

Kinetic Metallization

**Application of Alternative Sacrificial Anodic Coatings for
Landing Gear and Aerospace Components**

AeroMat 2004

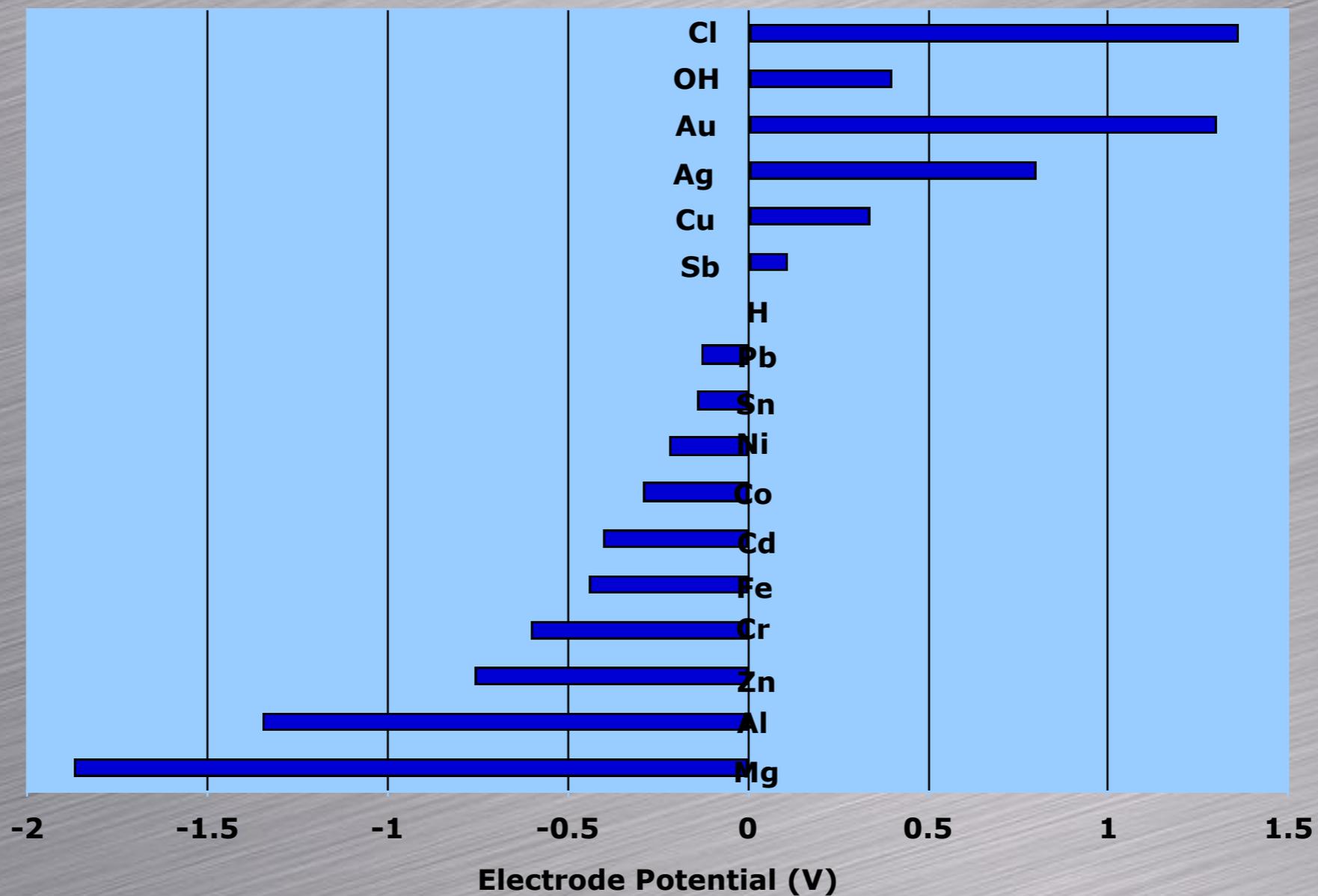
June 10, 2004

Ralph M. Tapphorn and Howard Gabel

Overview

- Theory of Sacrificial Anodic Coatings
- Introduction to **Kinetic Metallization**
 - Overview of KM Process and Equipment
 - Technical and Cost Advantages
- KM Commercial Applications
 - Aircraft Applications
 - Corrosion Resistance

Electrochemical Series



Galvanic Series

Cd Anodic Coatings

- Environmentally Hazardous
- EO13148
 - All Federal Agencies
 - Toxic Chemicals, **Hazardous Substances, and Pollutants Reduced** by 50% by 12/31/2006
 - Applies to Cadmium and Chromate Conversion Coatings

Cd Alternatives

● Electroplating Alternatives

- Zinc with Chromate Conversion?
- Zinc-Nickel Electroplate
- Zinc-Tin Electroplate

● **Aluminum Deposition Processes**

- Ion Vapor Deposition of Aluminum
- Alumiplate - Electroplate Aluminum
- *Kinetic Metallization - Aluminum Powder*

Qualification Tests

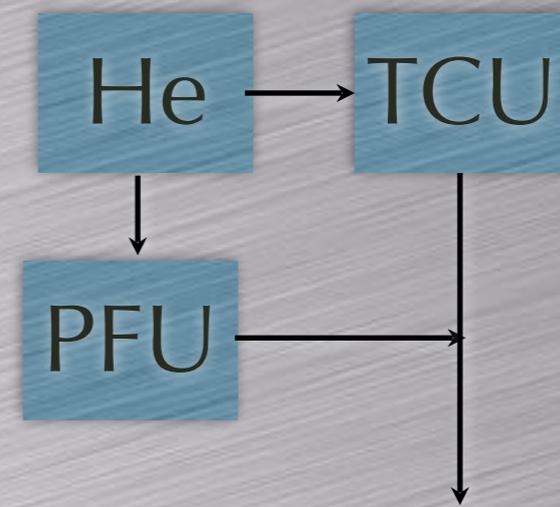
- Adhesion to Steel
 - Scrape and Strip Rupture per MIL-STD-83488D
 - ASTM C633 pull tests
- Thickness Magnetic (ASTM B499)
- Paint Adhesion (ASTM D3359)
- ASTM B117 Salt Spray > 3000 Hours
- Low Hydrogen Embrittlement (ASTM F519)
- Fatigue Screening
- Electrical Connectivity

Kinetic Metallization

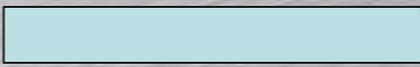
- Impact Consolidation Process
 - Feed-stock: fine powder
 - Accelerant: inert light gas
- Solid-state Consolidation
 - No Bulk Melting
 - No Liquid Chemicals
- Environmentally Innocuous
 - No Particle or Hazardous Gas Emission

KM Process Flow

- Powder fluidized using pressurized He gas (PFU)
- Powder/gas mix thermally conditioned to improve deposition efficiency (TCU)
- Deposition nozzle produces highly collimated spray pattern
- Area coverage using X-Y rastering of nozzle and/or rotation of substrate



Deposition
Nozzle

Substrate 

The diagram shows a light blue rectangular substrate positioned below the spray path. Above the substrate, a vertical line of five yellow dots represents the spray pattern from the deposition nozzle.

KM-CDS

First KM-CDS Shipped!!

Buyer: US Naval Academy

Located: NAVSEA-Carderock

- Coating Development System
- Desk sized
- Production unit
 - Same footprint
 - Remove spray enclosure

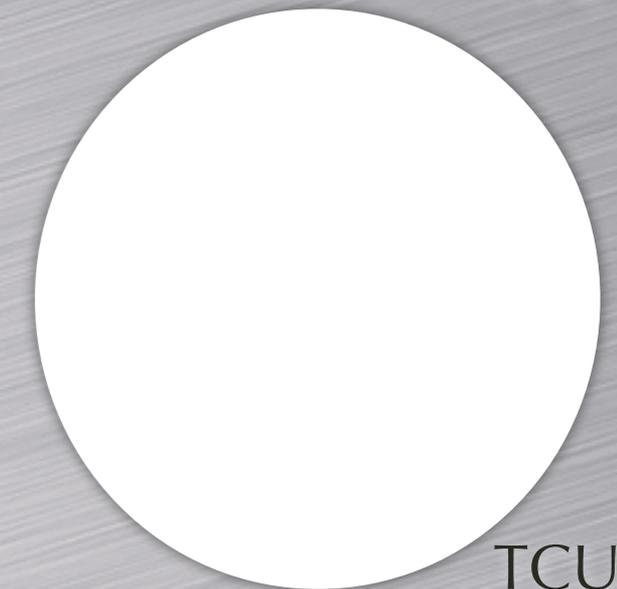


KM Critical Components

- Powder Fluidizing Unit
- Closed-loop mass-loss control
- Thermal Conditioning Unit
- Low power
- Deposition Nozzle
- Friction compensated



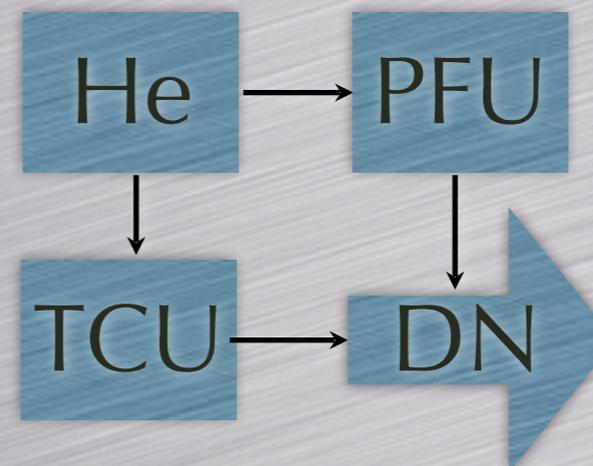
PFU



TCU



DN



PFU Set Point

lb/hr

TCU Set Point

deg F

Width



in

Step Size



in

Length



in

Sweep Velocity

in/s

Strokes/Step

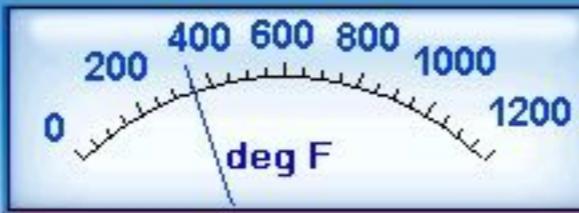
Layers



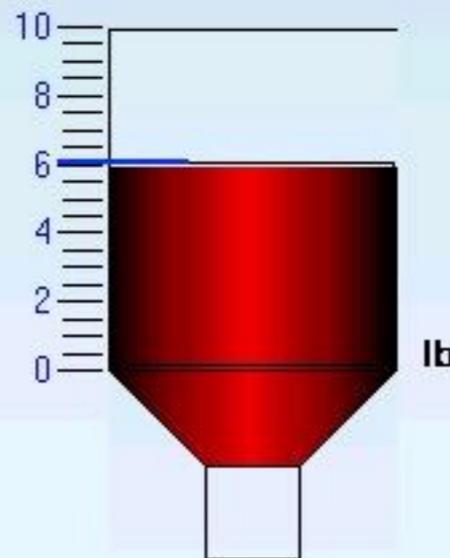
PFU Actual



TCU Actual



Powder Weight



Initial
 lb

Final
 lb

PFU Active



PFU ECV



TCU Active



TCU ECV



Operator Name

Test Name

Description

START

Preview



Powder Flow



Motion

PFU Heat



Units

English



SI

KM Robotic Control

- Compatible with any robot
- 5-pin connector provides
- All KM power/control interface



KM Nozzle Design

- Nozzle Anatomy

- Friction Compensated Sonic Nozzle

- Reference: Session 2: AeroMat 2004

- “Kinetic Metallization Process and Coating Development System” Howard Gabel



KM Al-Trans™

- Aluminum + Transition Metal Composite
 - Powder Blend: Solid-state Deposition
 - **Kinetic Metallization Process**
 - Transition Metal Admixtures - Cr, Ni, Ti, Cu
 - Admixture Concentration: 25-50% by Volume
- Aluminum + Ceramic Particles
 - SiC, Al₂O₃, BC₄, CrC₄, TiC
 - Admixture Concentration: 10-30% by Volume

Al-Trans™ KM Examples

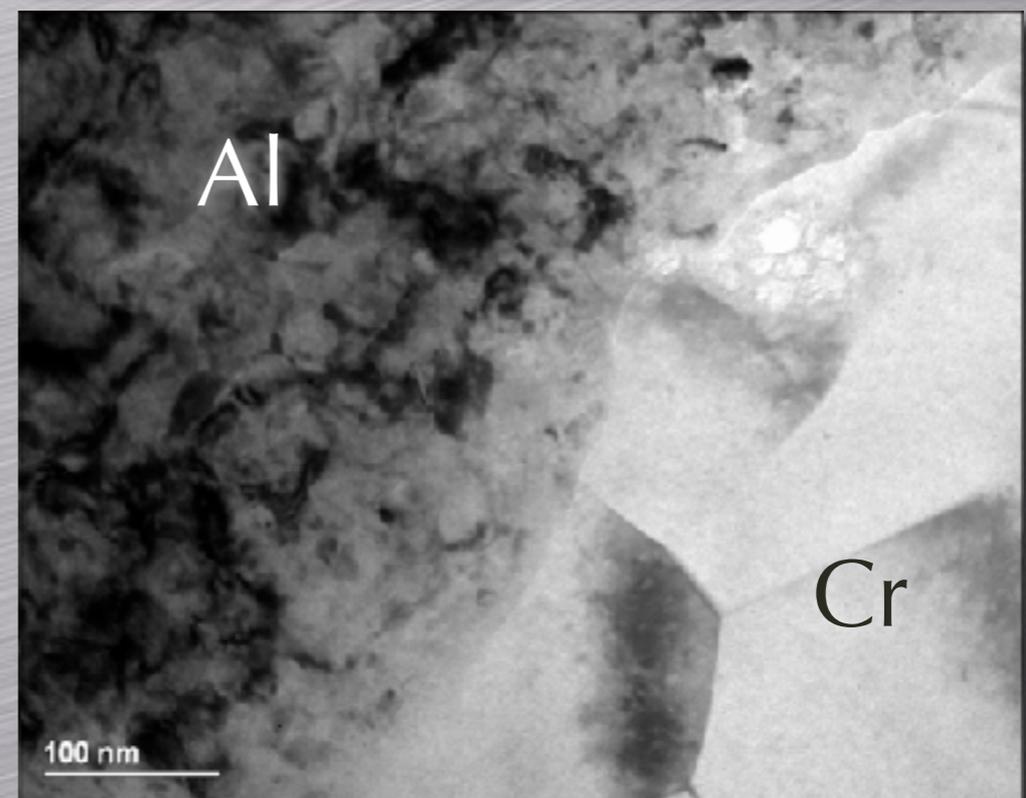
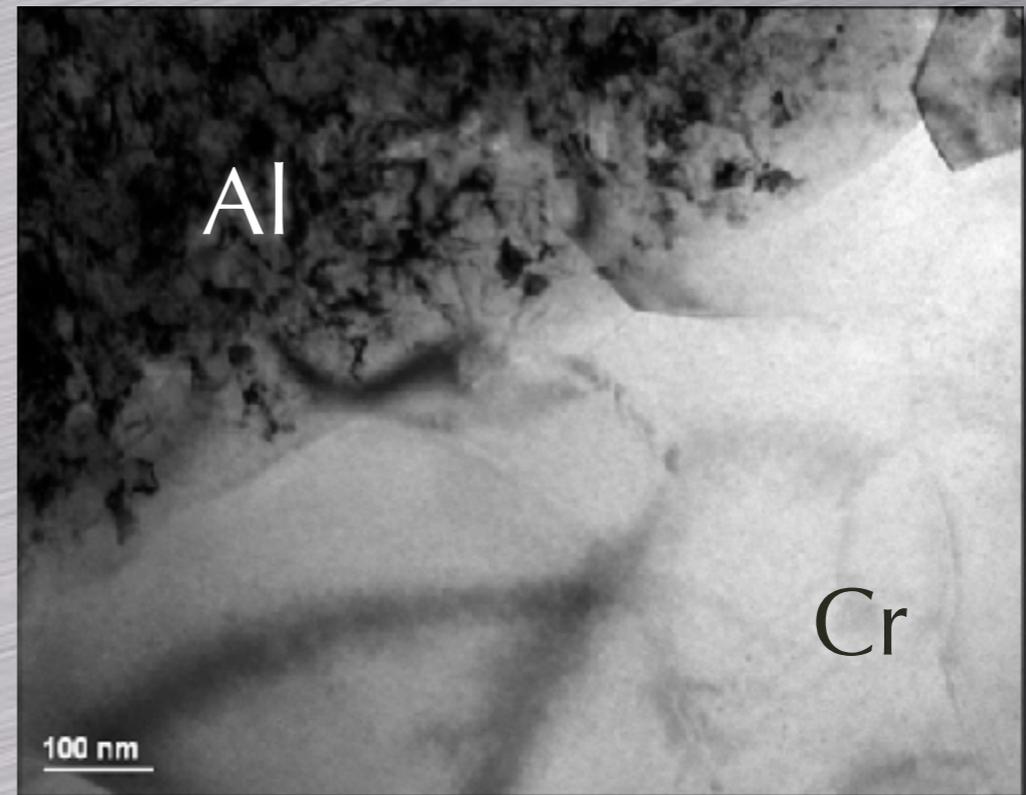
- Al-Trans™ Chromium Composite
 - Commercially Applied to Telecommunication Steel Racks
- Al-SiC Particle Reinforced MMC

KM Al-Trans™



TEM

- Tight Al-Cr interface
- No diffusion
- Superb cohesion
 - Lower image 140,000X
- Ion Etch - Sample Prep



KM Al-SiC PRMMC

● Al + SiC 30%
vol.

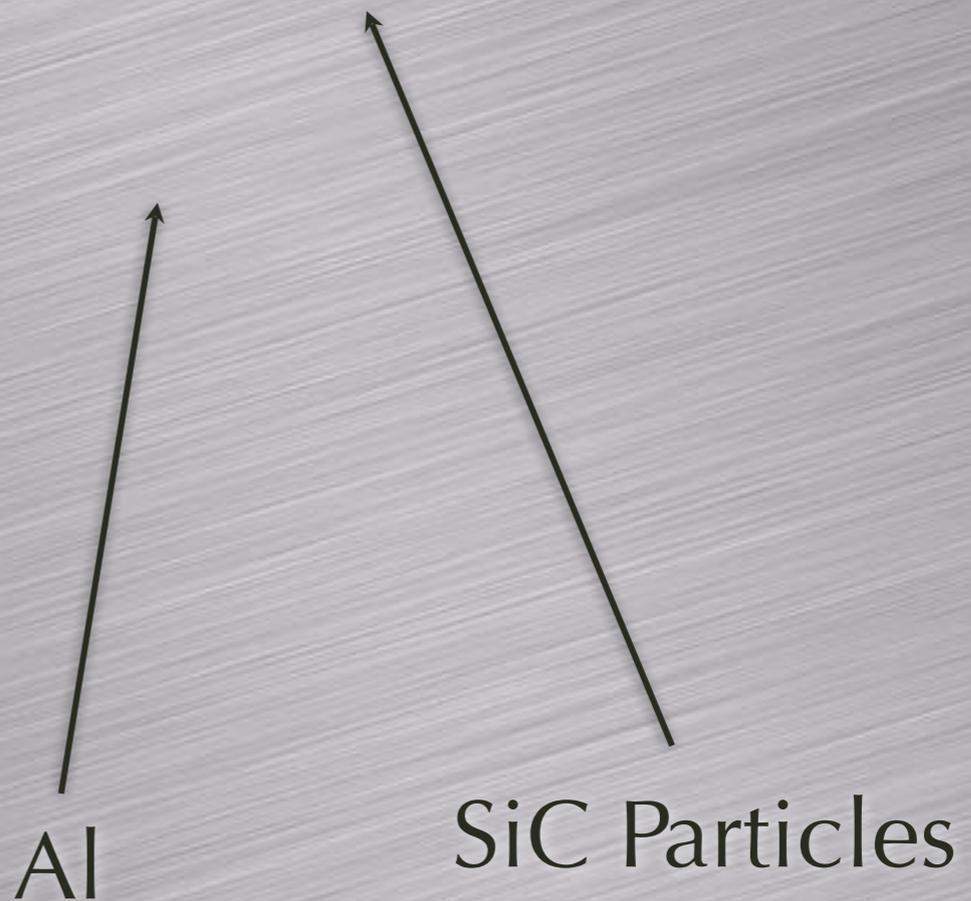
● Fully Dense



KM Al-SiC PRMMC

● Al + SiC 30%
vol.

● Fully Dense



KM Advantages

● Technical

- No Chemicals

- Low Application Temperature

- No Masking

- Portable Unit Permits Field Repairs

● Cost Considerations

- Less Expensive than Electroplating Repairs

- Feedstock <\$.50 sq ft for Al Coatings (0.001")

Al-Trans™ Applications

- Al-Tran™ (Cr) Electrical Conductor on Steel

- Telecommunication Industry

- Customer: Hendry Telephone Products, CISCO

- Al-Tran™ (Cr) Al-Clad Repair & OEM

- Aircraft Wings and Engine nacelles

- Customer: Regional/Corp Jet Repair Facilities

- Customer: Lockheed Martin

- Al-Tran™ IVD and Alumiplate Repair

- High Strength Steels for Landing Gear & Actuators

- Customer: Boeing & Lockheed Martin

KM Al-Trans™ Future

● Qualification and Development

- IVD and Alumiplate Repair Processes
- NAVAIR SBIR Phase I 2004.1
 - Topic Number N04-02
 - "KM - A Repair Process of IVD Al"
 - Contract Award: April 2004
- Portable Kinetic Metallization Unit

Portable KM Repair Unit

- Al-Trans™
- Portable KM
- Repair IVD Al
- Repair Alumiplate

Portable KM Unit

Handheld Nozzle

