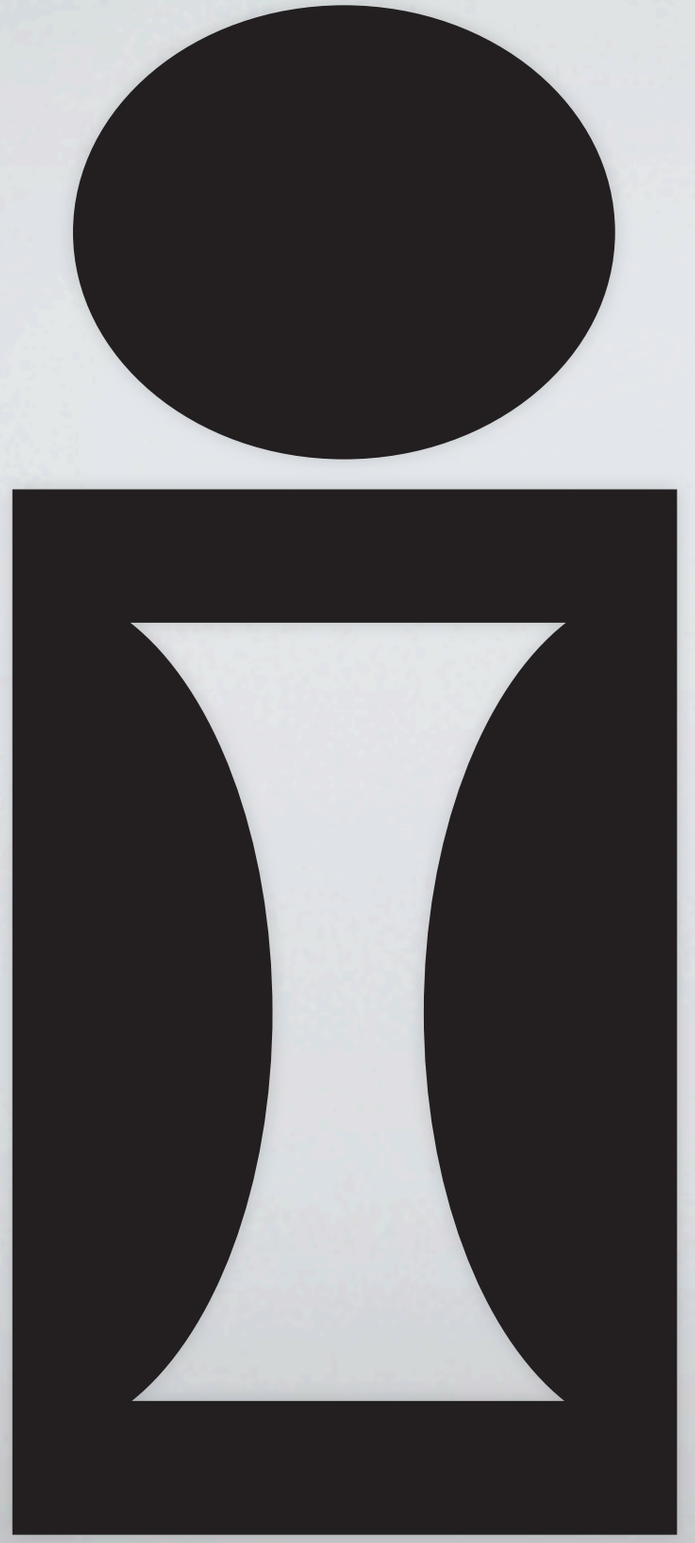


Kinetic Metallization™

Tungsten and Chrome Carbide Coatings

ITSC - New Materials for Wear and Corrosion Applications

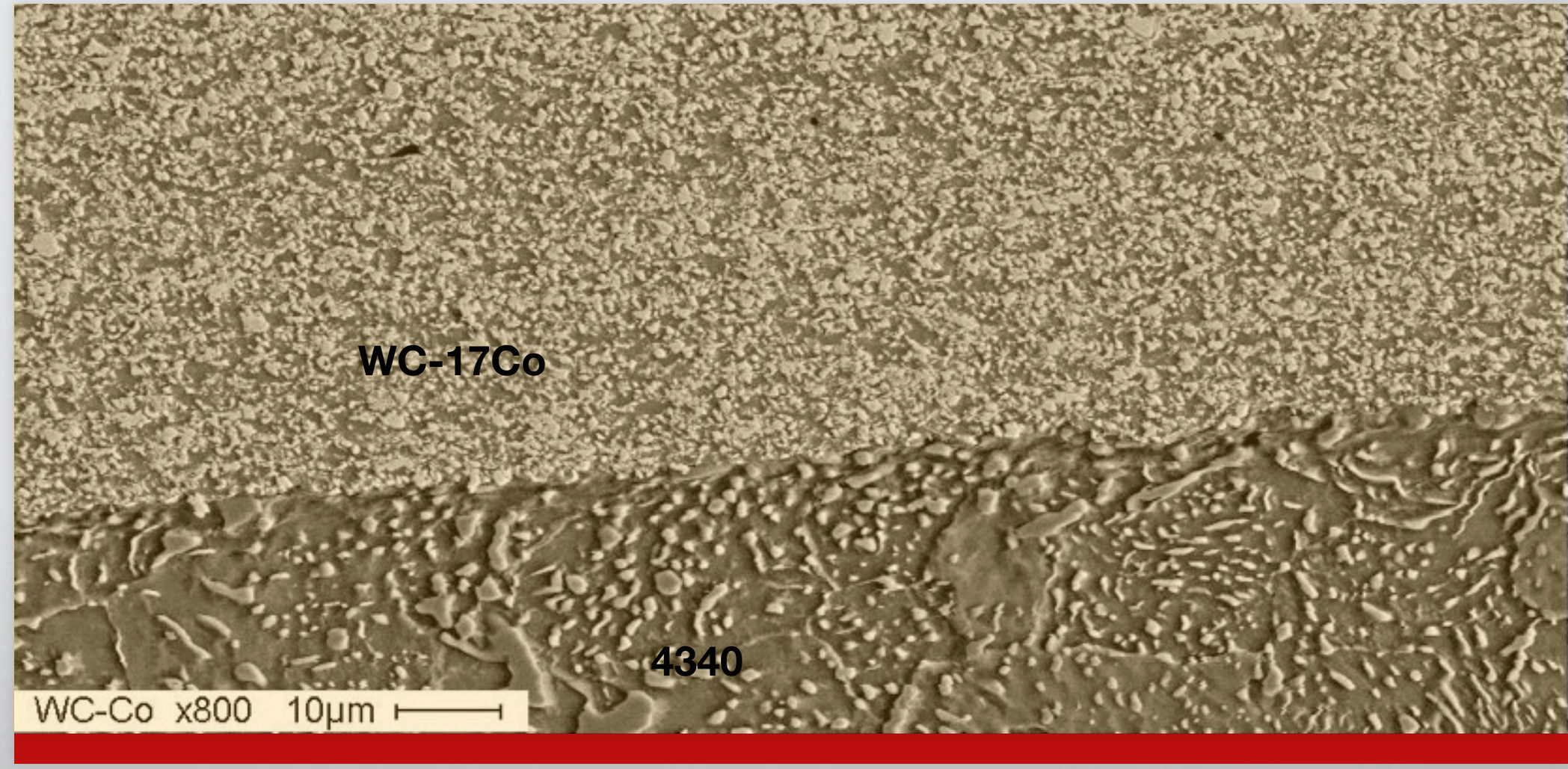
5 May 2009

Jeff Henness

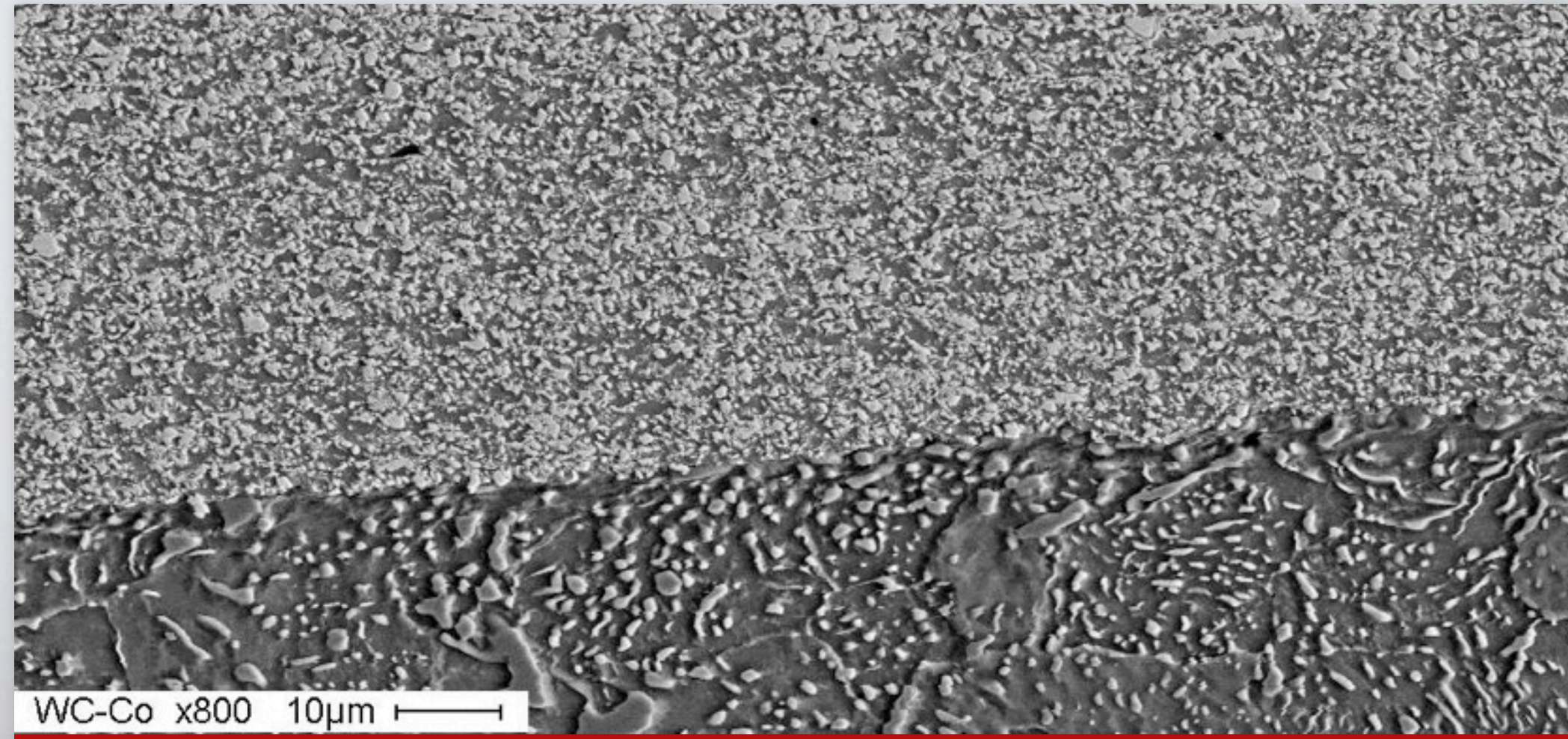
Overview

- Introduction to Kinetic Metallization™ (KM™)
  - Process, Equipment, and Control Parameters
- Tungsten Carbide Coatings
  - Comparison to HVOF
- Chromium Carbide Coatings

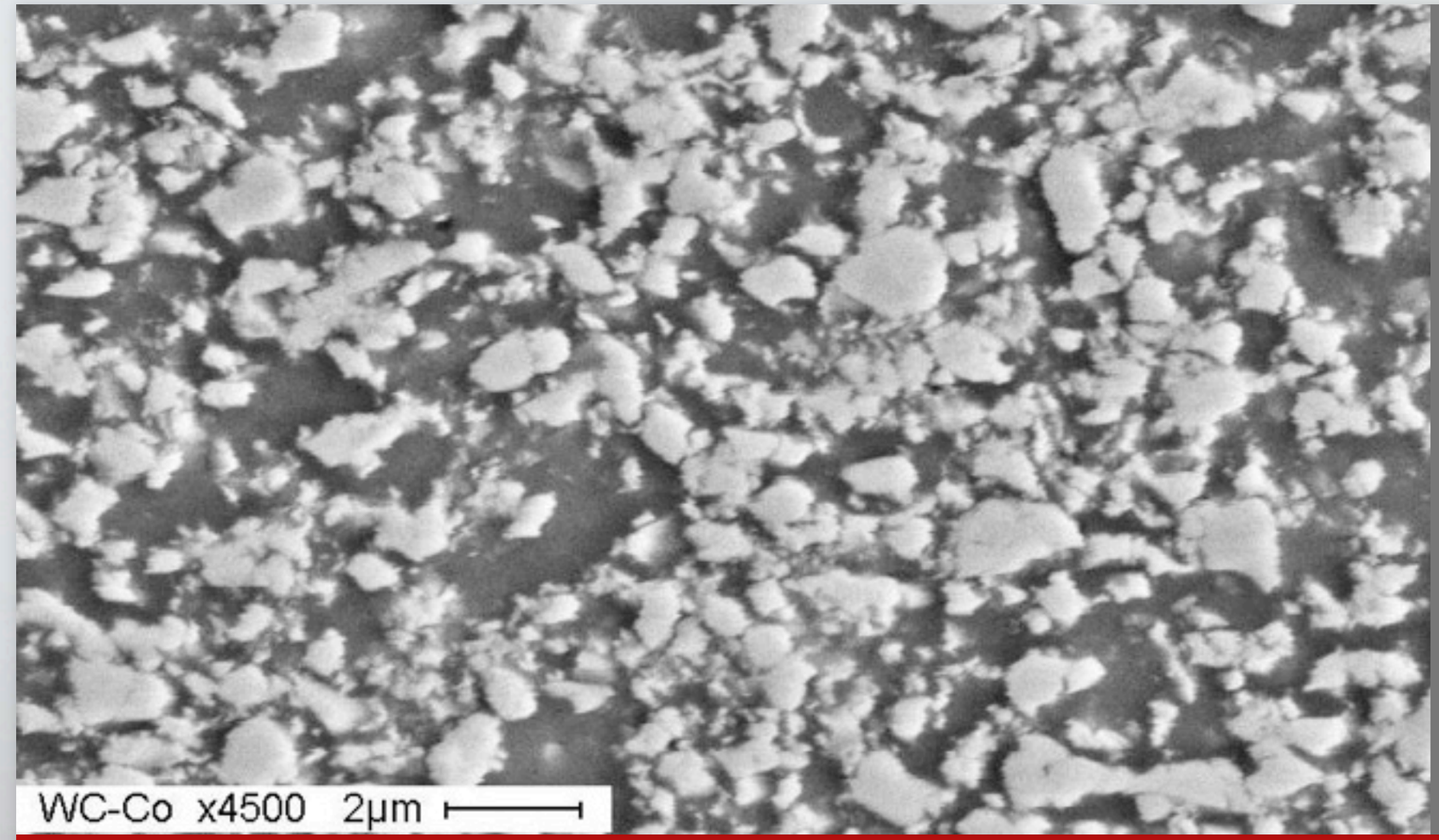
Introduction to Kinetic Metallization™ (KM)



Introduction to Kinetic Metallization™ (KM)



Introduction to Kinetic Metallization™ (KM)



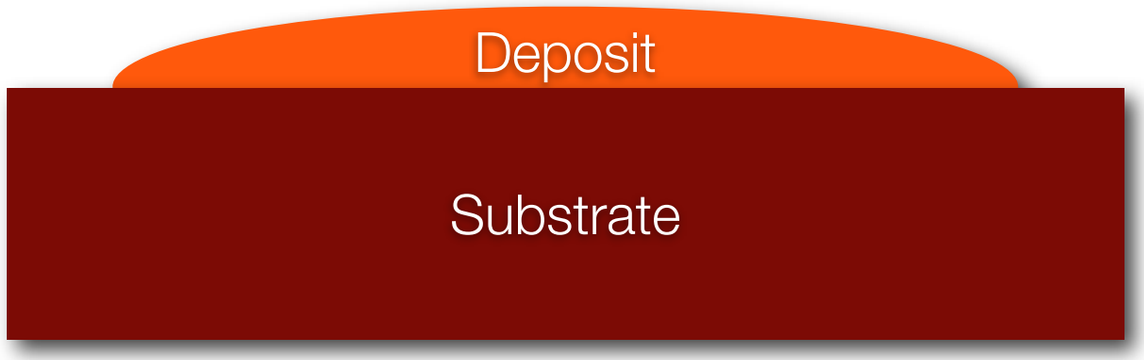
Introduction to Kinetic Metallization™ (KM)

- Metal deposition through particle impact
- low-temperature << melting point
- high particle velocity > 500 m/s
- gas velocity below Mach 1
  - He, 300K, 980 m/s
  - GN2, 300K, 330 m/s

Substrate

Introduction to Kinetic Metallization™ (KM)

- Metal deposition through particle impact
- low-temperature << melting point
- high particle velocity > 500 m/s
- gas velocity below Mach 1
  - He, 300K, 980 m/s
  - GN2, 300K, 330 m/s

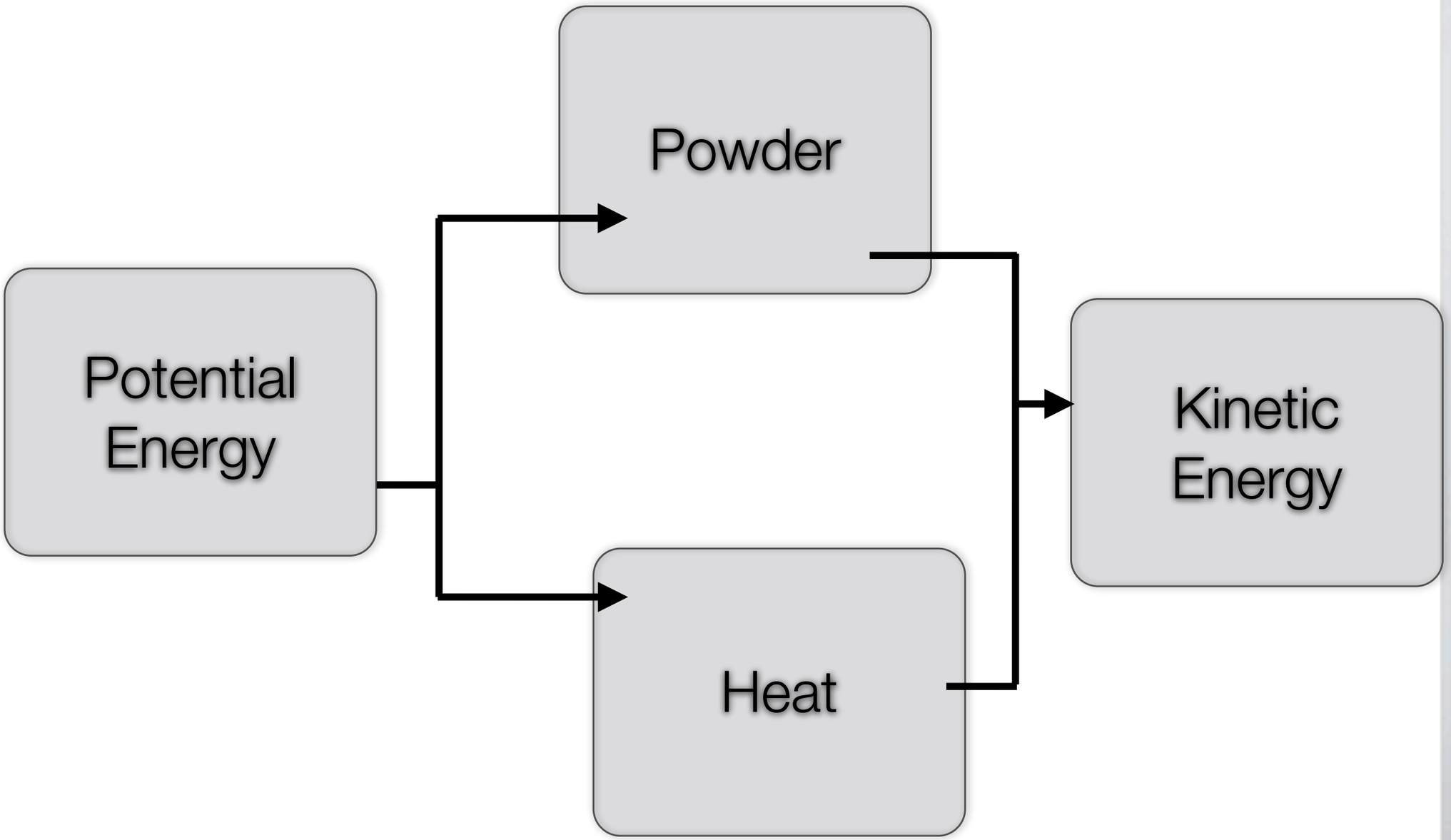


Powder

Potential Energy

Kinetic Energy

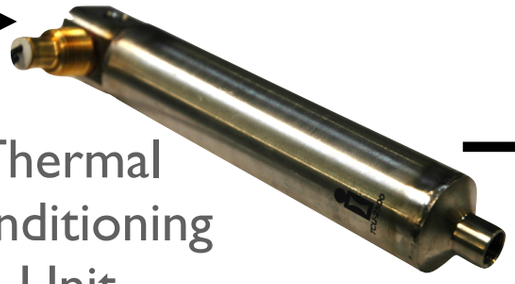
Heat


Powder
Potential Energy
Kinetic Energy
Heat

Gas Storage System

Powder Fluidizing Unit

Deposition Nozzle



Thermal Conditioning Unit

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Control Parameters

- Nozzle
  - Temperature
  - Pressure
- Powder
  - Feed rate
- Translation
  - Speed / Step size
  - Layers

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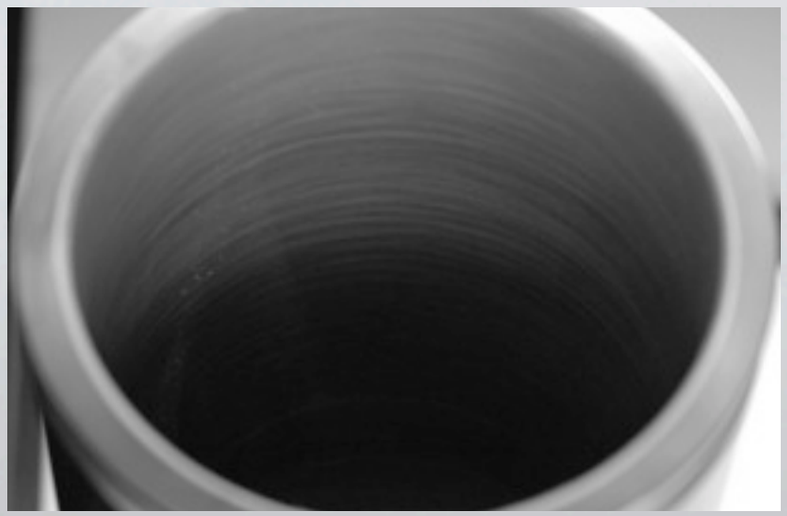
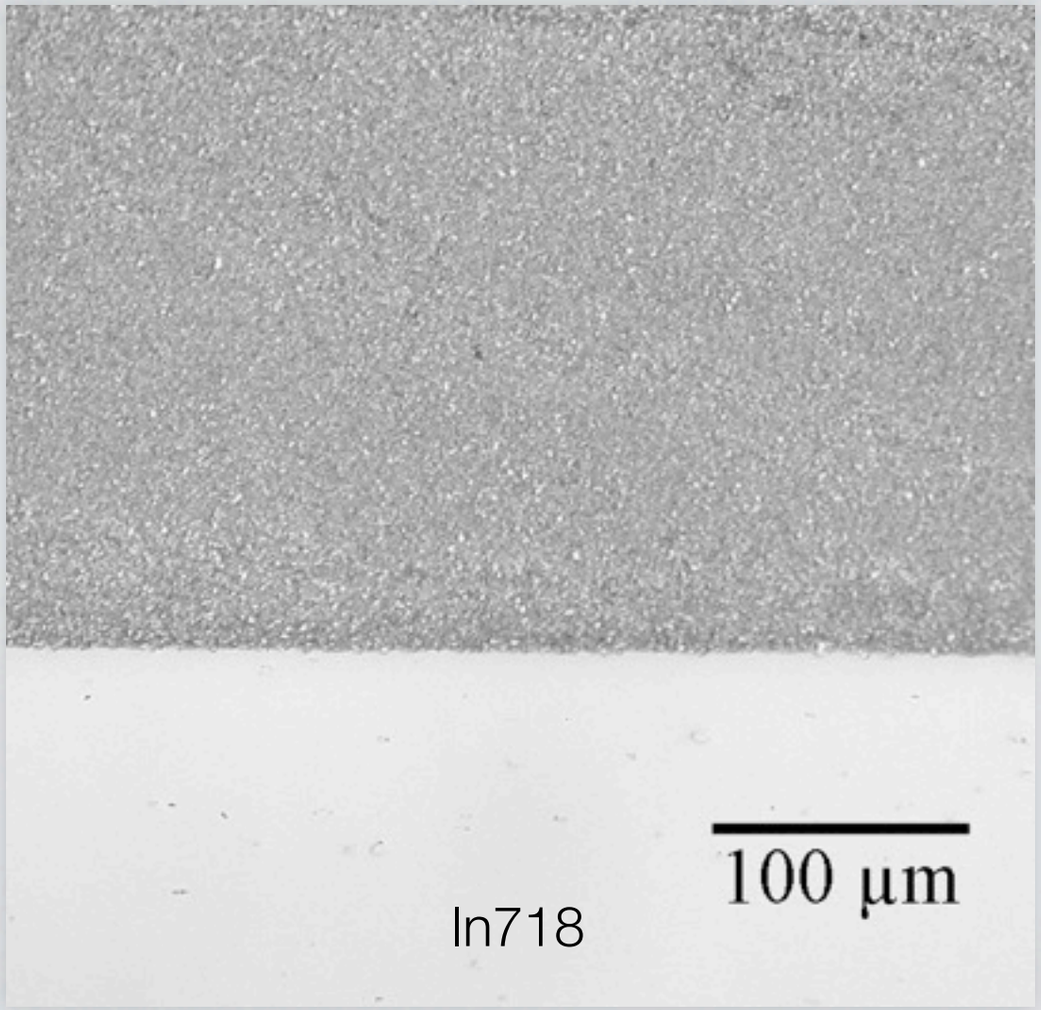
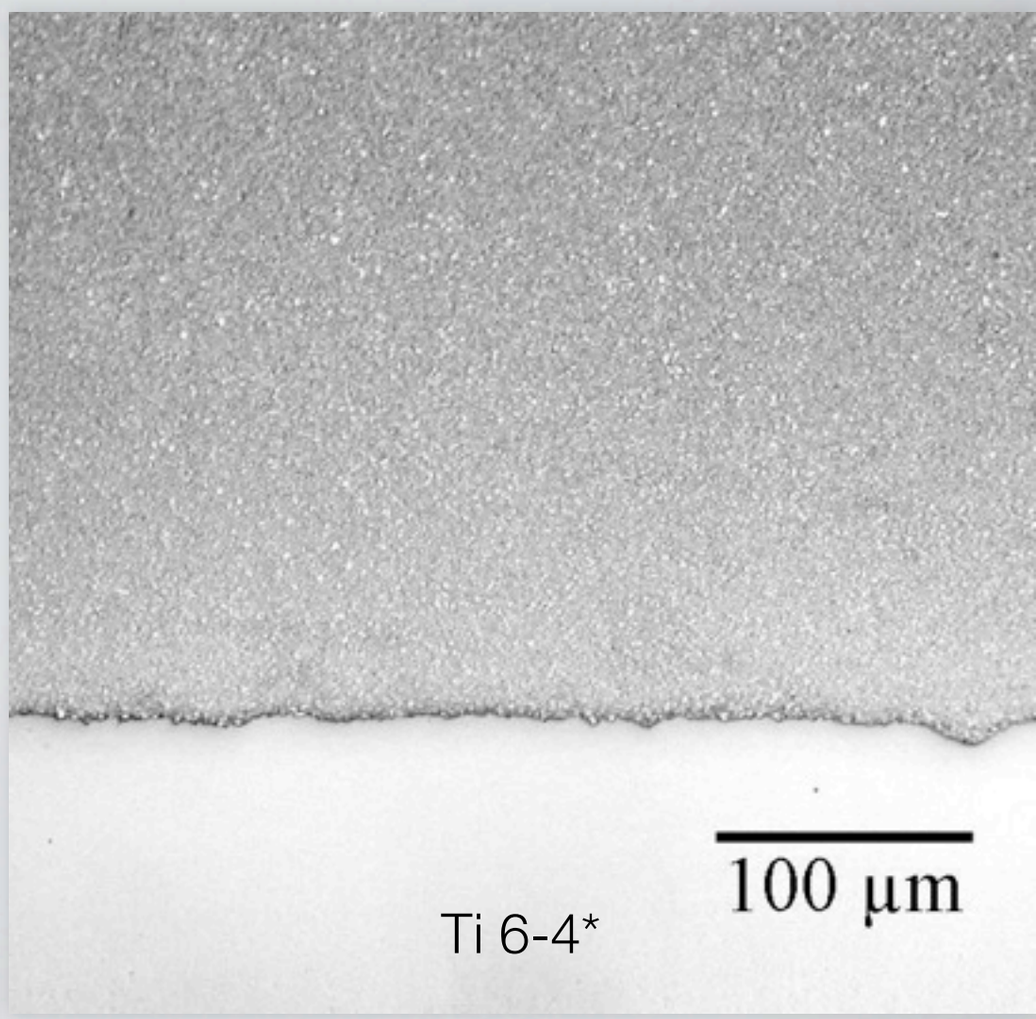


Tungsten Carbide Coatings

KM1000 WC-Co



In718



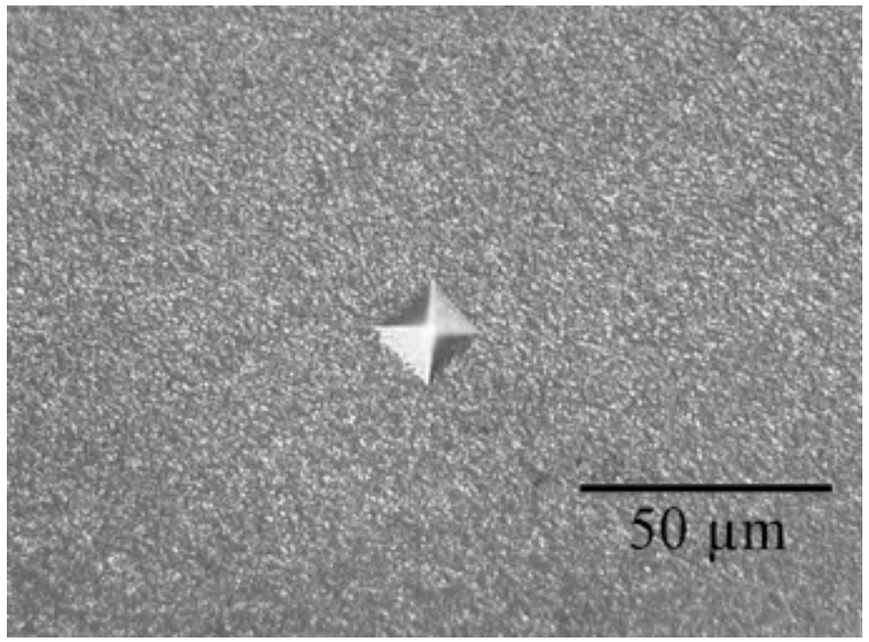
Ti 6-4*

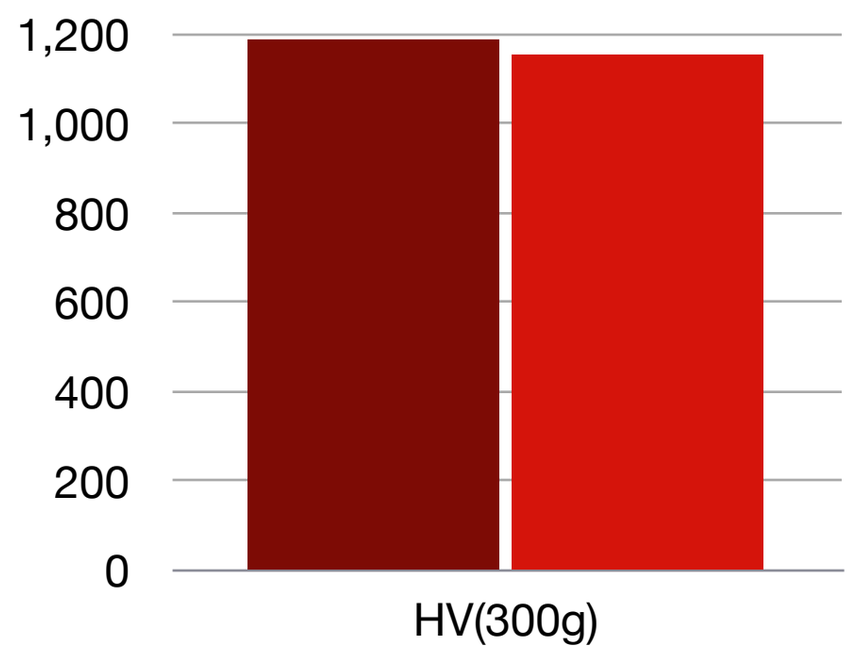
WC-Co
Typical Microstructure

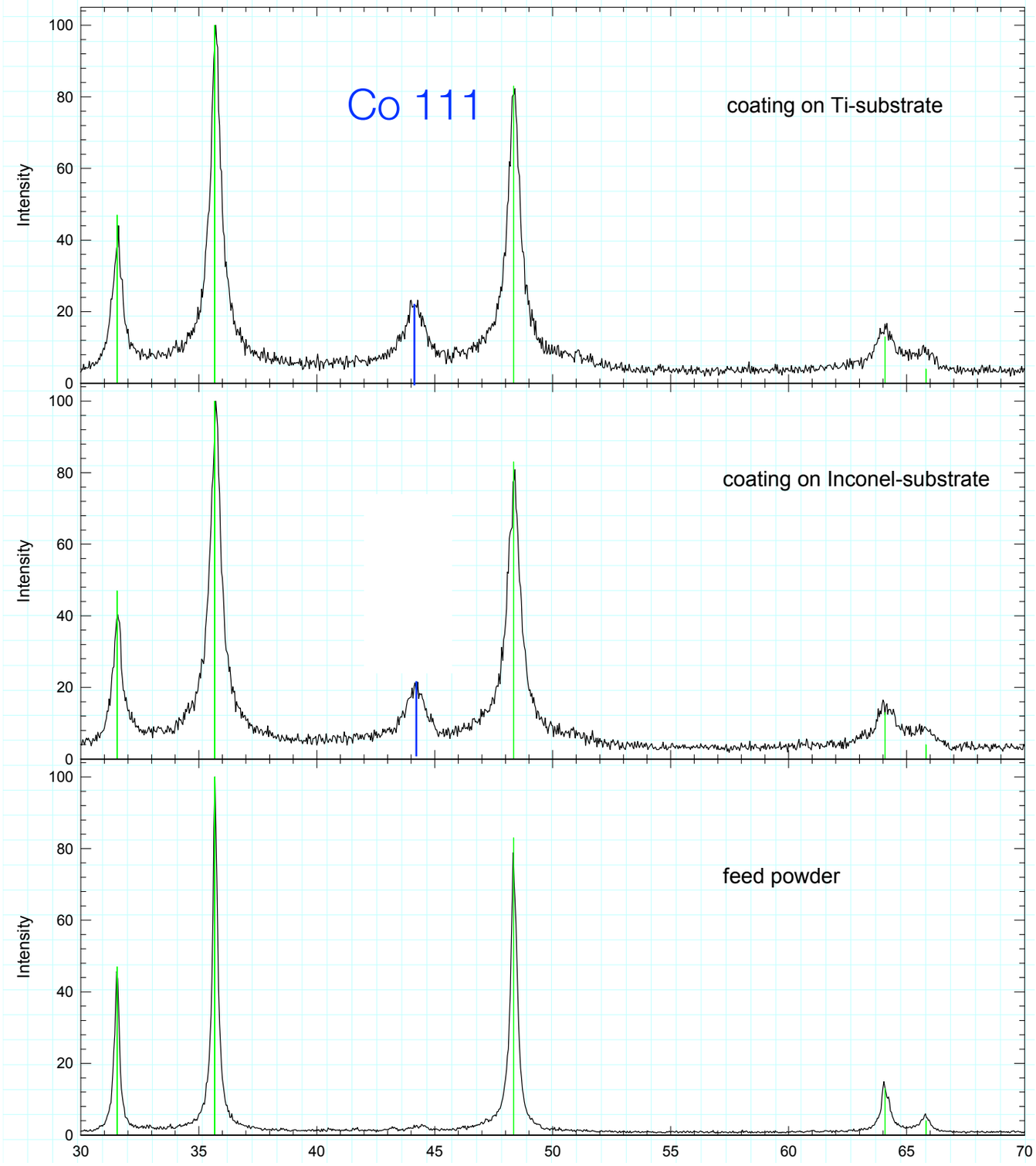
*relief at interface introducing image contrast

KM1000 WC-Co Microhardness

- Vickers hardness - 300g load



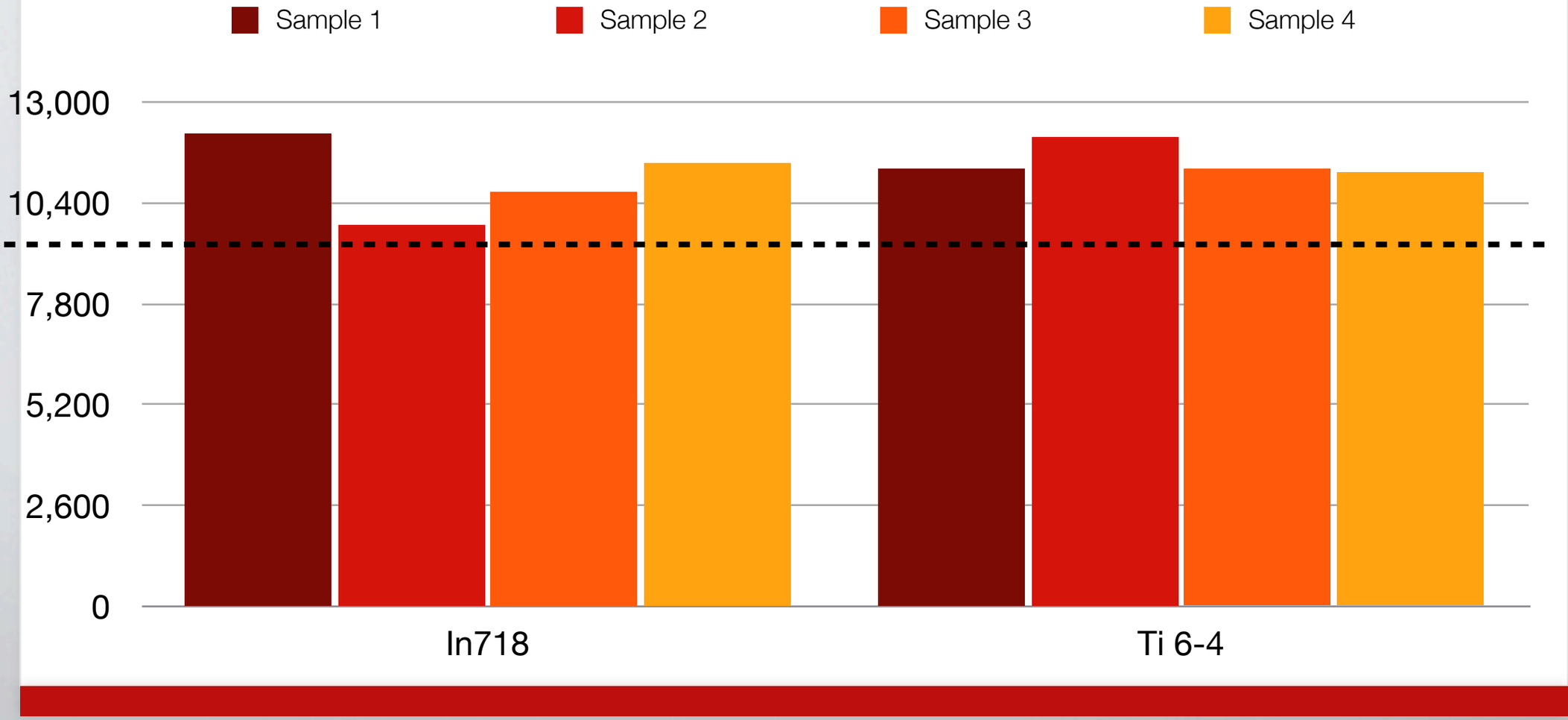




- X-Ray Diffraction
- No decarburization
  - No W metal
- No conversion
  - No cobalt carbide
- No oxides present

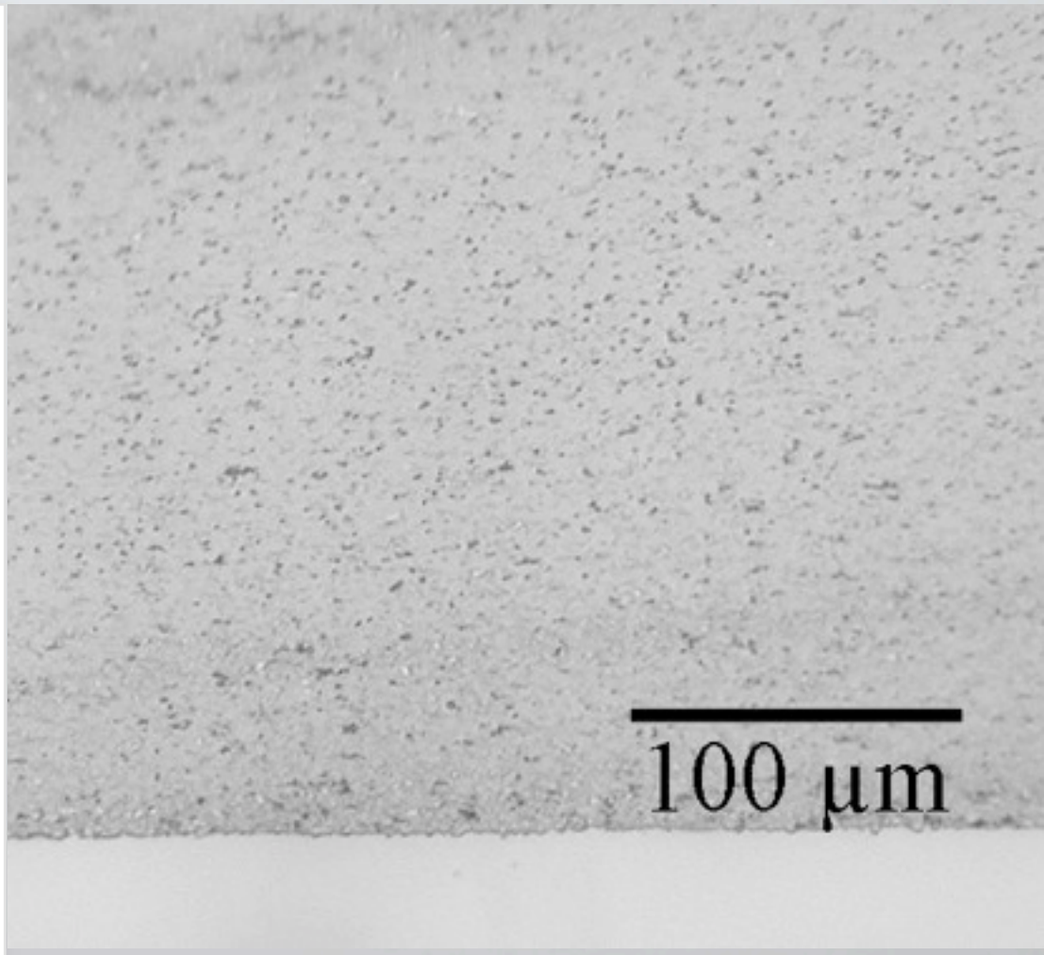
WC WC WC

ASTM C633 Adhesion Testing



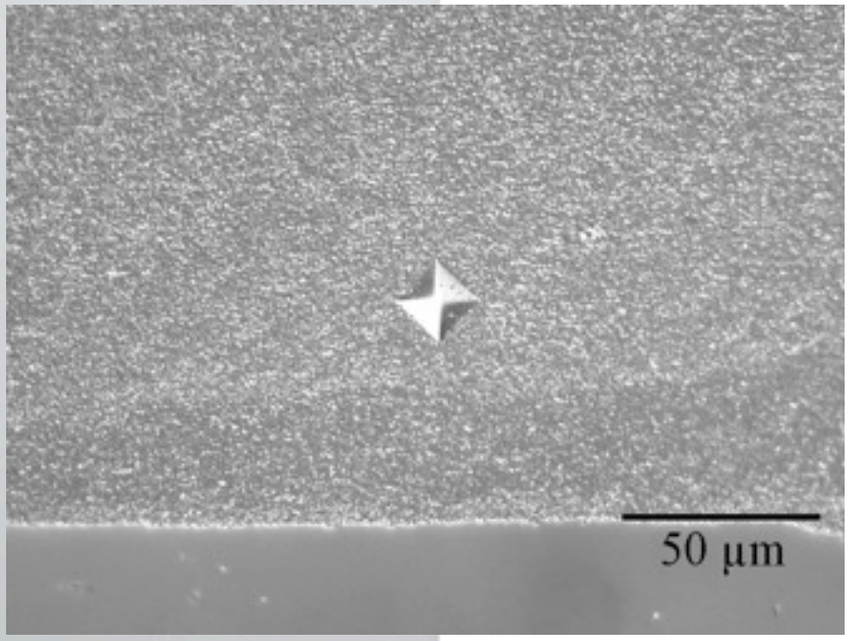
WC-NiCrCo on In718

- Higher hardness than WC-Co
- Superior corrosion resistance

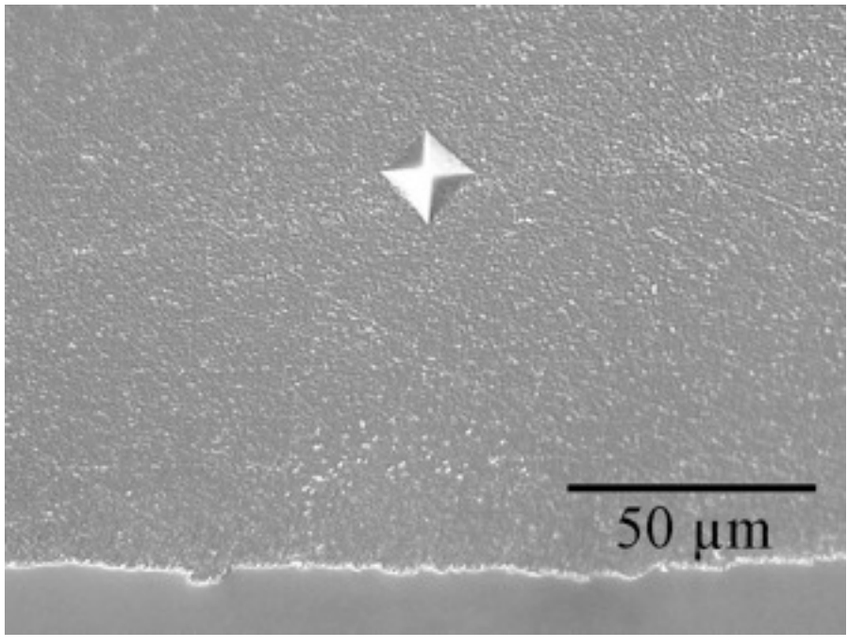


WC-NiCrCo Microhardness

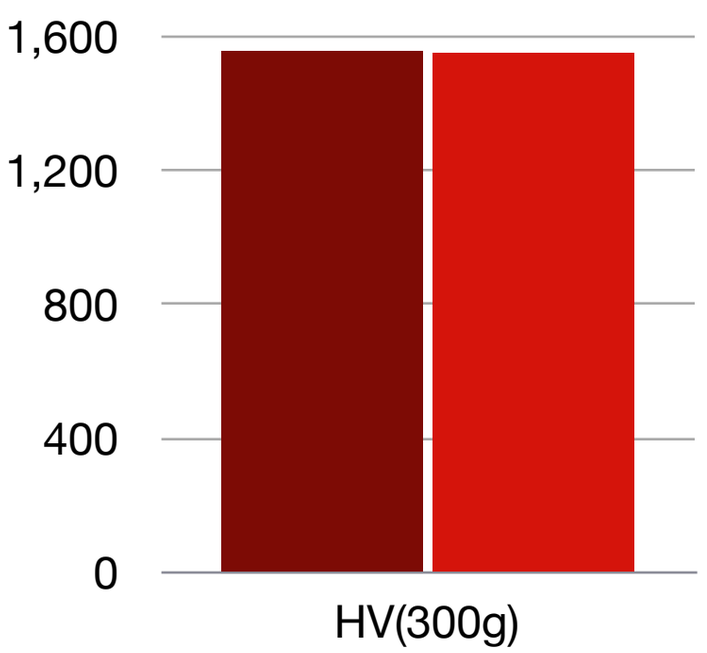
- Vickers hardness (300g load)
- Hardness >1,500HV



In718

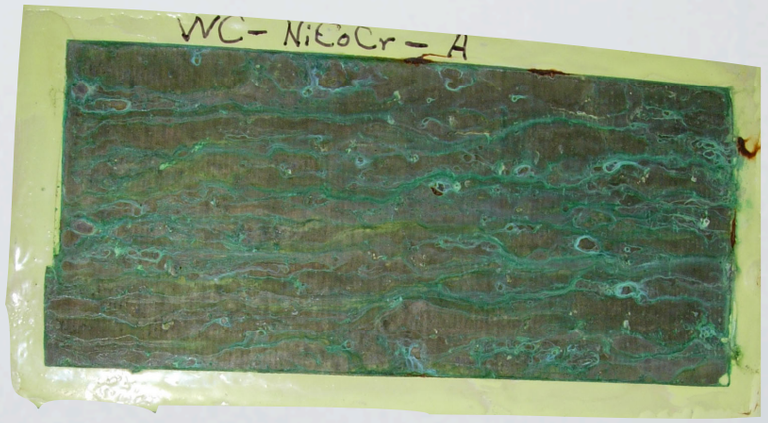


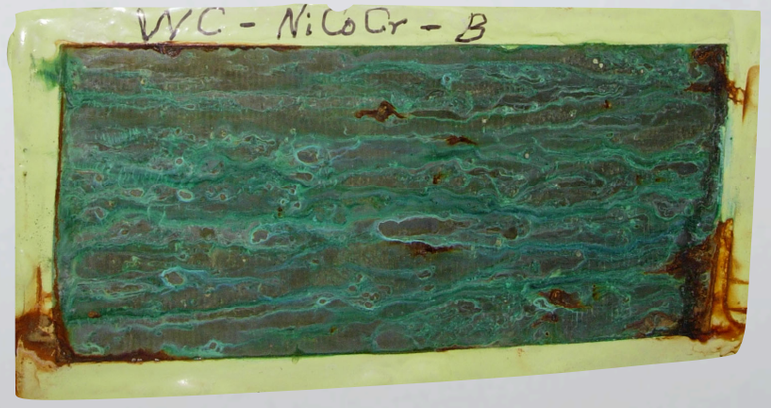
Ti 6-4



WC-NiCrCo Corrosion Resistance

- ASTM B117 Neutral Salt Fog
  - Photos after 900 hours exposure
- Surpasses WC-Co baseline





Chromium Carbide Coatings

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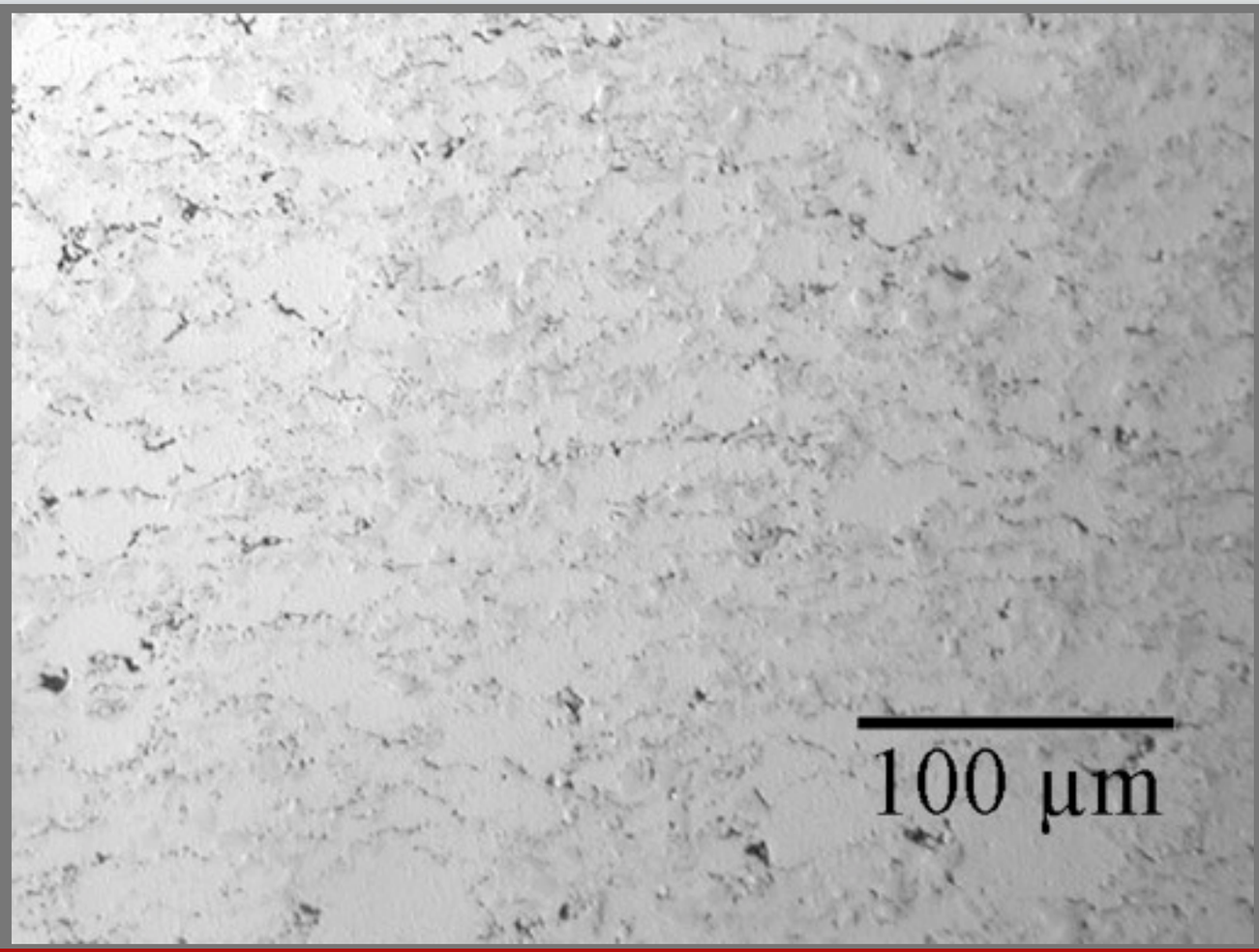
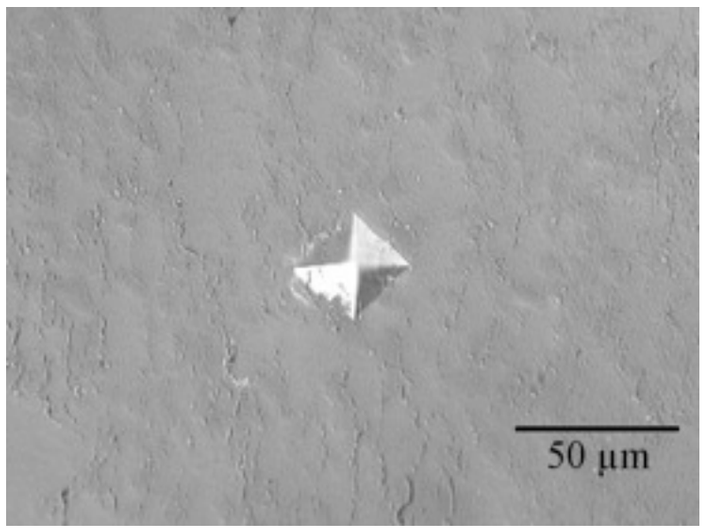
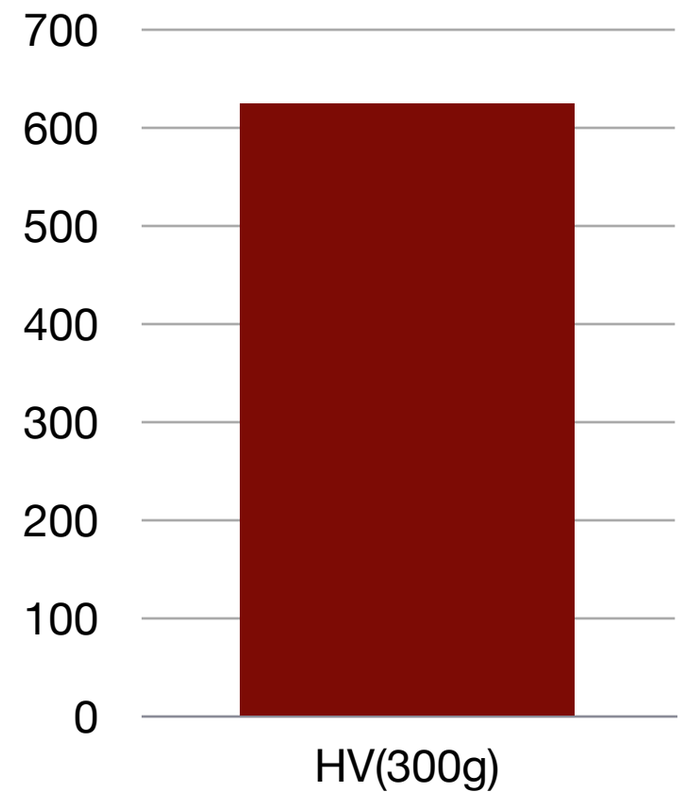
Cr_3C_2-NiCr Micrograph



Cr_3C_2-NiCr Microhardness

- Vickers hardness
  - 300g load





KM – HVOF Microstructure, Superfinishing and Cost Comparison

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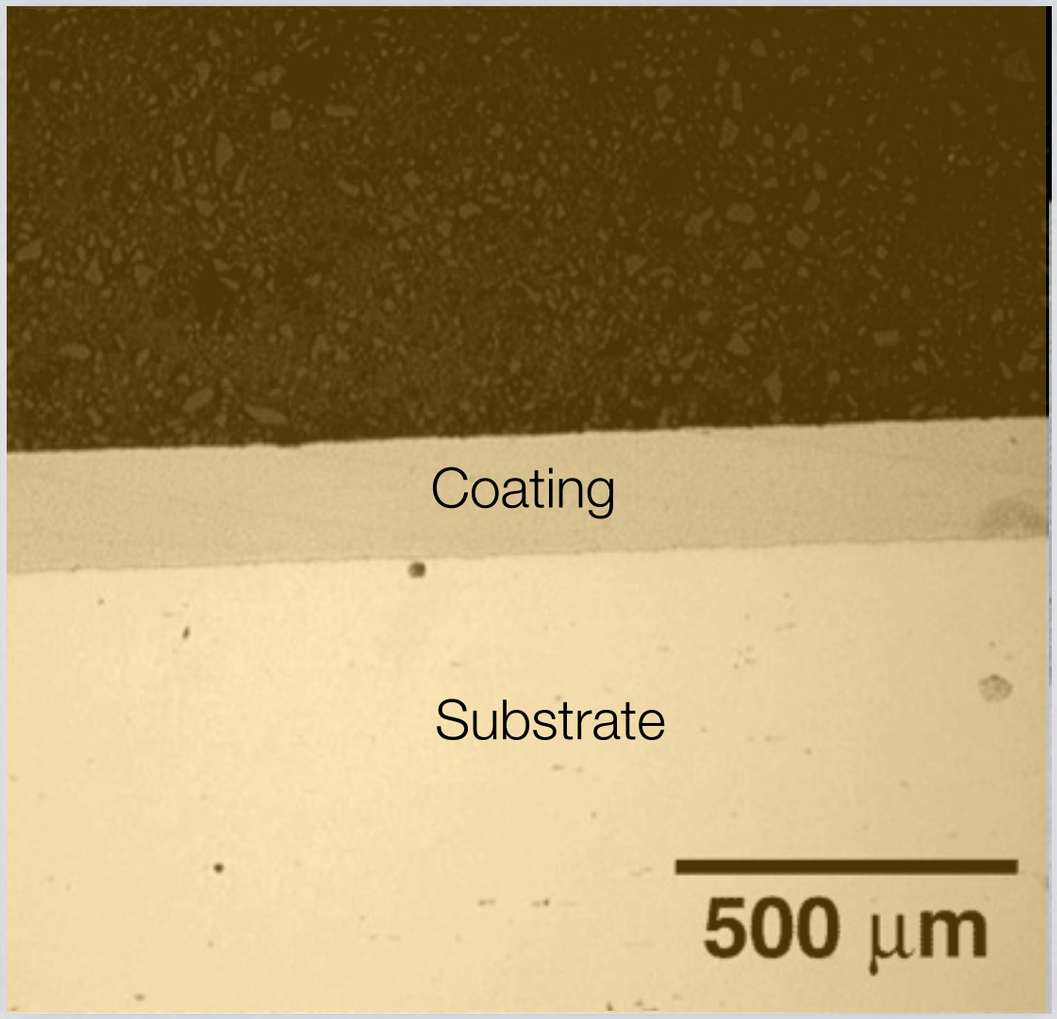
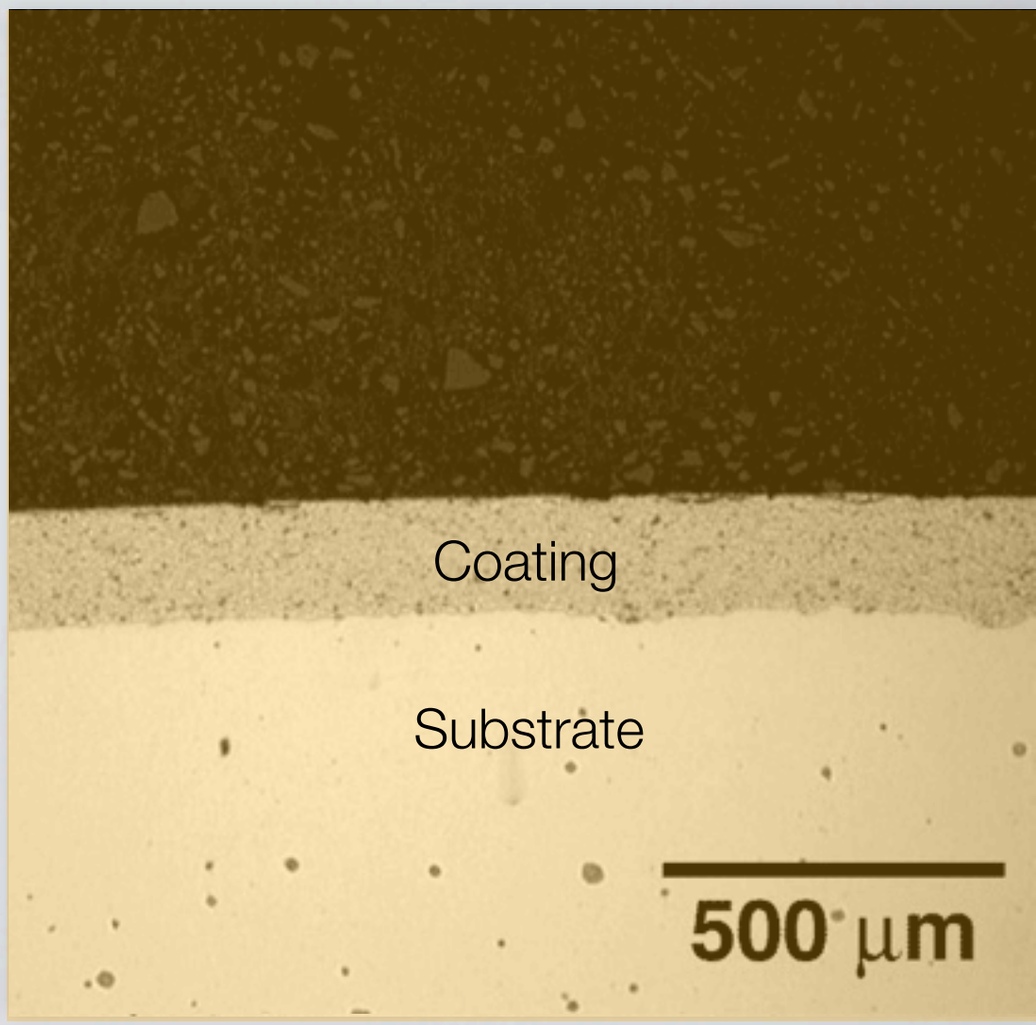


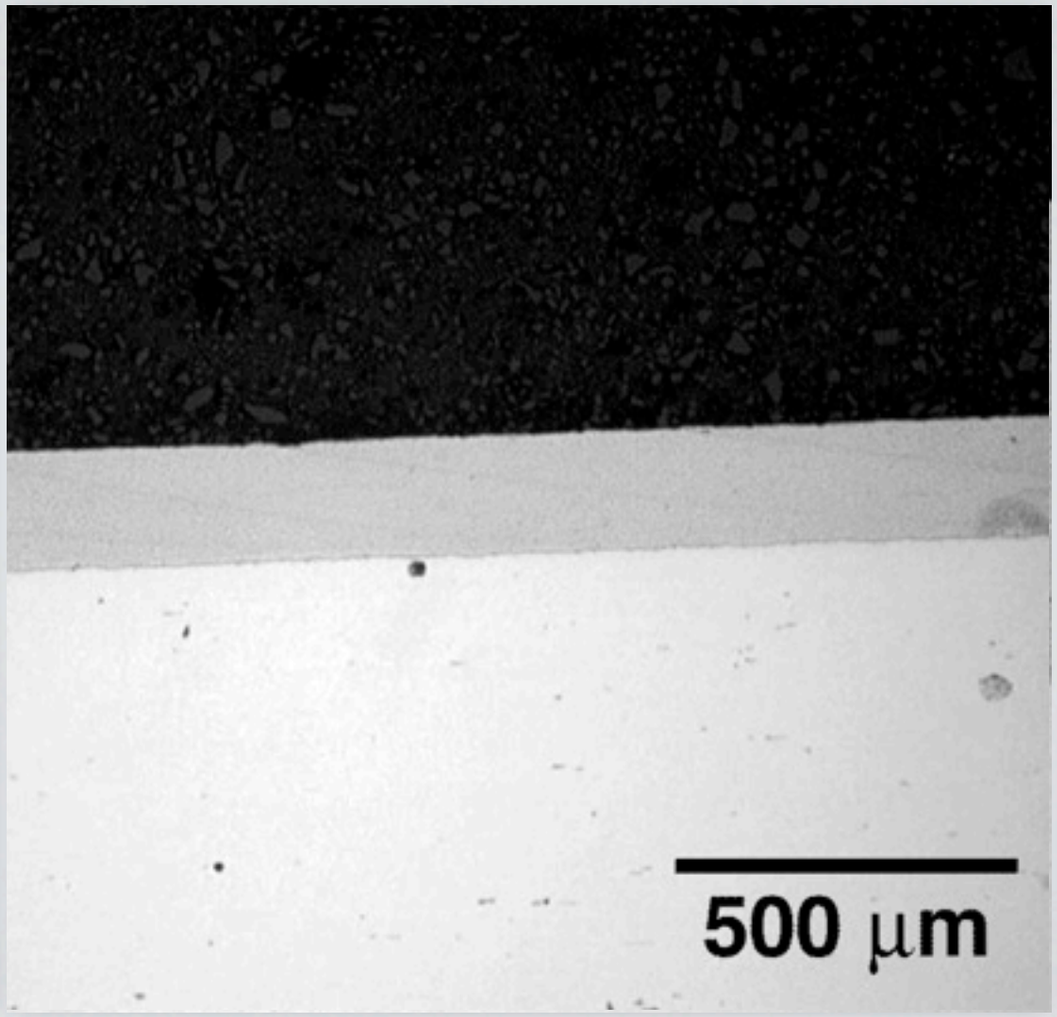


KM

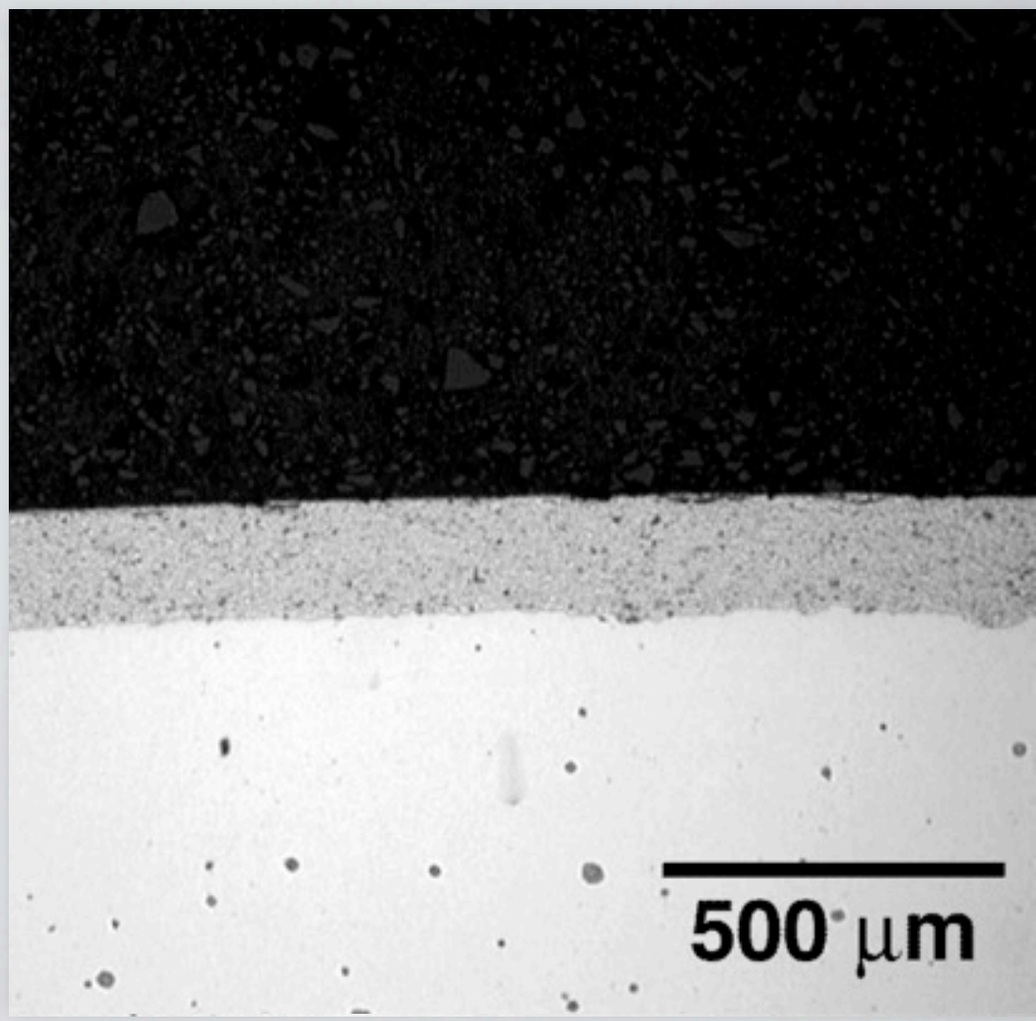
HVOF

KM vs HVOF - Microstructure

50x Bright Field



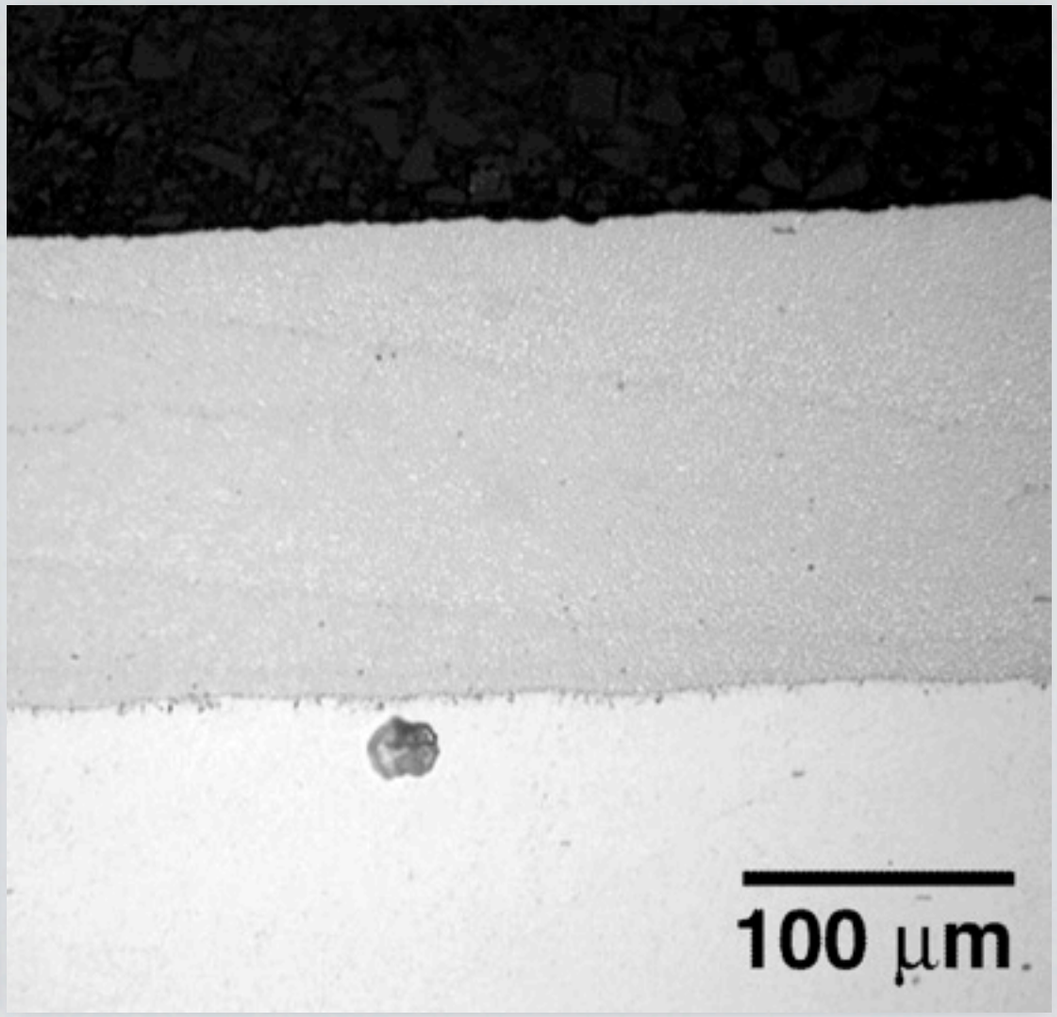
KM



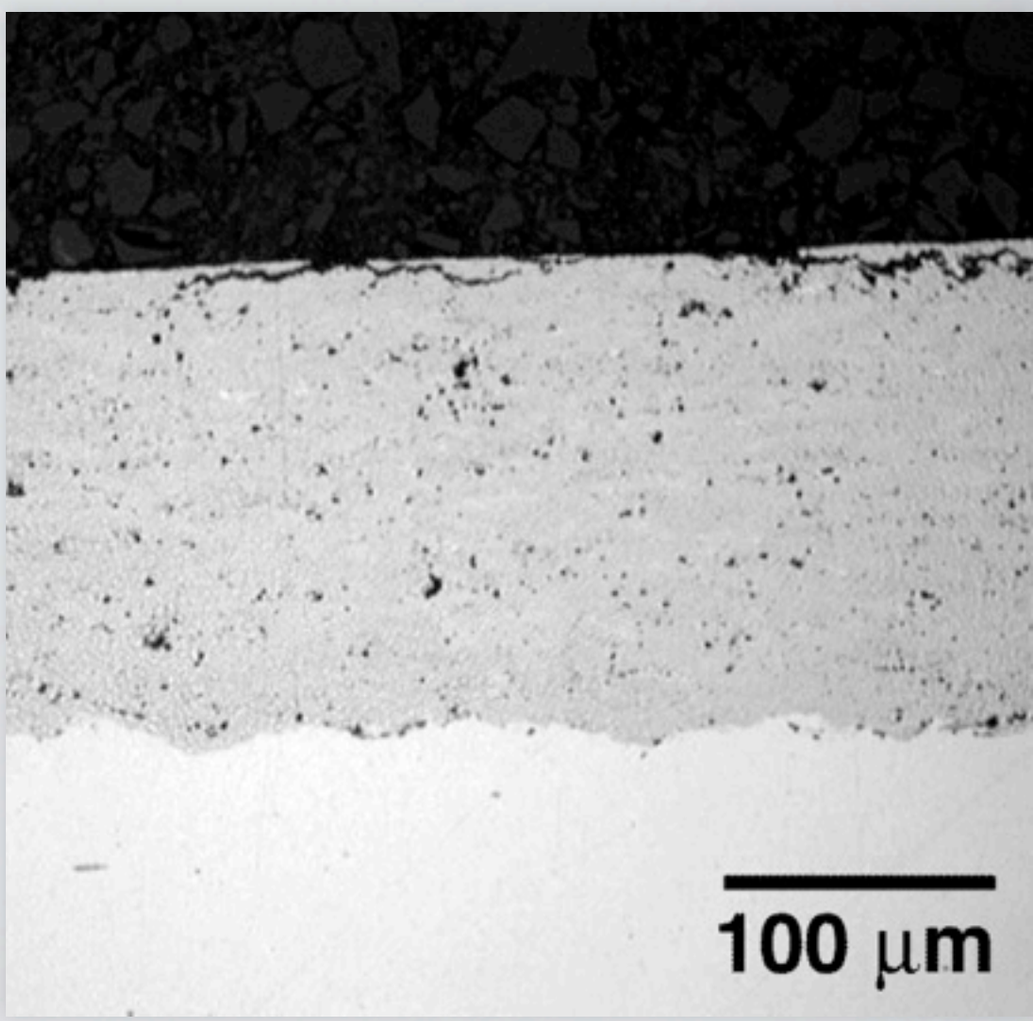
HVOF

KM vs HVOF - Microstructure

200x Bright Field



KM

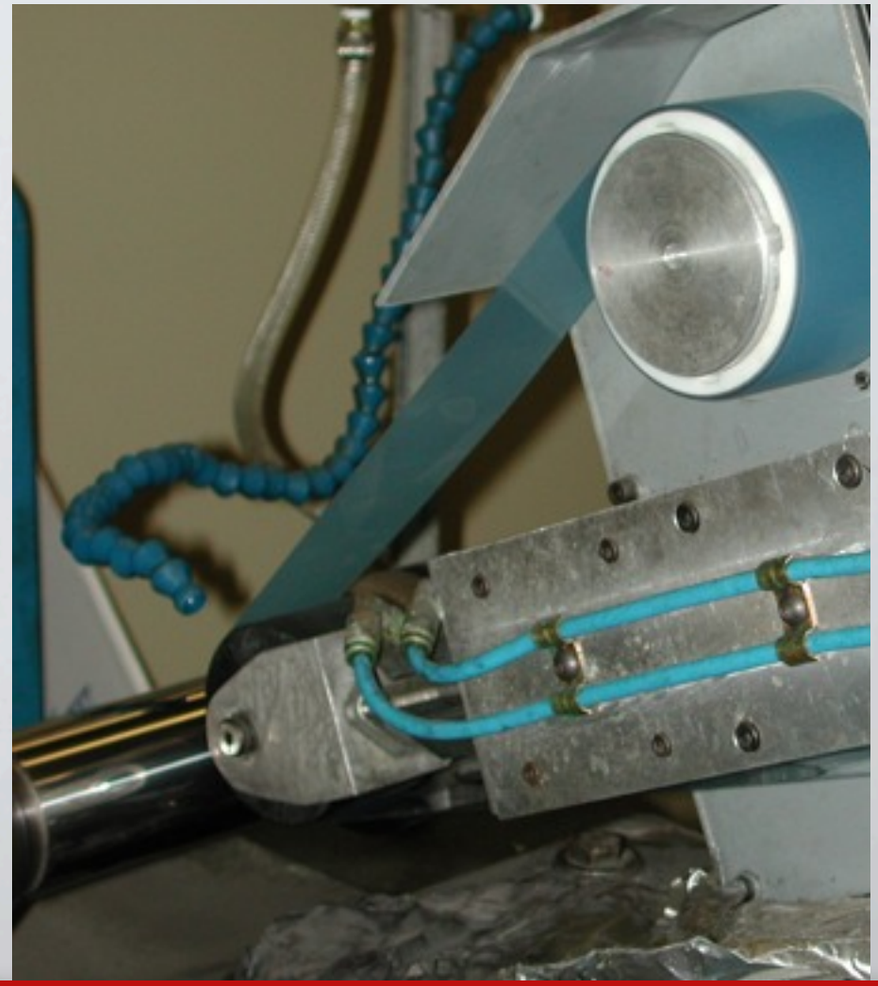


HVOF

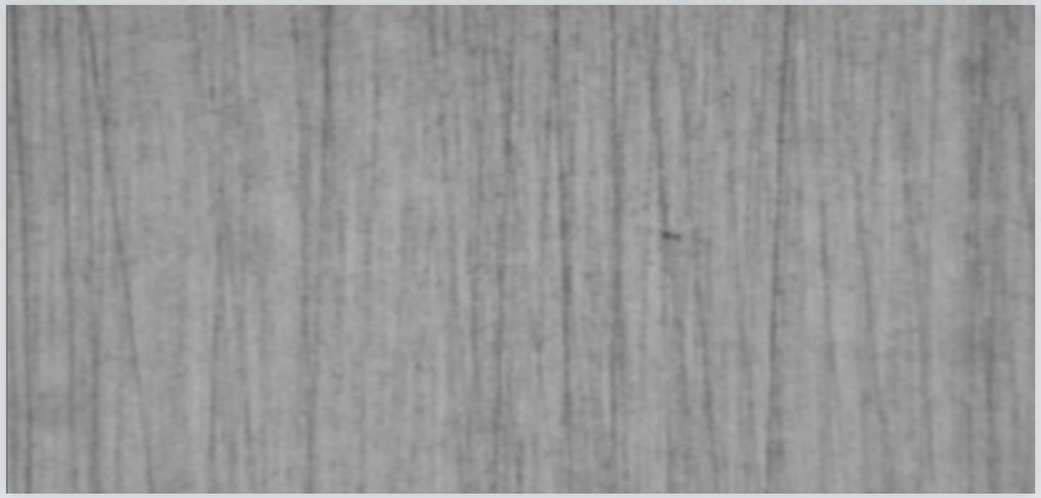
KM vs HVOF - Microstructure

Superfinishing Study Objective

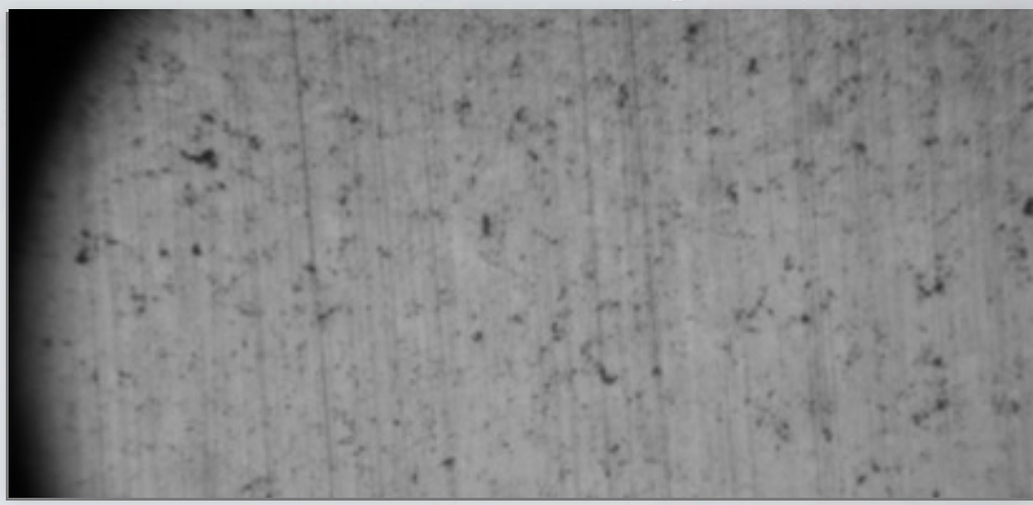
- Compare resultant surface finishes
- Compare visual appearances
- Coatings evaluated
  - WC-Co (85%, 15%) – Kinetic Metallization™
  - WC-Co-Cr (86%, 10%, 4%) – High Velocity Oxygen Fuel (HVOF)



KM (50X original)

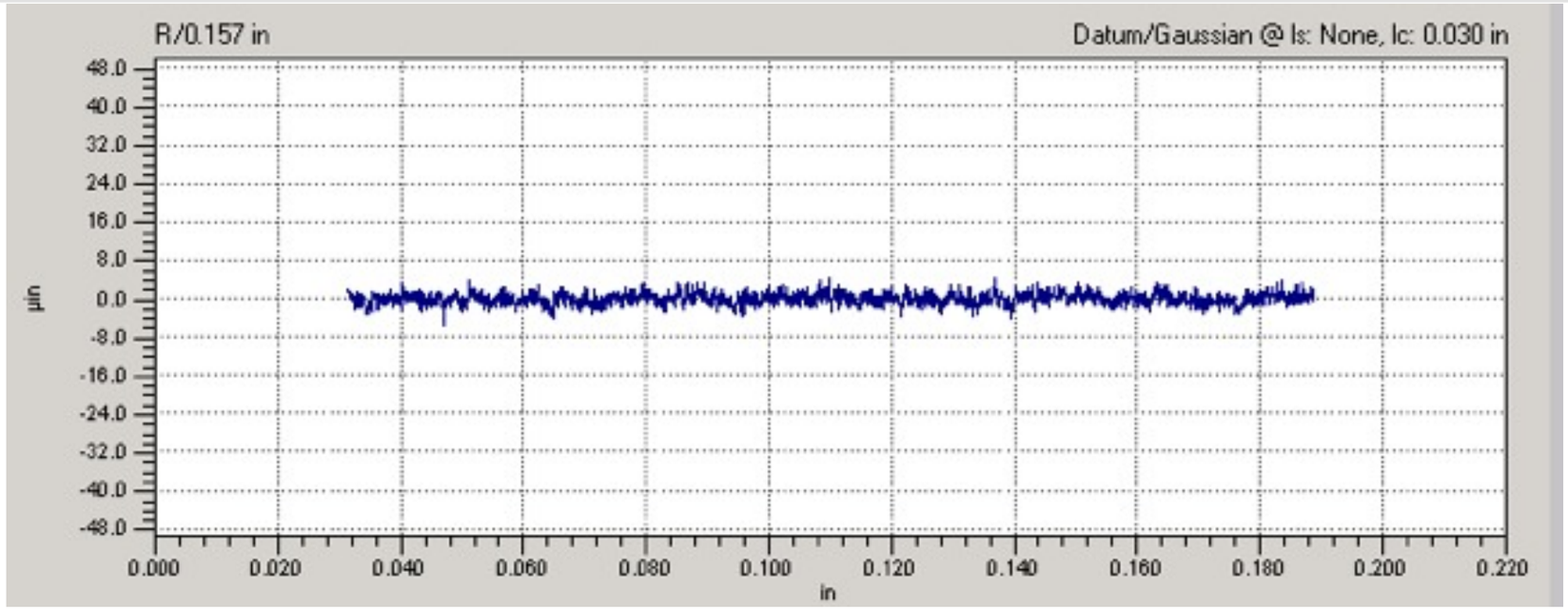


HVOF (50X original)

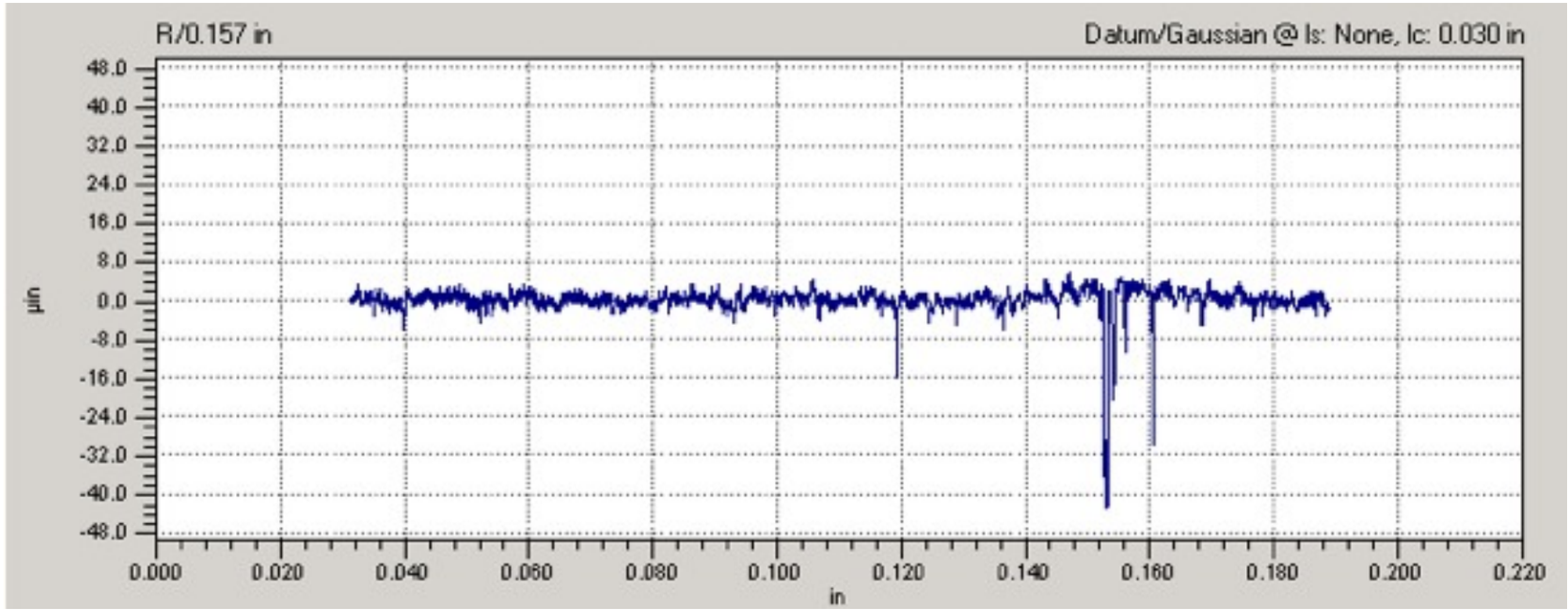


9µ Finishes & Photos

	Ra	Rz	Tp%
KM	1.03	7.97	100
	1.08	8.1	100
HVOF	1.17	12.16	99.42
	1.05	10.28	99.77



KM 9µ DLF Trace



HVOF 9µ DLF Trace

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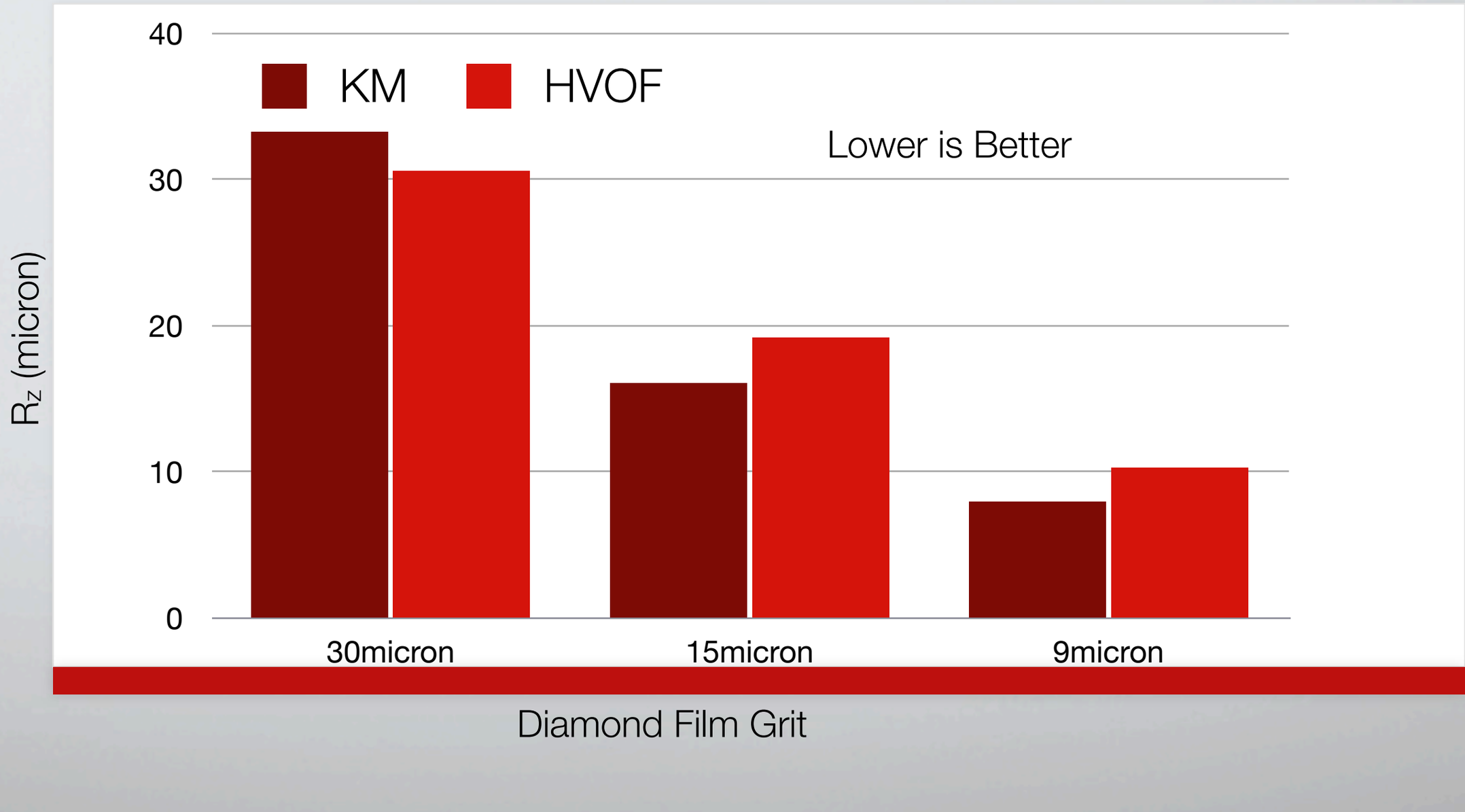
Surface Finish Summary



KM – HVOF
Cost Comparison

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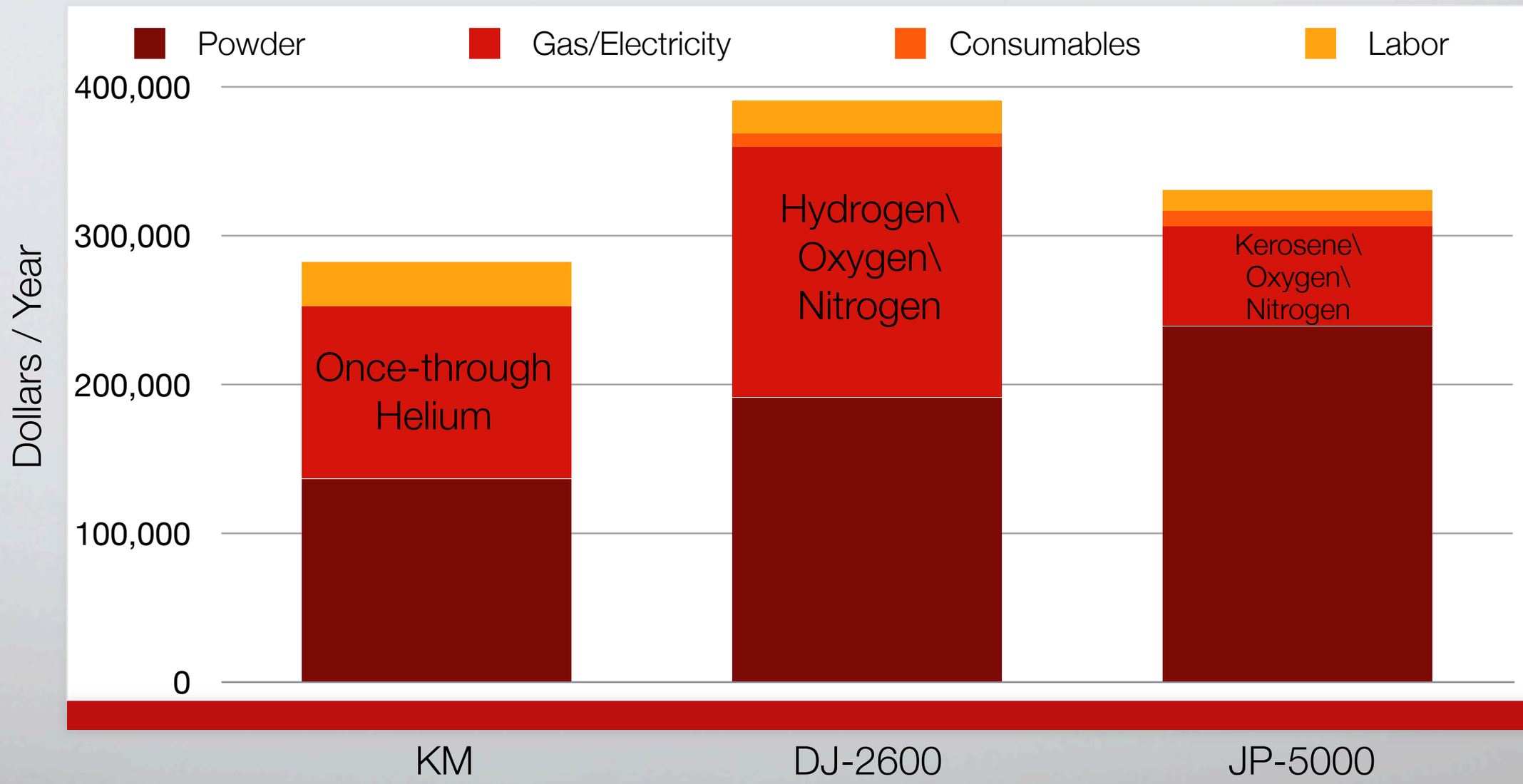
KM vs. HVOF* Operational Costs

- KM compared to DJ-2600 (hydrogen) and JP-5000 (kerosene)
- WC-Co at 0.010” thickness
- Calculate annual costs on square foot basis (300 sq. ft. per month)
- KM gas costs based on ***once-through*** helium
- Labor Rate $20/hr
- Costs associated with masking, loading, preparation not included
  - Analysis ***understates*** HVOF cost

*HVOF costs courtesy of VandenBergh & Associates

Annual Cost Summary



Summary

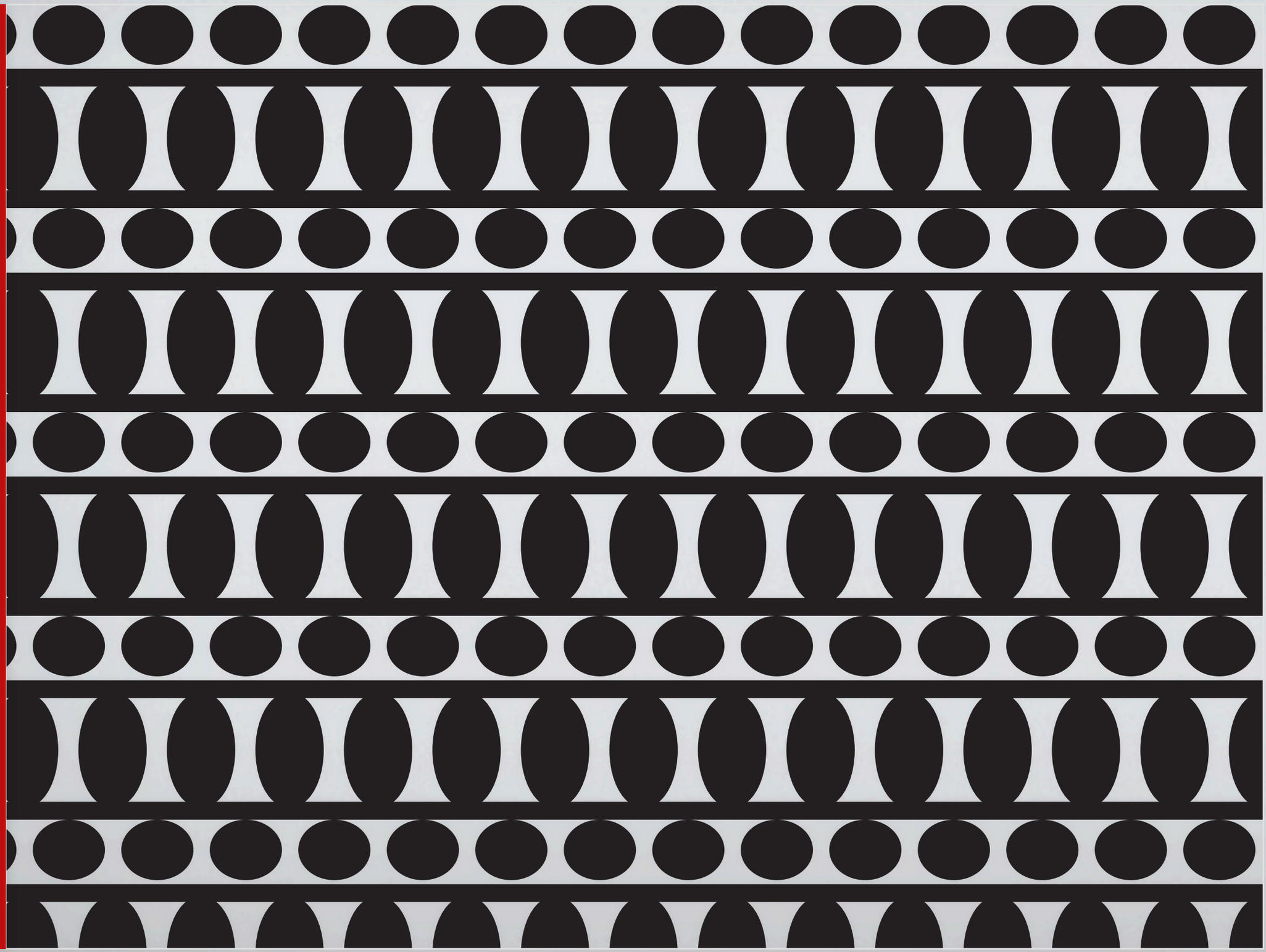
- KM deposited WC-Co coatings exhibit:
  - Low porosity and high adhesion
  - No conversion of coating material
- WC-NiCrCo
  - Higher hardness and better corrosion performance than WC-Co
- Chromium Carbide Coatings
  - Fully Dense

KM-MCS

Mobile Coating System

KM-PCS

Production Coating System



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