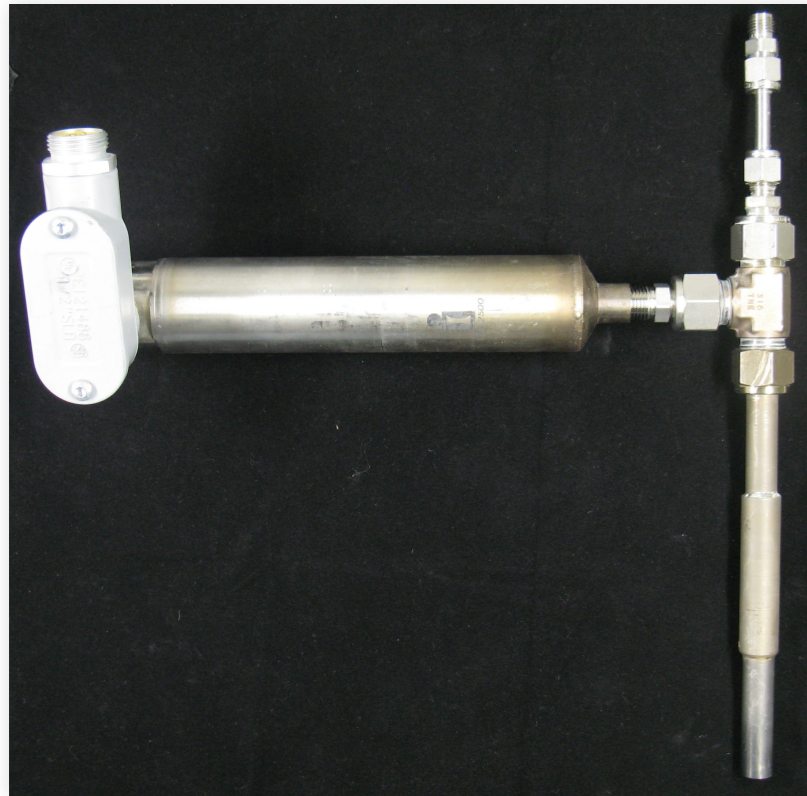
# KM-Mobile Coating System (KM-MCS)

- ❖ **KM-Mobile Coating System**
  - ❖ Handheld KM Spray Gun
  - ❖ Brush-sieve powder fluidizing units
  - ❖ Integrated subsystems on cart
- ❖ **Applicable Coatings**
  - ❖ GN2 (Al-Trans® , Cu, Zn, Ni)
  - ❖ He/GN2 (WC-Co, Ni alloys)
  - ❖ Composite polymers (PEEK, PTFE)





# KM Guns



INOVATI

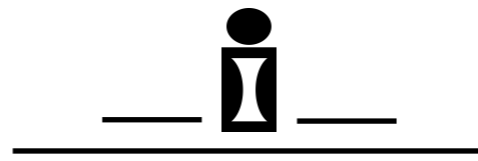




# KM ID Gun

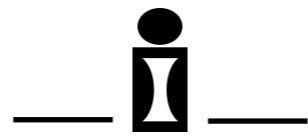
Bore Dimensions  
Down to 50 mm ID  
Bore Lengths > 1 meter



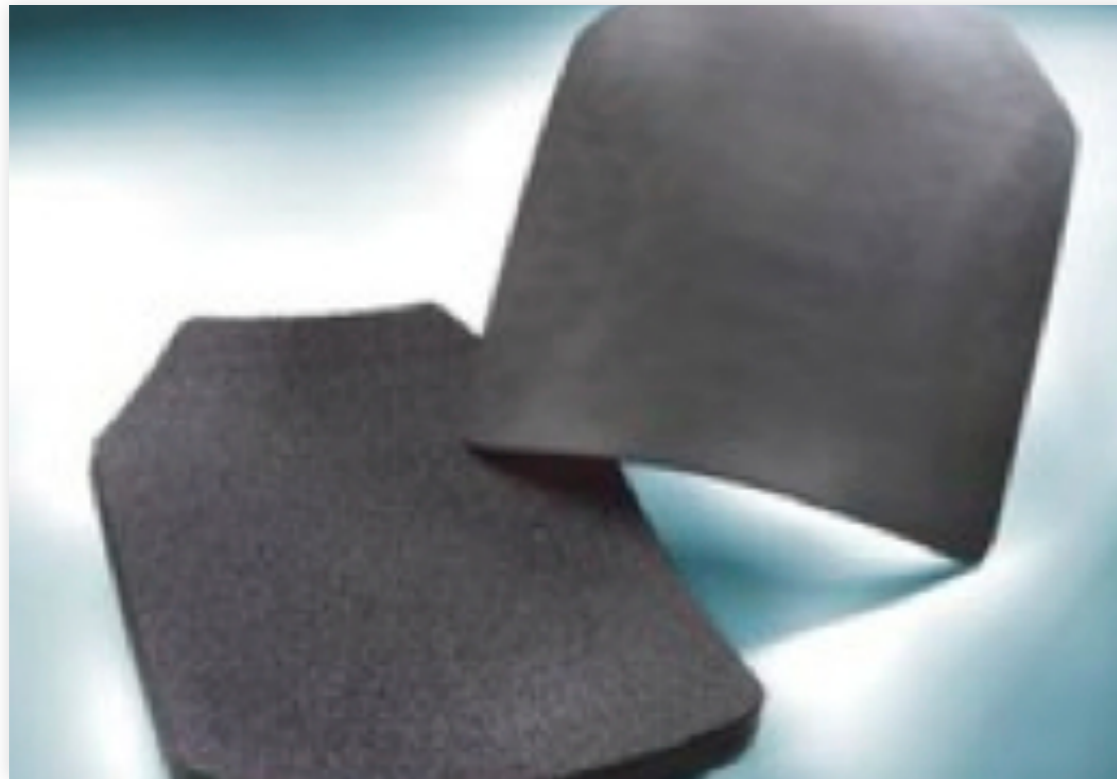


# Personnel Ballistic Vest Armor





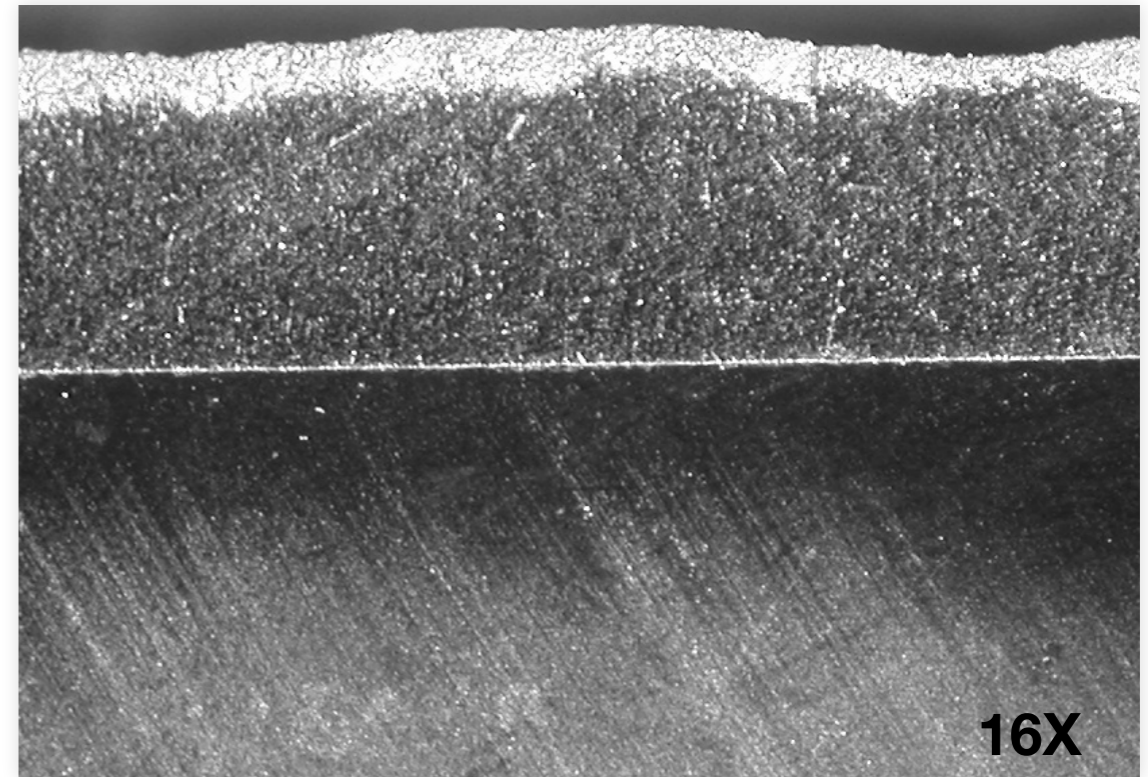
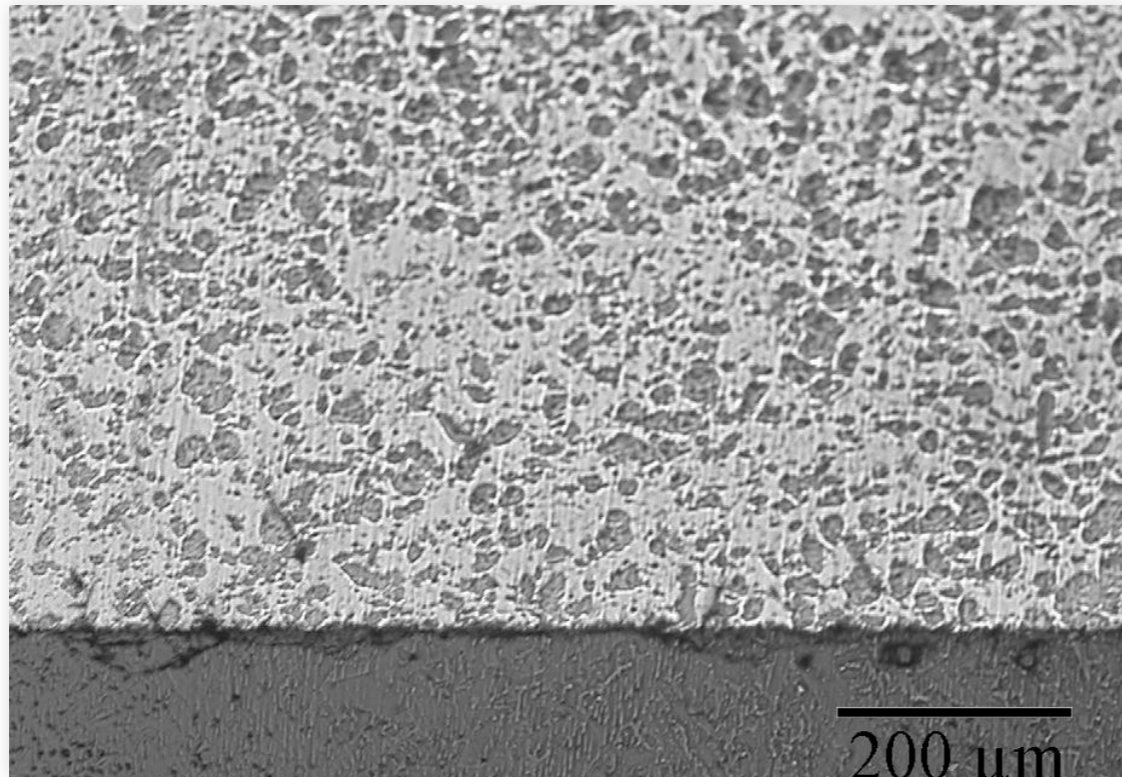
# Photo of Al-Trans® Coated Personnel Armor Plates





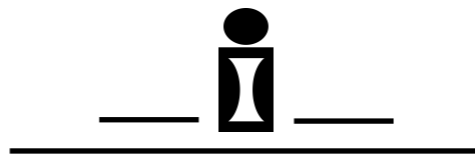


# Metallic Coating Micros



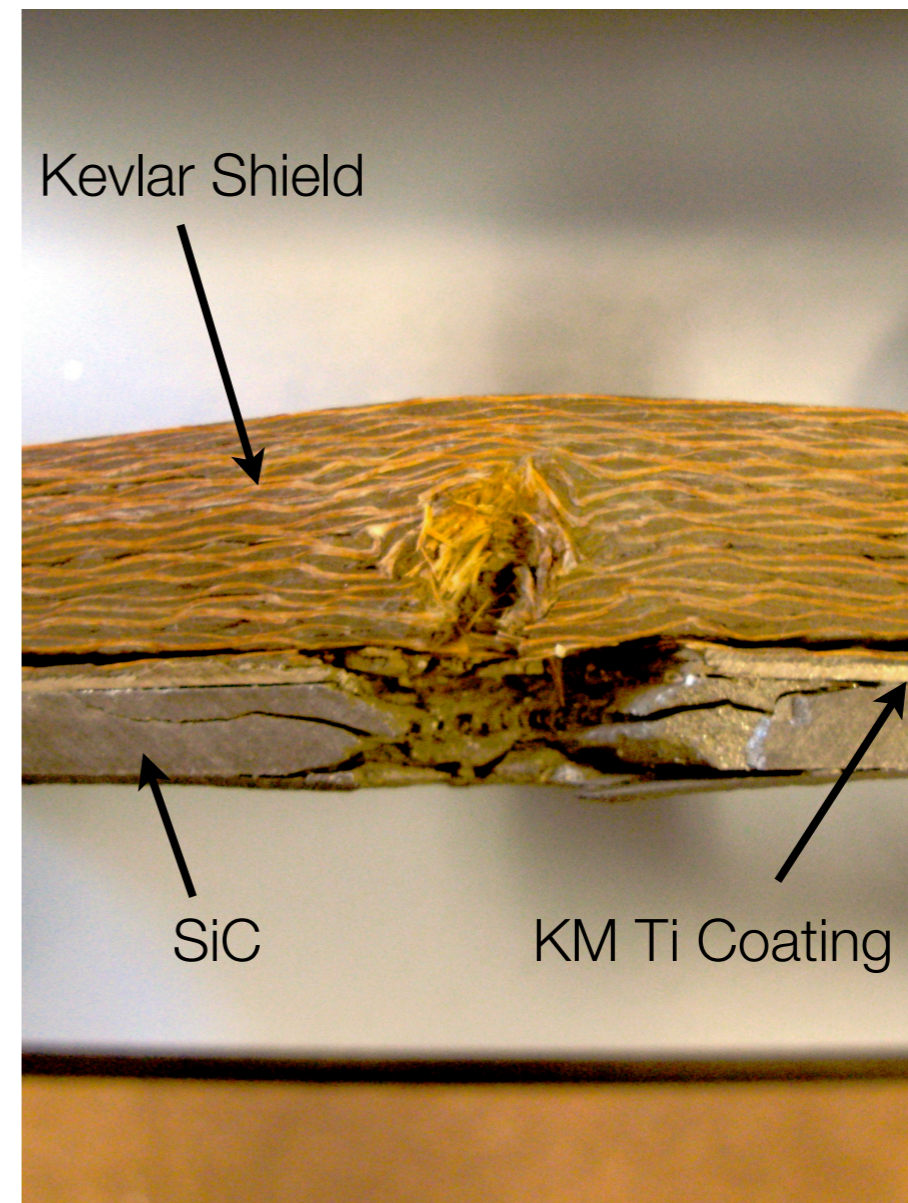
❖ Al-Trans® Coated SiC

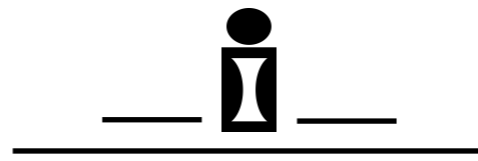
❖ Excellent Bond to SiC



# Ballistic Test

- ❖ **Ti Coated SiC Armor**
- ❖ Enhanced performance
- ❖ Precludes spalling
- ❖ Multiple hits





# Metallic Coatings

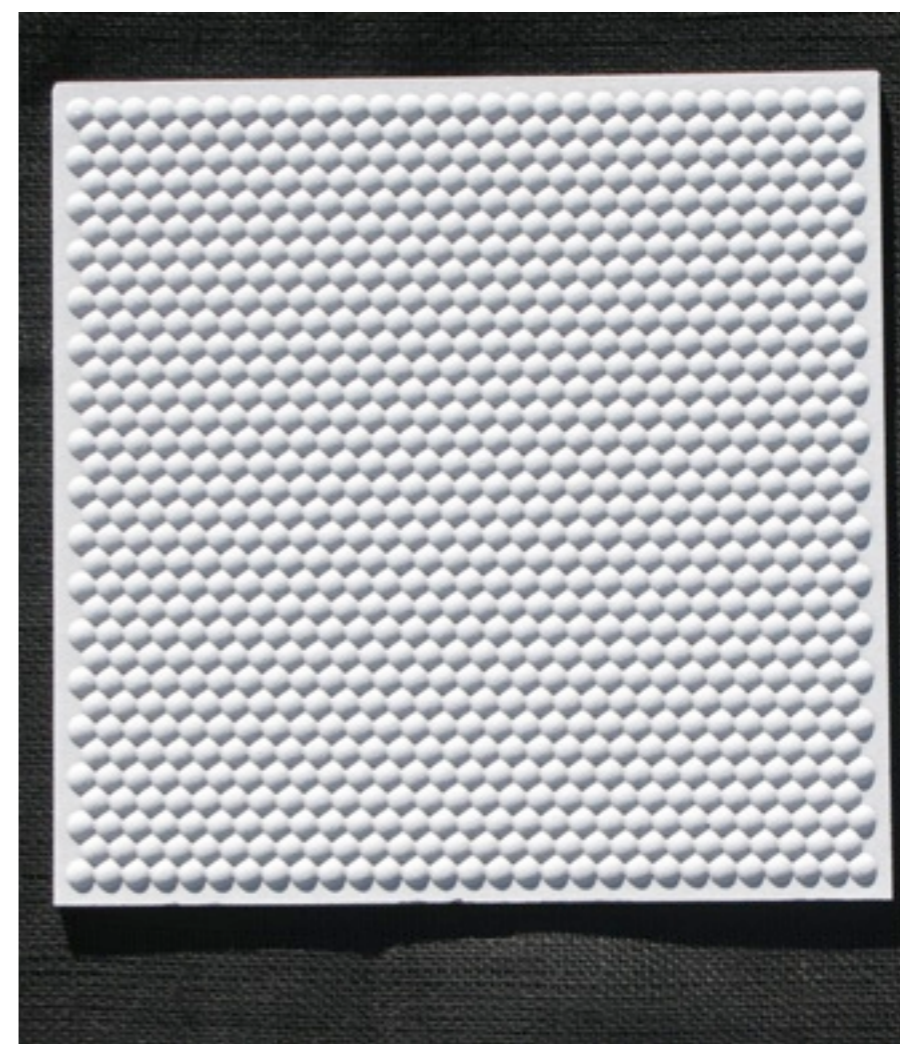
# Aircraft Armor Tiles

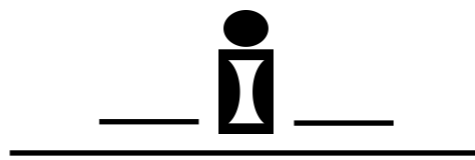




# KM of Al-Trans® Coated Aircraft Armor SiC Tiles

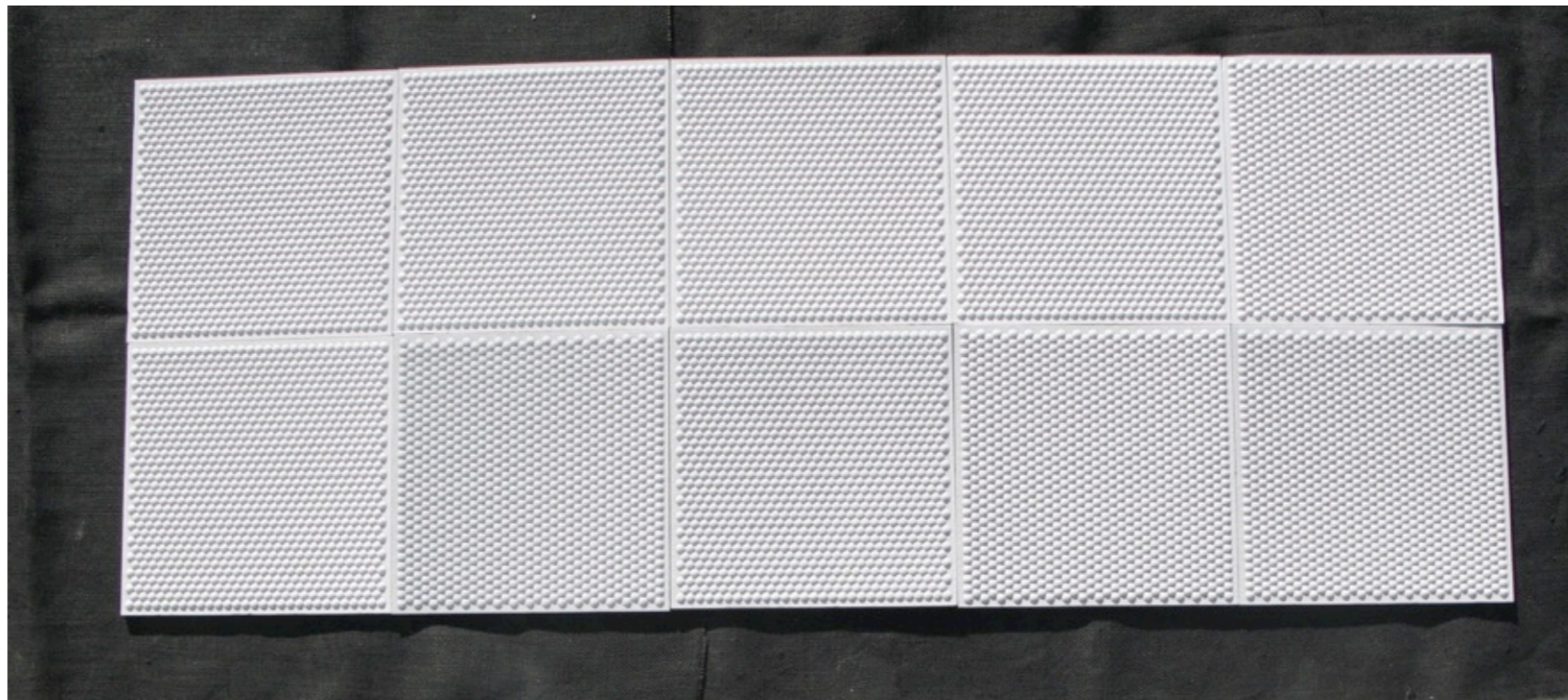
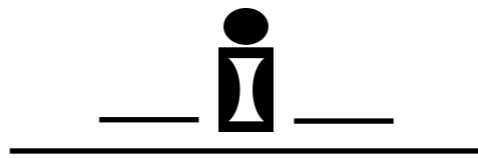
- ❖ **Enhanced ballistic performance**
  - ❖ Multiple hit resistance
  - ❖ Hydrostatic confinement
  - ❖ Improve durability and damage tolerance





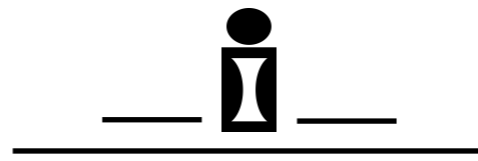
KM of Al-Trans® on SiC



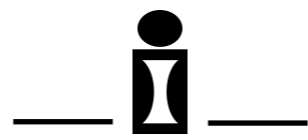


# Al-Trans® Coated SiC Panel





# Other Ceramic Bonding Applications



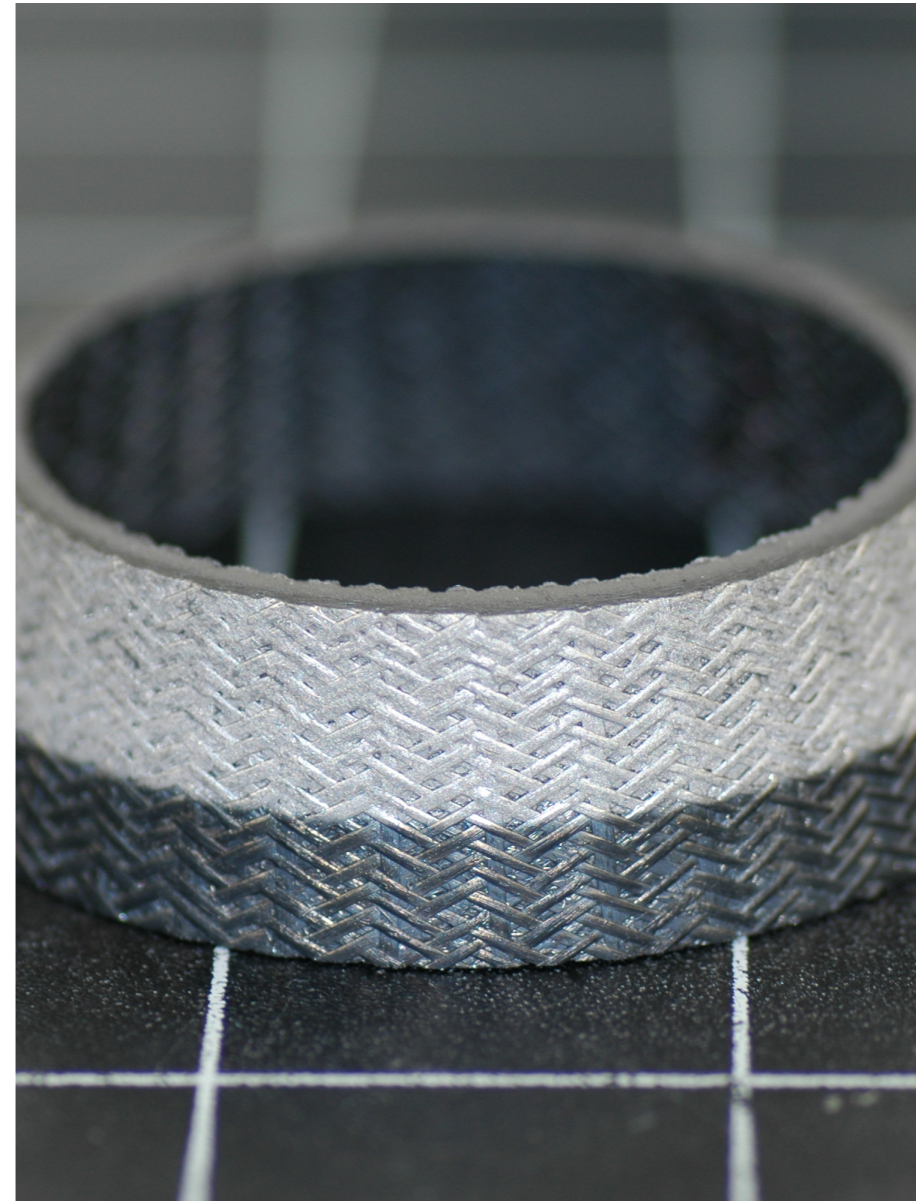
# Other Applications

- ❖ **Ceramic Matrix Composites**

- ❖ SiC & B<sub>4</sub>C CMC

- ❖ Braze fillers

- ❖ Ti, Nb, and Ni alloys

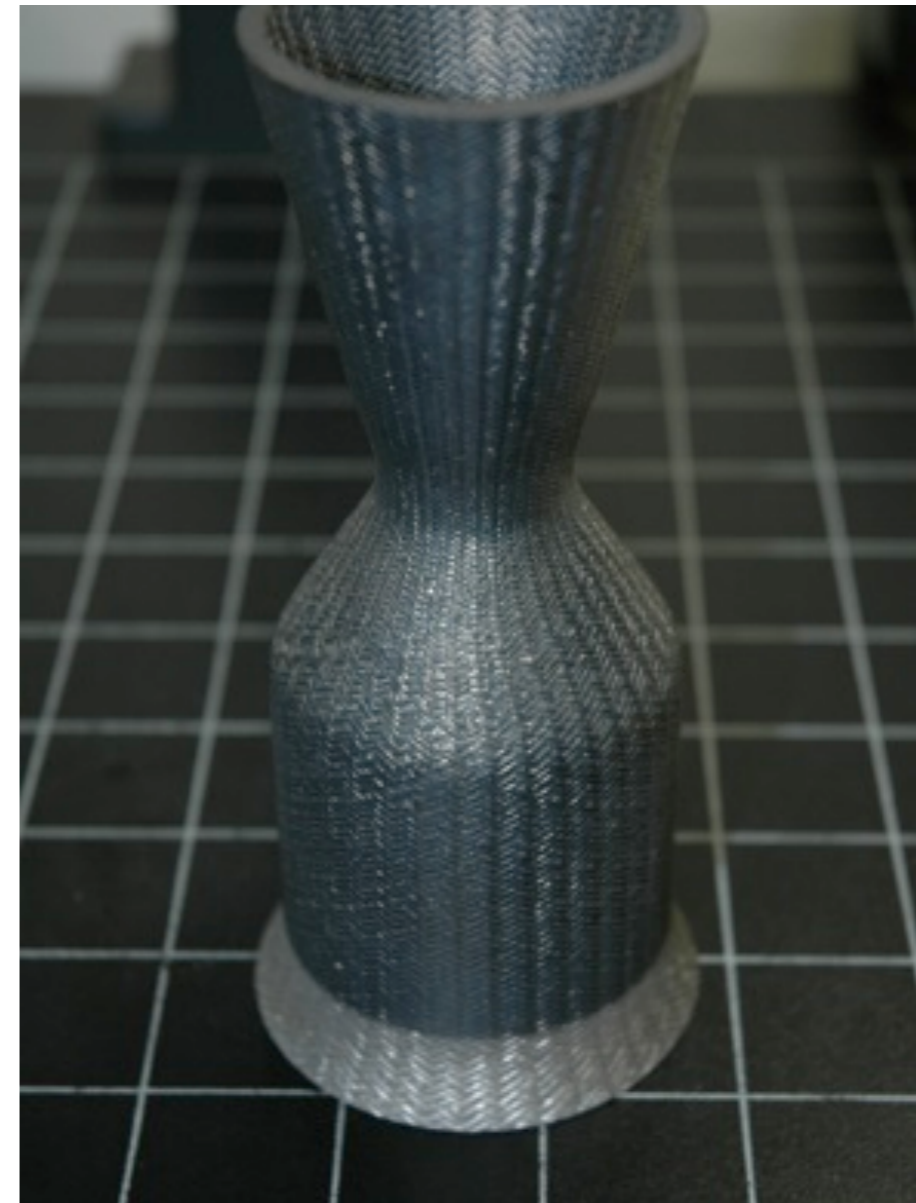


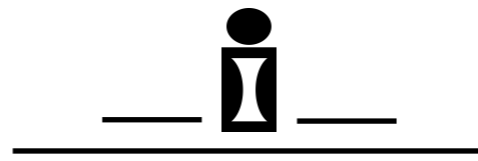


# KM Coatings on CMC Structures

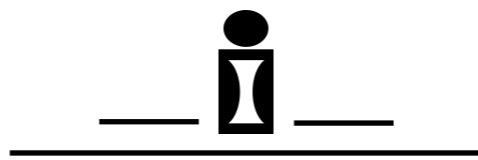
## ❖ DDM CMC Structures

- ❖ Titanium
- ❖ Niobium
- ❖ Tantalum
- ❖ Ni Alloys



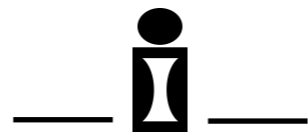


# Summary



# KM Coatings Ceramic Armor Tiles

- ❖ KM Coatings of Al-Trans® or Ti Coatings
- ❖ SiC and B<sub>4</sub>C armor tiles
- ❖ Improves ballistic performance for multiple hit resistance
- ❖ Low temperature deposition (< 600 °F)
- ❖ CTE matching with ceramic blended bond coats
- ❖ Enhanced adhesion to ceramic tiles
- ❖ Fast with robotic patterns - complexed shapes



# Applications for KM Coating Ceramics

- ❖ **Metallic Encapsulation of Armor Tiles**
  - ❖ Enhanced personnel protection
  - ❖ Aircraft & vehicle armor
- ❖ **Structural Bonding to Ceramic Components**
  - ❖ SiC & B<sub>4</sub>C CMC technology
  - ❖ Braze filler coatings
  - ❖ Free-form fabrication of structural elements.