

Kinetic Metallization™

Repair of Alclad

ITSC 2012 Session 1

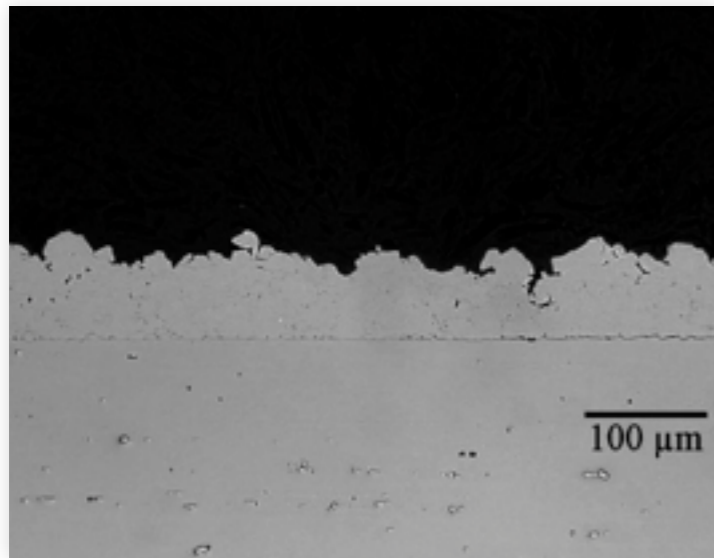
21 May, 2012

Howard Gabel, R. Tapphorn, K. Hashimoto and T. Crowe

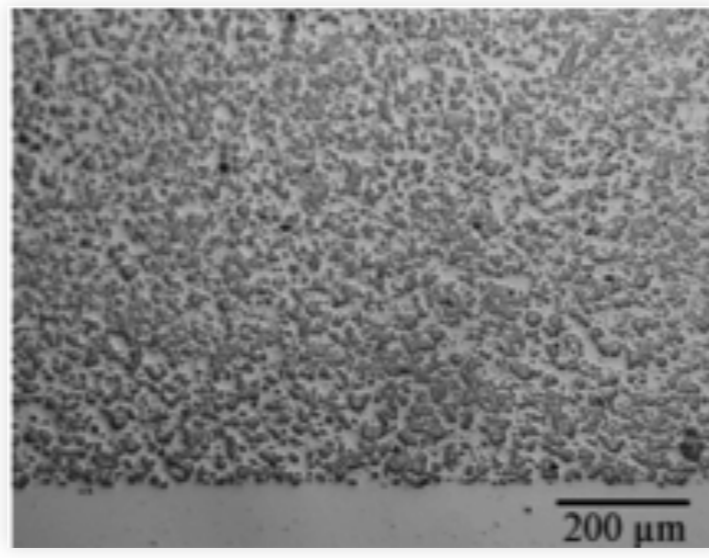




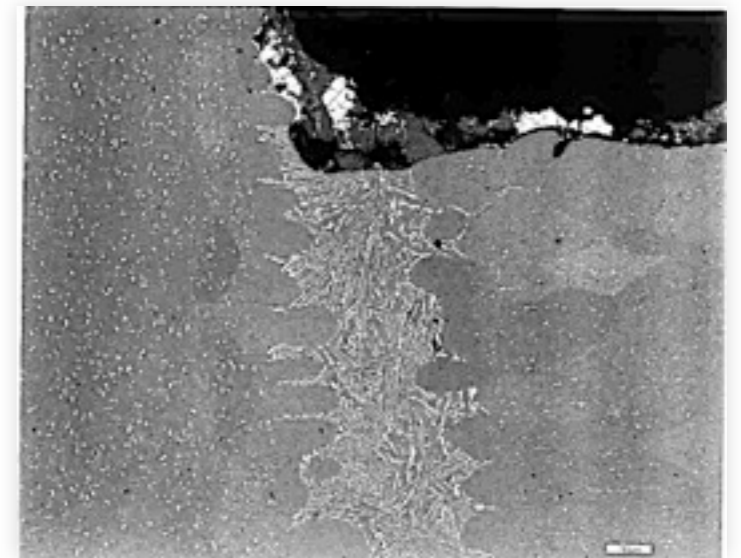
Kinetic Metalization Alternative for Al Based Coatings



CP Al



Al-Trans[®]/Cr



4047 Braze Alloy



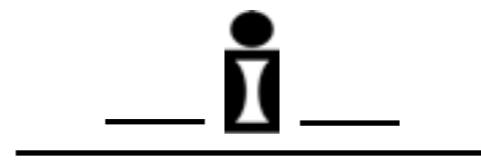
Alclad™ Alcoa

Low alloy environmental layer
Hot roll bonded to
High strength Al

Corrosion protection

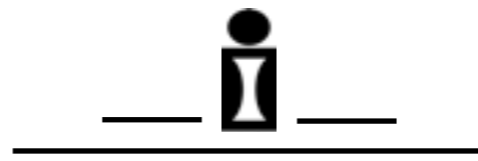
High-gloss finish





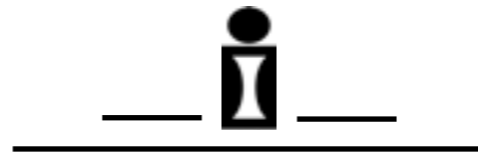
First use 1927



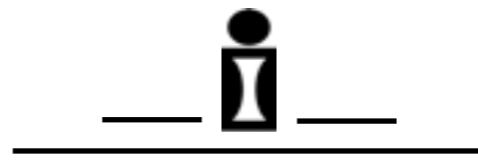


Problem



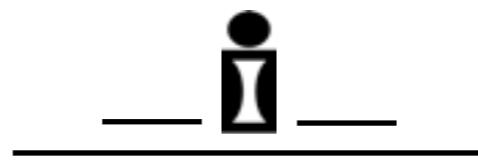


Requirements



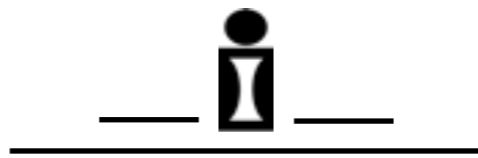
Functional

- ❖ Adhesion
- ❖ Polishable
 - ❖ conventional compounds/techniques

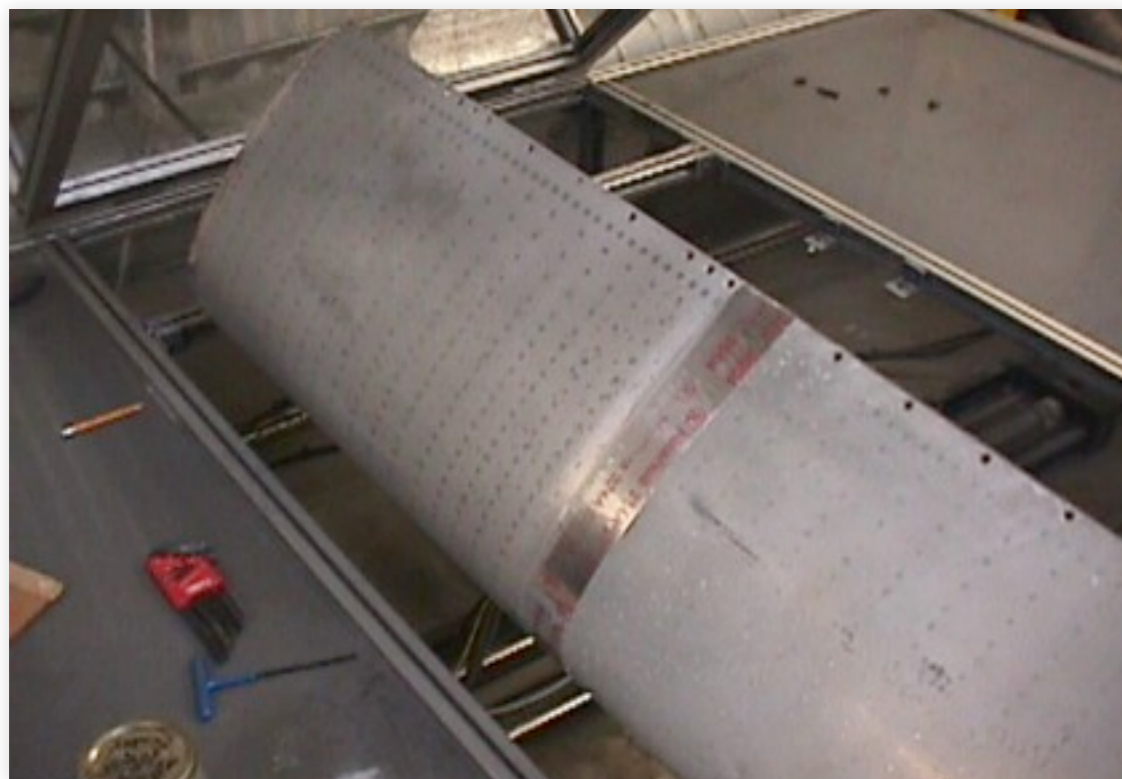


Decorative

- ❖ Color space
- ❖ Optically distortion free
- ❖ low porosity
- ❖ smear resistance



Alclad Repair Leading Edge



Before

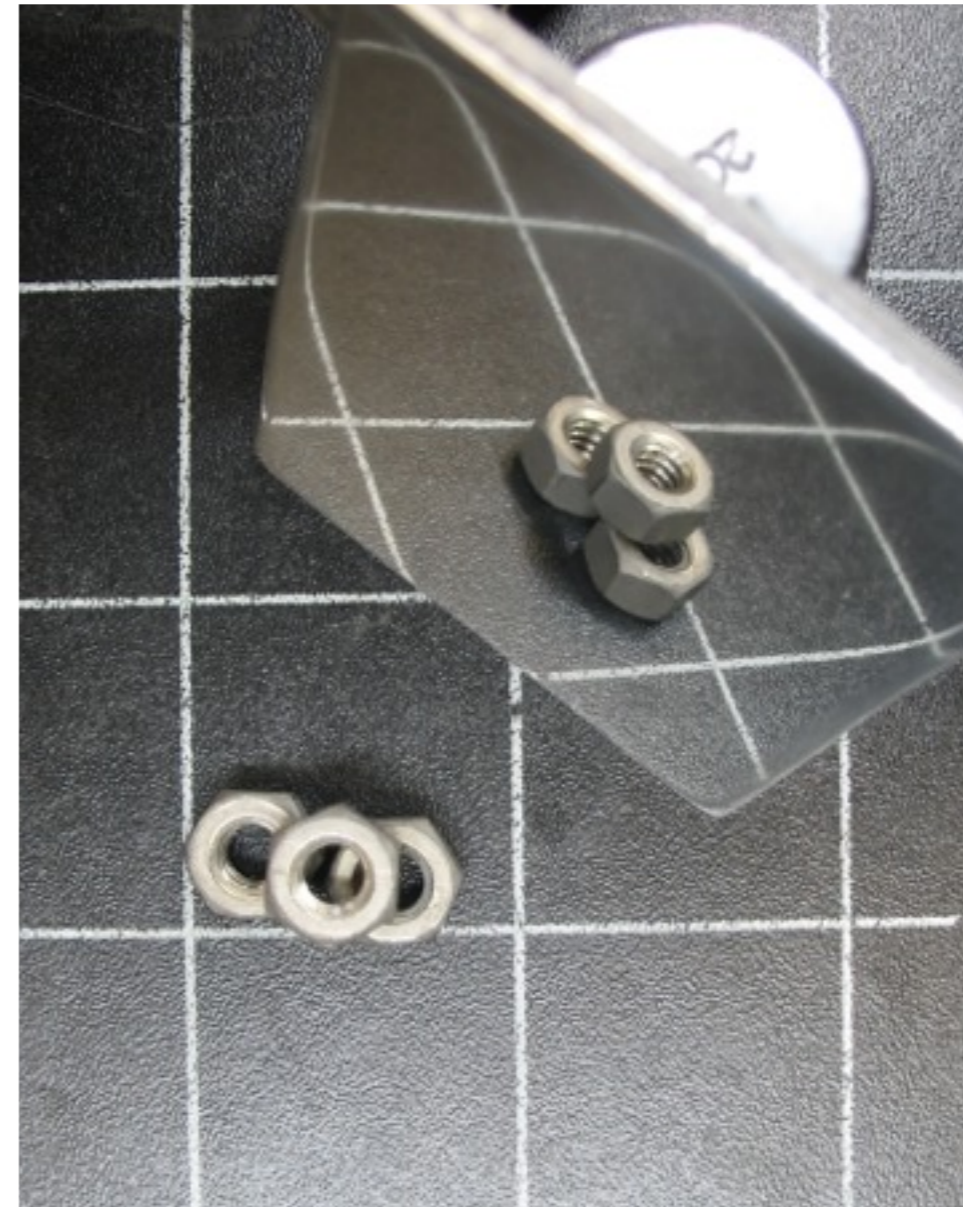


After

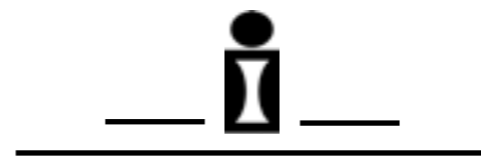


Alclad Repair

- ❖ Pure Al coating on 2024 Al substrate
- ❖ Coating thickness: 7 mils
- ❖ Polished to mirror finish using same method used on Alclad

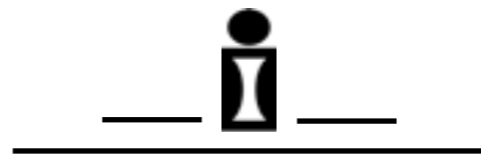


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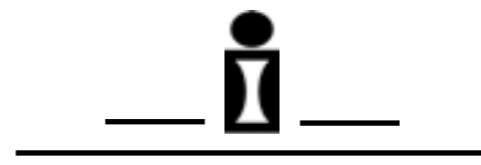
Solution

- ❖ Deposition equipment
- ❖ Gun translation
- ❖ Feedstock



Introduction to KM

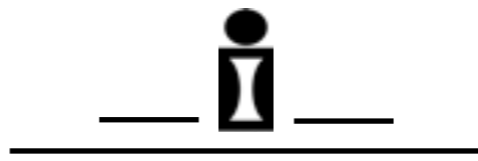
- ❖ Metal deposition through particle impact
- ❖ Low-temperature \ll melting point
- ❖ Low noise < 75 dBa @ 1 m
- ❖ Highest quality — Lowest cost



Sonic Mach 1 Nozzle

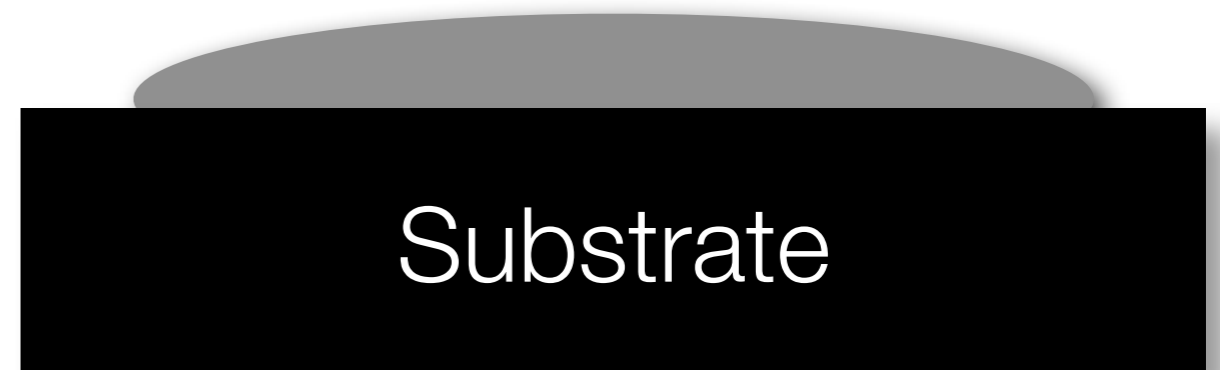
- ❖ High particle velocity
> 750 m/s
- ❖ Powder injection at
nozzle inlet
- ❖ Pressure < 1 MPa
(150 psig)
- ❖ Temperatures to
1100C
- ❖ Powder preheater &
mixer

Substrate



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





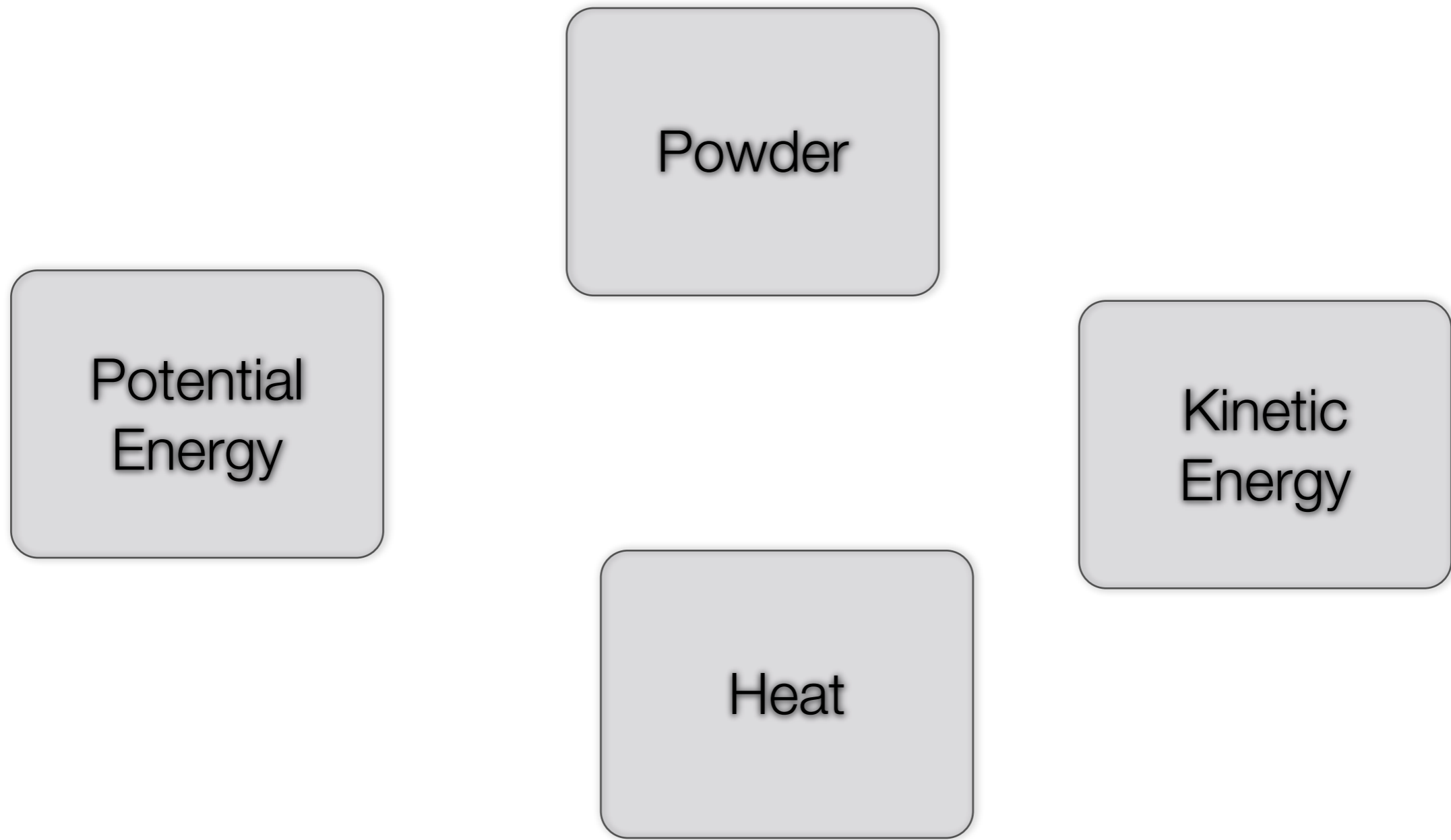
KM-Production Coating System

- ❖ Robotic KM Spray Gun
- ❖ Data accession and process control
- ❖ Gas flow control





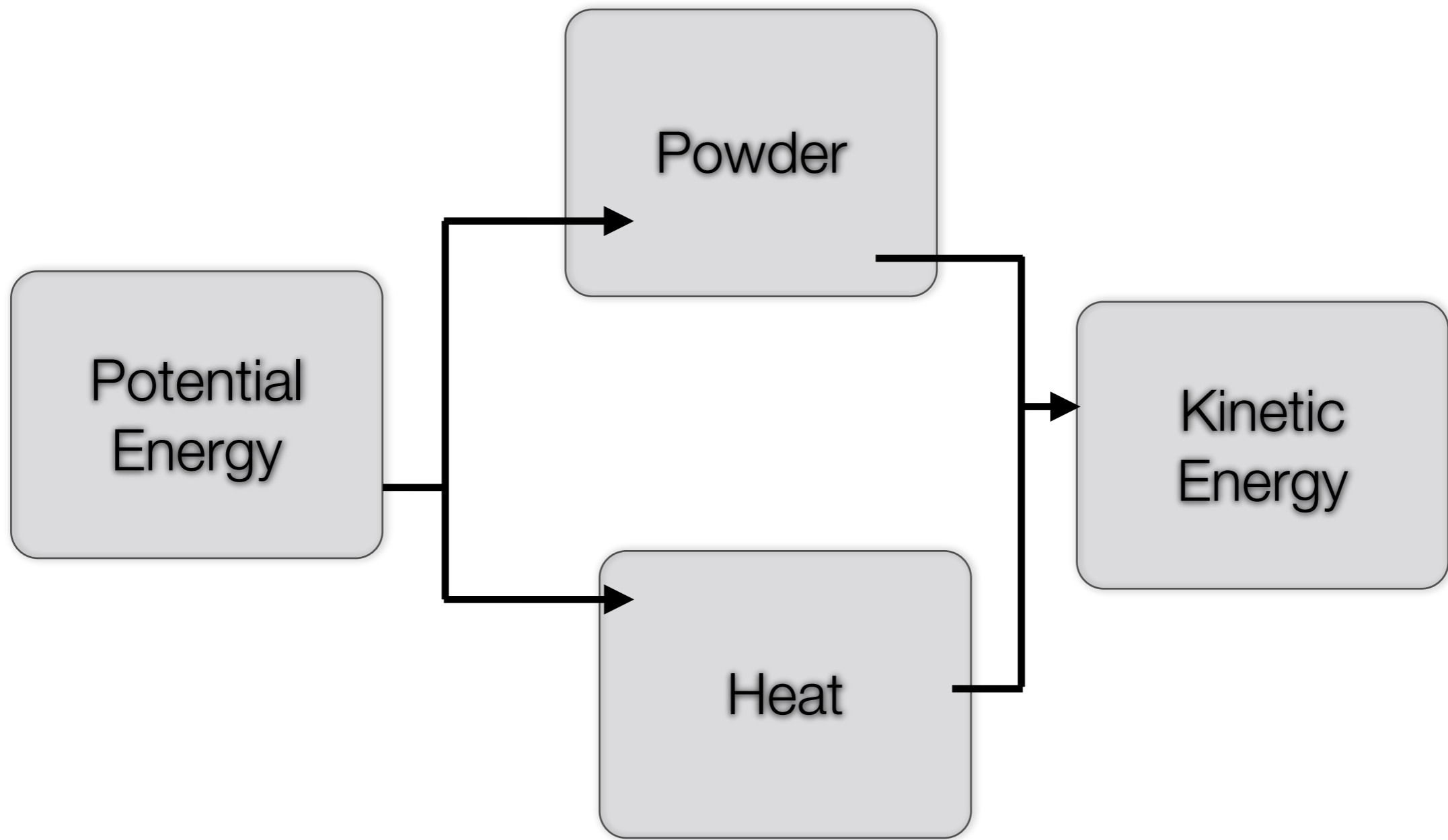
Kinetic Metallization™ Process



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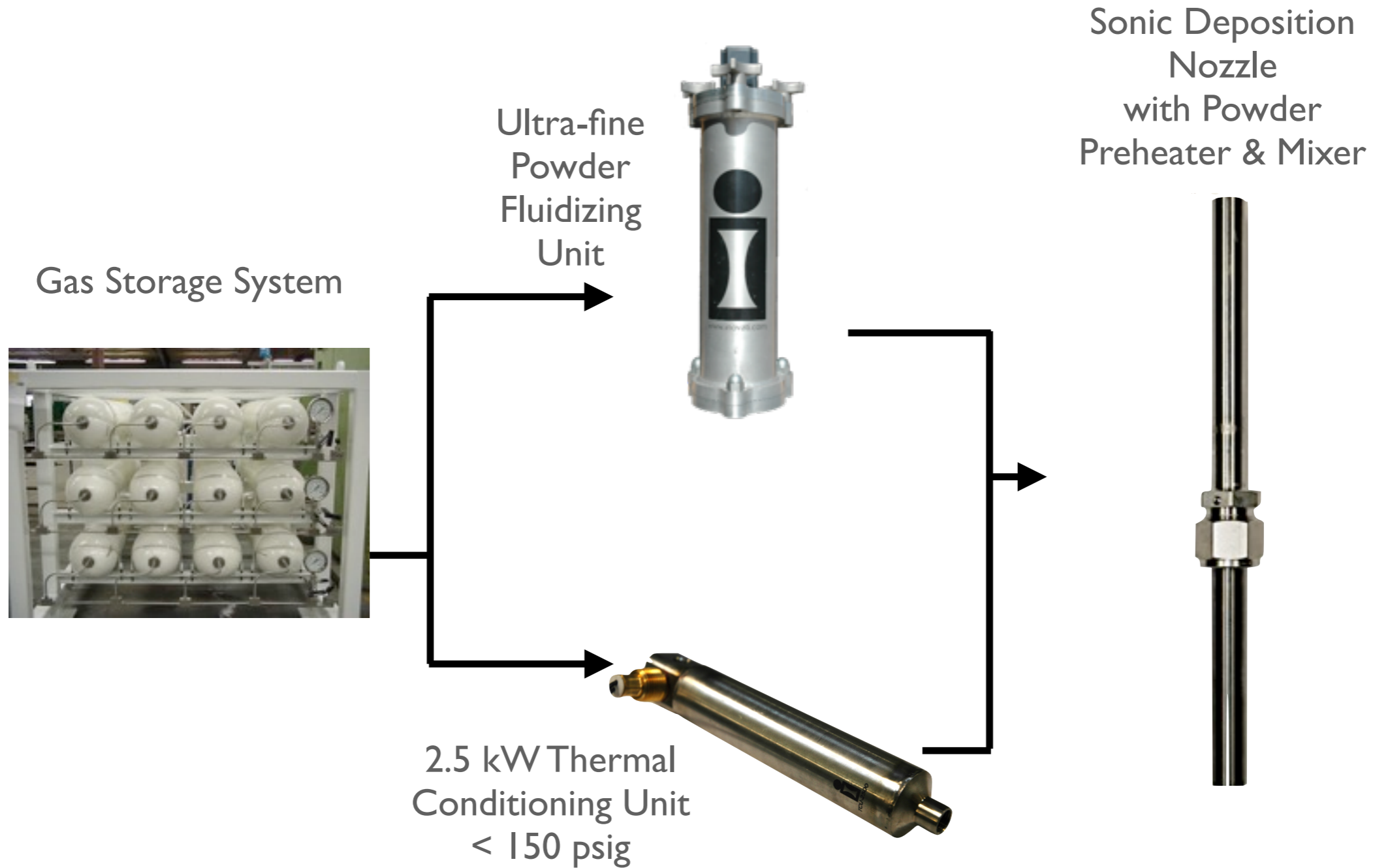
Kinetic Metallization™ Process



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Kinetic Metallization™ Process





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 (e.g.)**
 - ❖ Air/GN2 (Al-Trans[®] , Cu, Zn, Ni)
 - ❖ He/GN2 (WC-Co, Ni alloys, Nb, Ta)
 - ❖ Composite polymers (PEEK, PTFE)



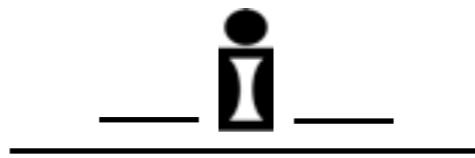


Al-Trans[®] IVD Aluminum Repairs

- ❖ Surface Repair of IVD Al coating
 - ❖ Alternative to brush cadmium repairs
 - ❖ Environmentally compliant
- ❖ Al-Trans[®] Coating Properties on High Strength Steels
 - ❖ Adhesion of > 10 ksi without de-lamination
 - ❖ Coating protection >3000 hrs in salt fog per ASTM B117
 - ❖ Superior corrosion protection in SO₂ salt fog per ASTM-G85
 - ❖ Passed Joint Test Protocol-2003 specifications

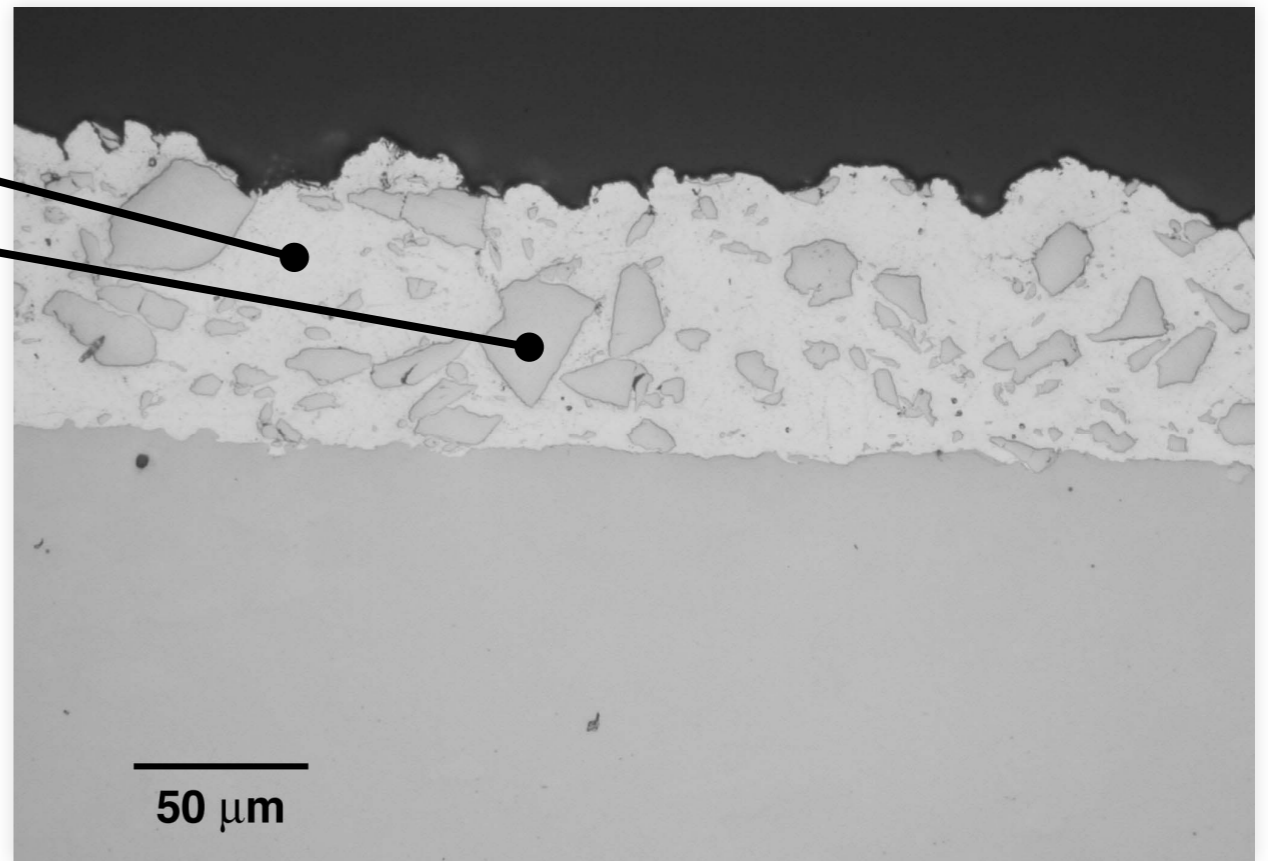


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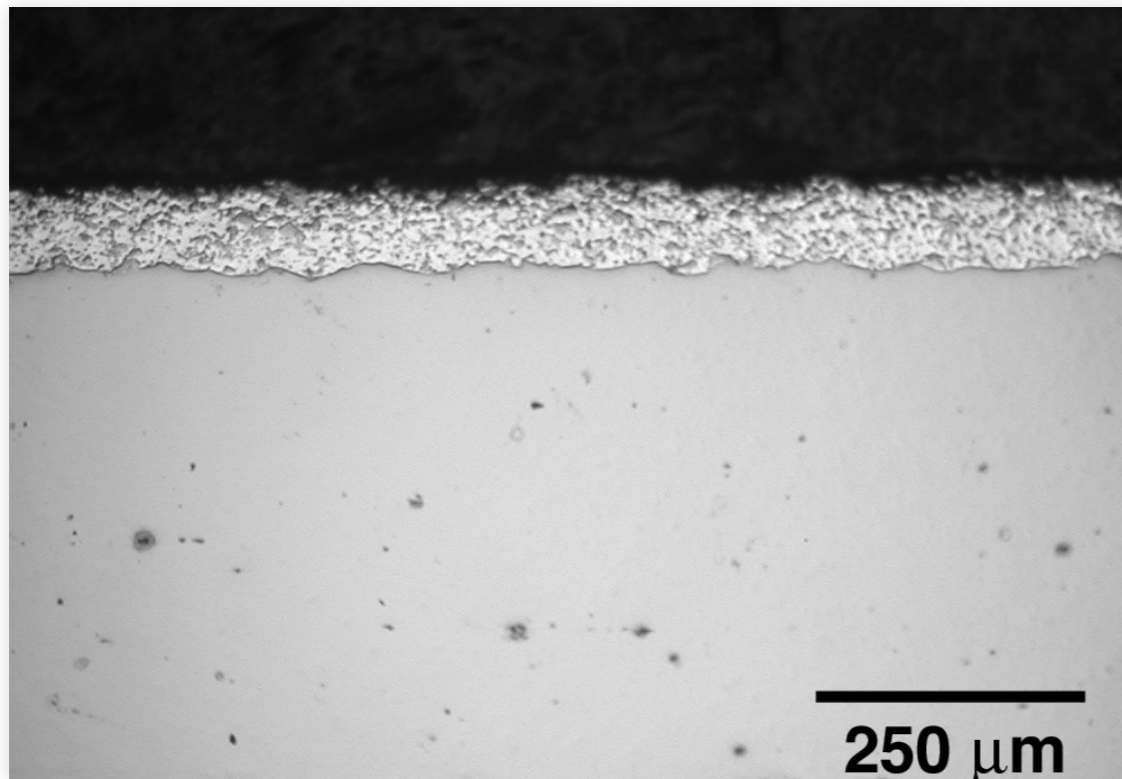
Al-Trans[®] On Steel

- ❖ Al-Trans[®] mixture
 - ❖ Aluminum
 - ❖ Transition metal
- ❖ Adhesion to:
 - ❖ Substrate: ASTM B571
 - ❖ Paint: ASTM D2794, 120 ft-lb
- ❖ Corrosion
 - ❖ ASTM B117, 5,000 hrs



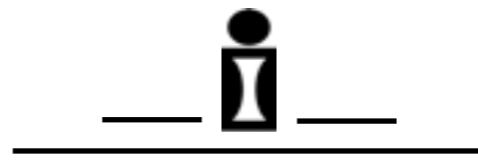


Al-Trans[®] Corrosion Protection IVD-AI Repairs

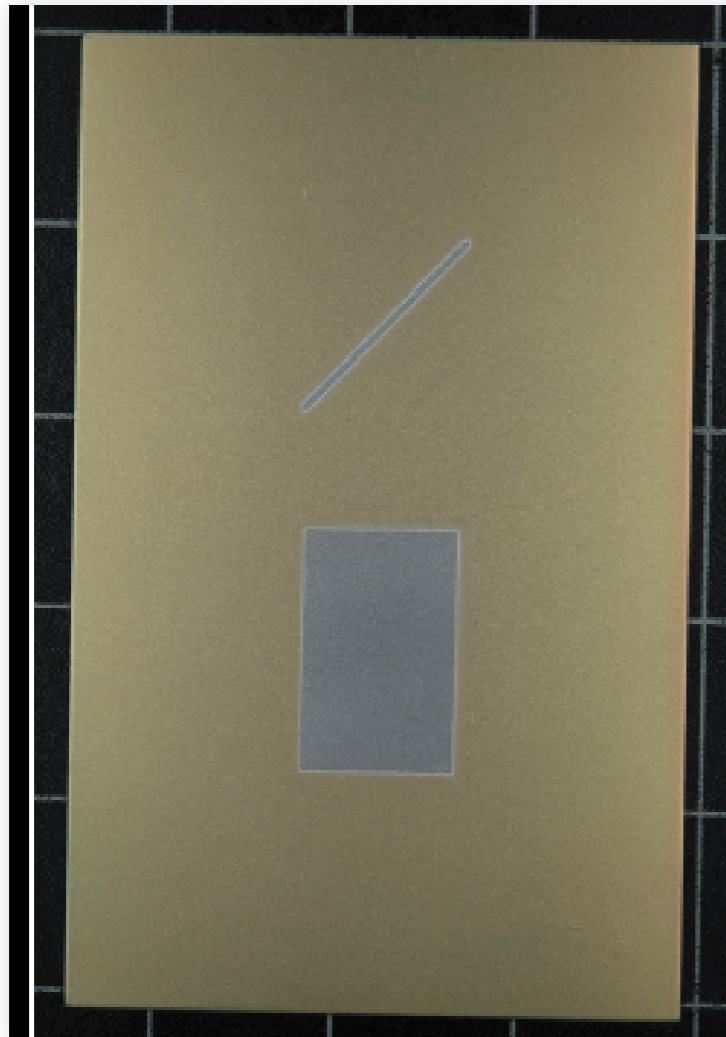


Composite Al-Trans[®] Coating

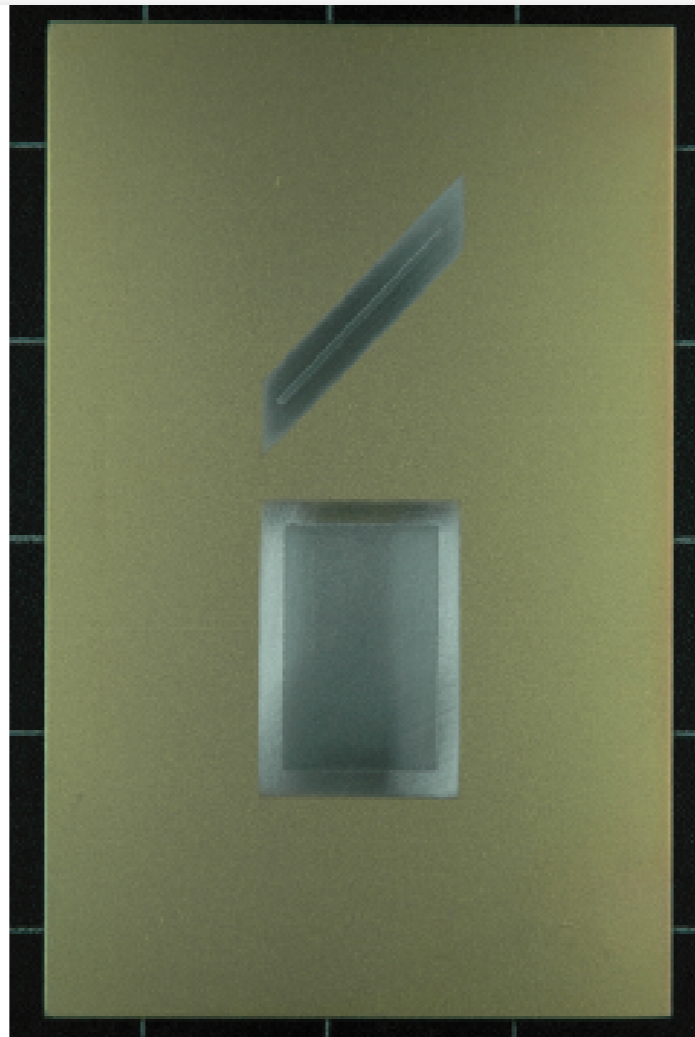
- ❖ Composite Al-Trans[®]/Cr Coating
- ❖ Properties
 - ❖ Hardness HRB = 62
 - ❖ Porosity < 0.5%
 - ❖ Corrosion - Salt Fog B117
 - ❖ 3000 Hrs
 - ❖ Substrate 4130 steel



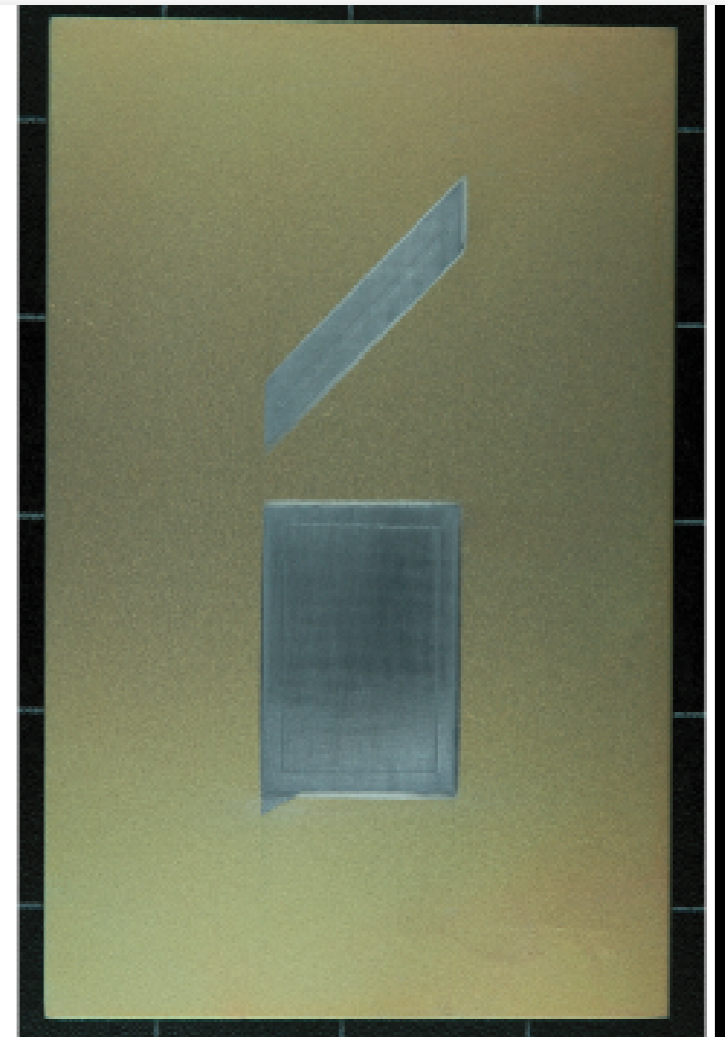
KM Repair Sequence for IVD-AI



IVD-AI Removed



Feather Edges



KM AI-Trans[®] Repair





Al-Trans[®] Kinetic Metallization JTP-2003 Qualification Tests

Reparability Test	JTP	Acceptance Criteria	Pass/Fail
Unscribed Salt Fog	3.3.1 3.7.1	3000 Hrs ASTM B117-94	Pass
Scribed Salt Fog	3.3.2 3.7.1	1000 Hrs ASTM B117 94	Pass
Unscribed SO2 Salt Fog	4.1.1	500 Hrs ASTM G85	Pass
Scribed SO2 Salt Fog	4.1.2	500 Hrs ASTM G85	Pass
Unscribed Salt Fog	3.1.4	3000 Hr ASTM B117-94	Pass

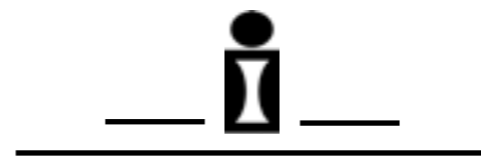


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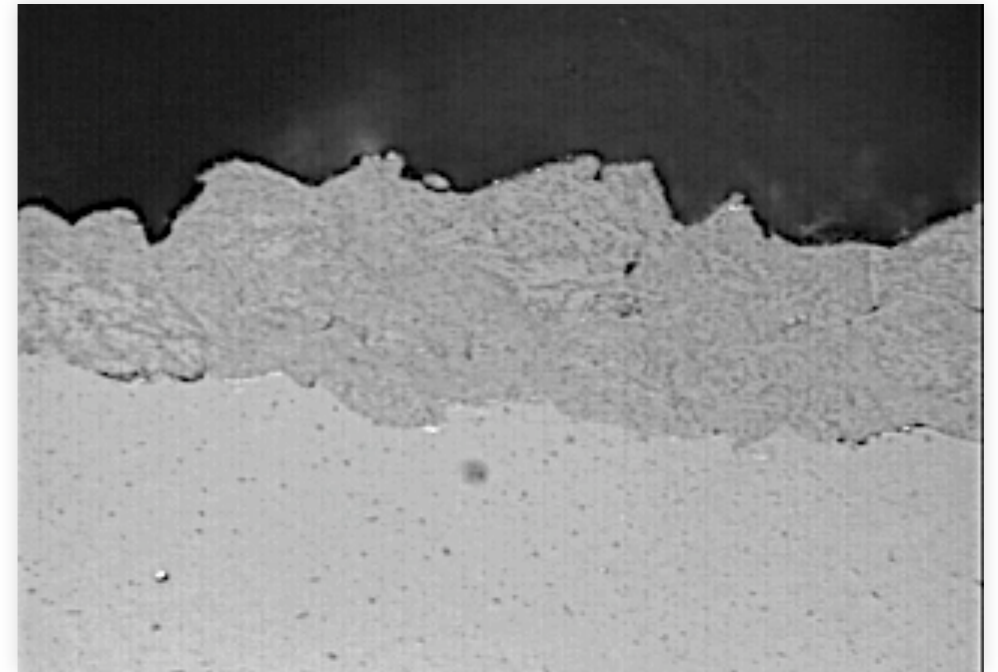
Al-Trans[®] Kinetic Metallization JTP-2003 Qualification Tests

Reparability Test	JTP	Acceptance Criteria	Pass/Fail
Hydrogen Embrittlement	3.6.1	200 Hr/75%	Pass
	3.7.1	ASTM F519	
Hydrogen Re-Embrittlement	3.6.1	200 Hr/75%	Pass
	3.7.1	ASTM F519	
Corrosion Resistance 14 Fluids	3.3.4	No Coat Degradation Compared to Brush Cd	Pass
Stress Corrosion Cracking	4.3	SEM Fractography	Pass
Scribed Painted Coating	3.3.5	3000 Hrs ASTM B117 - 94	Pass



4047 Braze Alloy Deposition

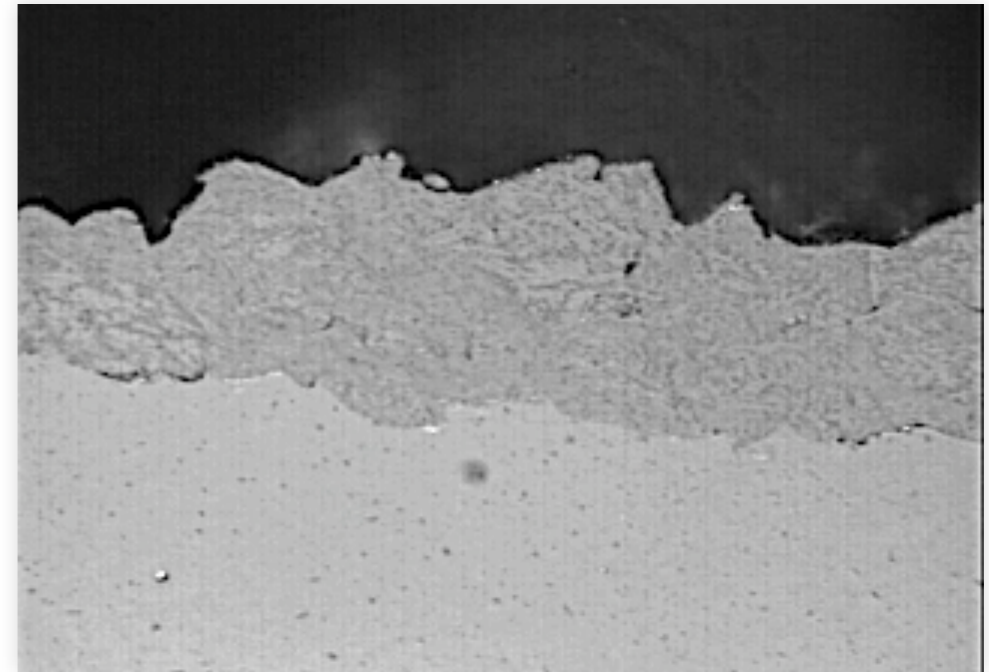
- ❖ Alternative to foil or paste
- ❖ KM handheld gun enables deposition on complex geometry
- ❖ Uniform braze joint



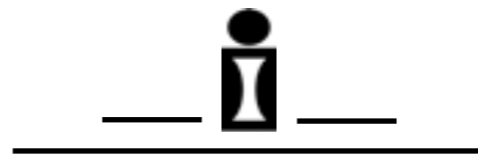


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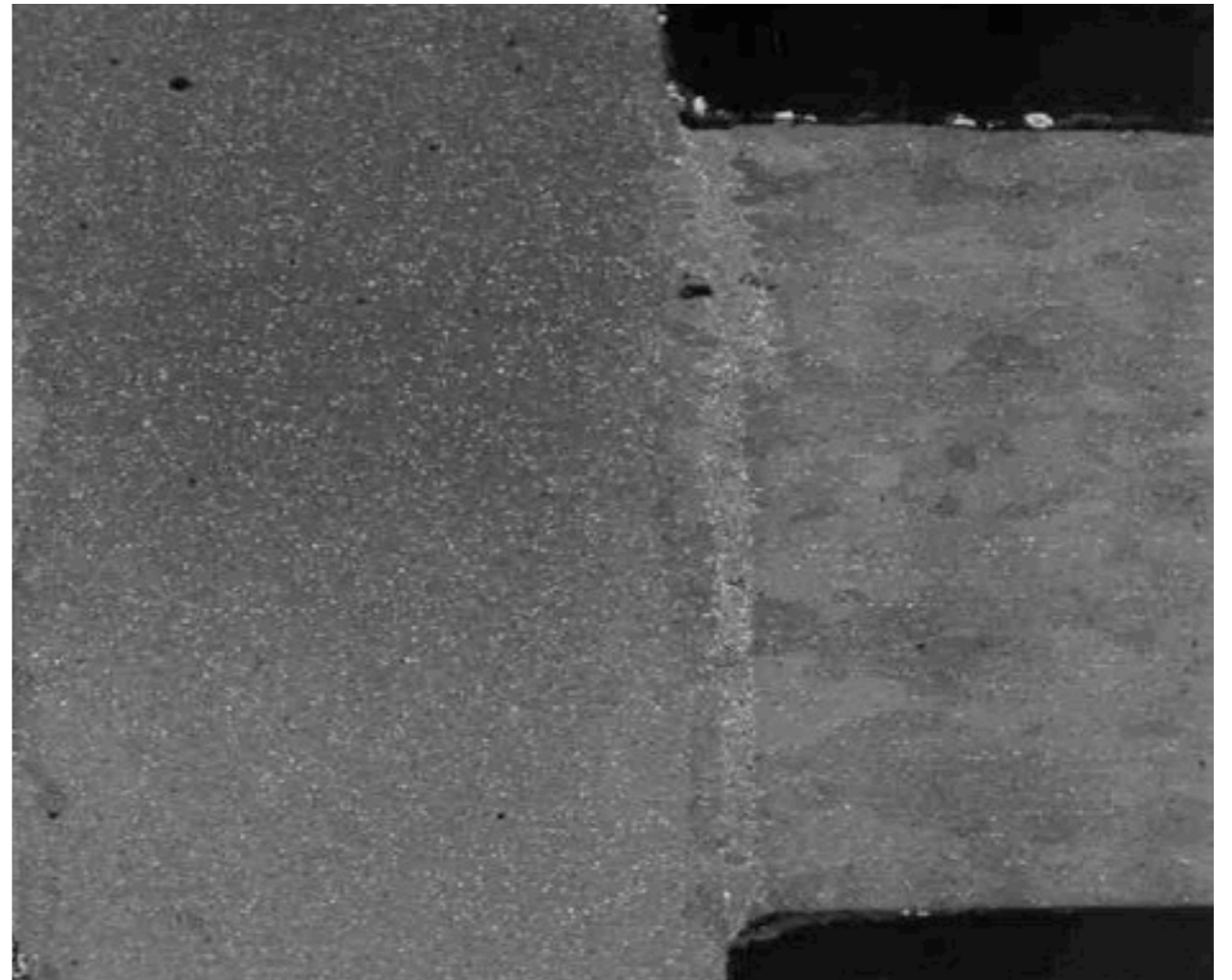


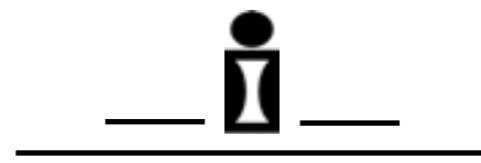
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4047 Braze Joint

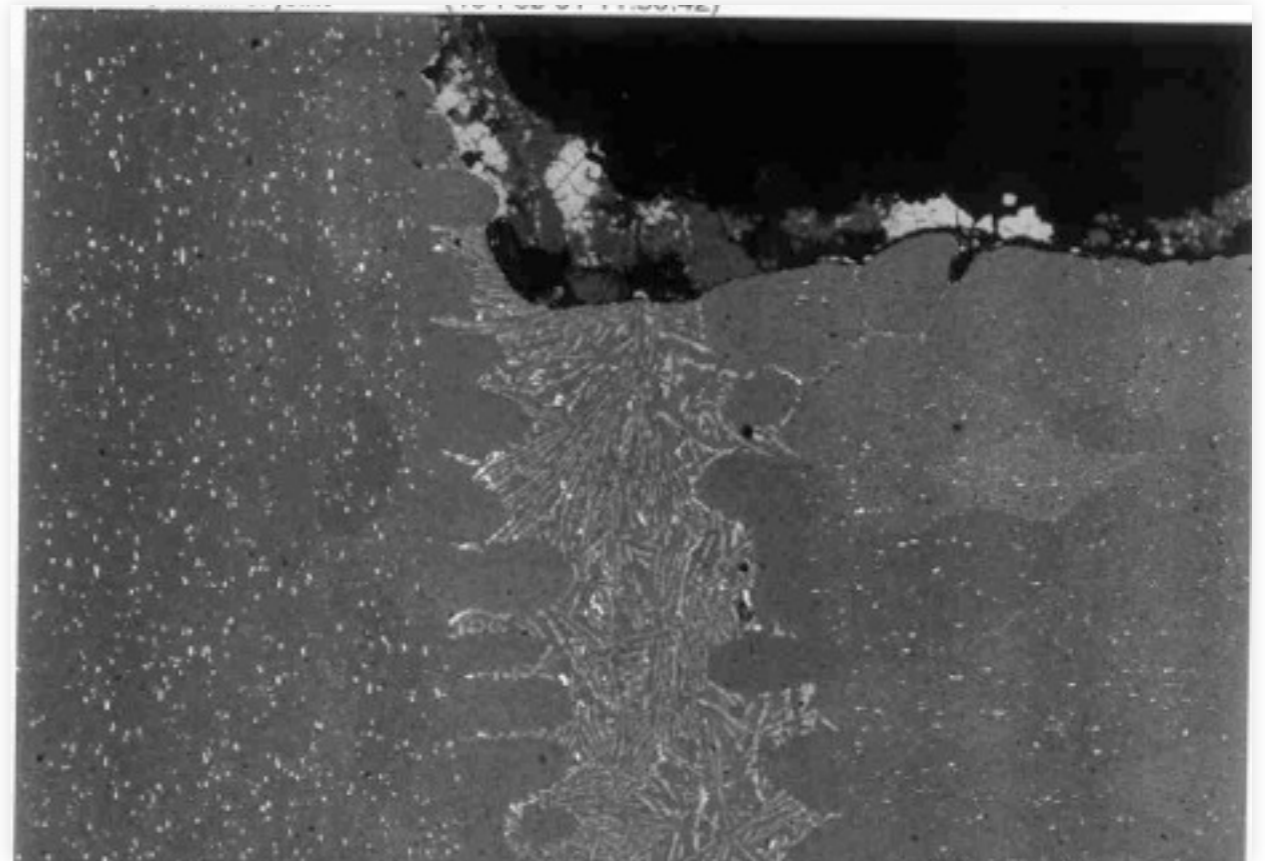
- ❖ 4047 Braze alloy
- ❖ Controlled atmosphere brazing
- ❖ Al-K-F Flux

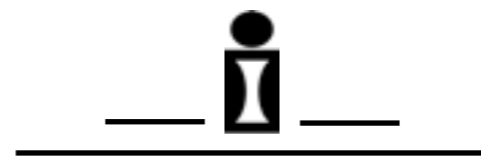




4047 Braze Joint Detail

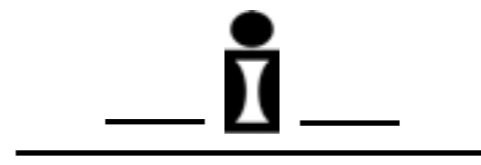
- ❖ High quality braze
- ❖ Good wetting
- ❖ Uniform distribution
- ❖ Minimal grain boundary penetration





Summary

- ❖ KM Al base coatings offer alternatives to existing processes
- ❖ CP Al coating replacement/repair of Alclad
- ❖ Al-Trans[®]/Cr replacement/repair of Al IVD Coatings
- ❖ 4047 Braze alloy deposition replacement of braze foil or paste



Latest Development

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