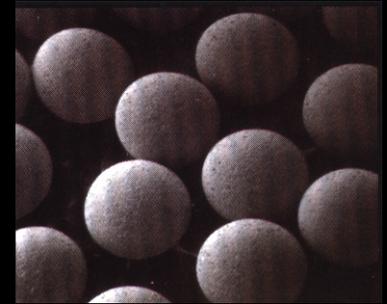
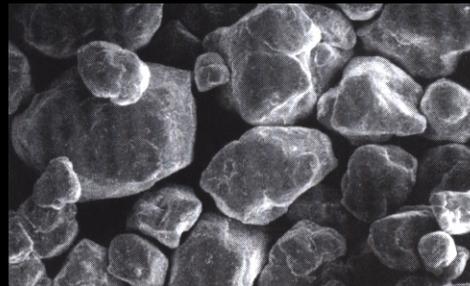


Alternatives to Chrome VI Coatings

Pollution Prevention through Nanotechnology
Conference
Arlington , VA
September 25, 2007



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Powdermet Coatings
Technologies
Powdermet, Inc.
Euclid, OH



POWDERMET INC.

The Cutting Edge in Metal Powder Technology

Overview

- Chrome Coatings
- Hazards Associated with CrVI
- Powdermet, Inc.
- PComP™ Nano-composite technologies
- Conclusion

Chrome

- Generally considered to be relatively inert
- Used in the production of stainless steels, and even in prosthetic devices for implant within the body
- Impart wear and corrosion resistance to components in the aerospace, oil and gas, and other industries
- **So, what's the big deal?**

Hard Chrome VI Coatings

- Deposited through a plating process
 - Utilizing a chromic acid solution
 - Solution is released locally as a fine mist containing Cr6+
- \$3B of Cr plating conducted annually, producing:
 - 1.4 million pounds of hexavalent Cr sludge
 - 130 MGal of hexavalent Cr contaminated water
- Environmental and occupational hazard

What is being done?

- Regulation
- Innovation

Regulating the Problem

- Under the Clean Air Act, the EPA enacted more stringent rules limiting CrVI releases
- OSHA implemented decrease in the PEL from $52 \mu\text{g}/\text{m}^3$ to $2.5 \mu\text{g}/\text{m}^3$ (Jan. 1, 2007)

Innovating Around the Problem

- Thermal spray application of WC coatings
 - Thermal spray includes HVOF, Plasma, wire transferred arc
 - Cost of WC has increased
 - Requires special tooling for finish machining
- Trivalent Cr plating
 - Expensive and brittle
- **What else is being done?**

Enter Powdermet

- Powdermet uses a top-down/bottom-up approach to materials design
 - Reduce existing materials through grinding and milling
 - Form new materials through synthesis and formation
- Powdermet combines the hardness of a ceramic reinforcement phase with the toughness of a ductile matrix phase

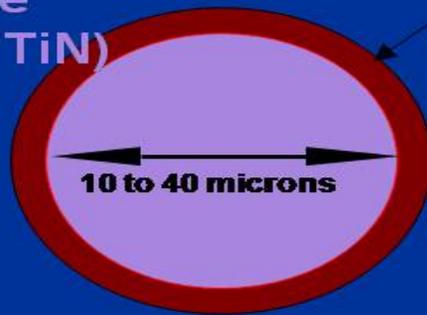
PComP™ (Particulate Composite Powders)



POWDERMET INC.

Thermal spray particle design

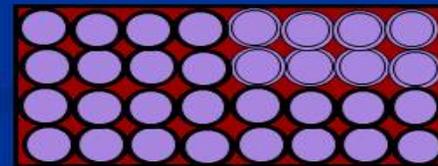
10-40 micron
ceramic/compo
site core
(Si₃N₄, TiN)



Composite
Powder

1-3 micron
Metallic
coating

Thermal Spray



Thermal Spray
Composite

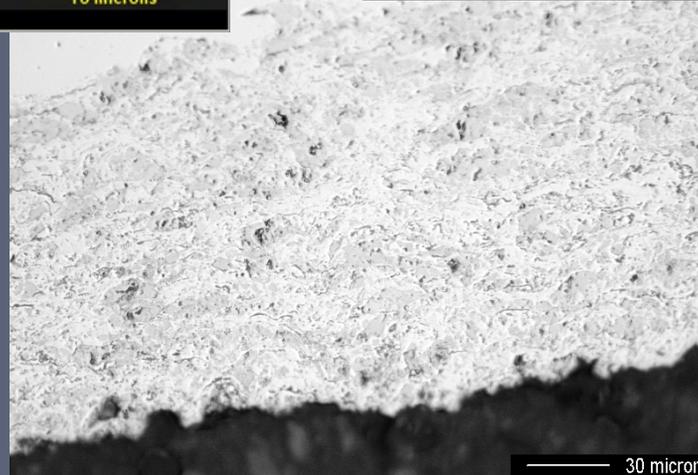
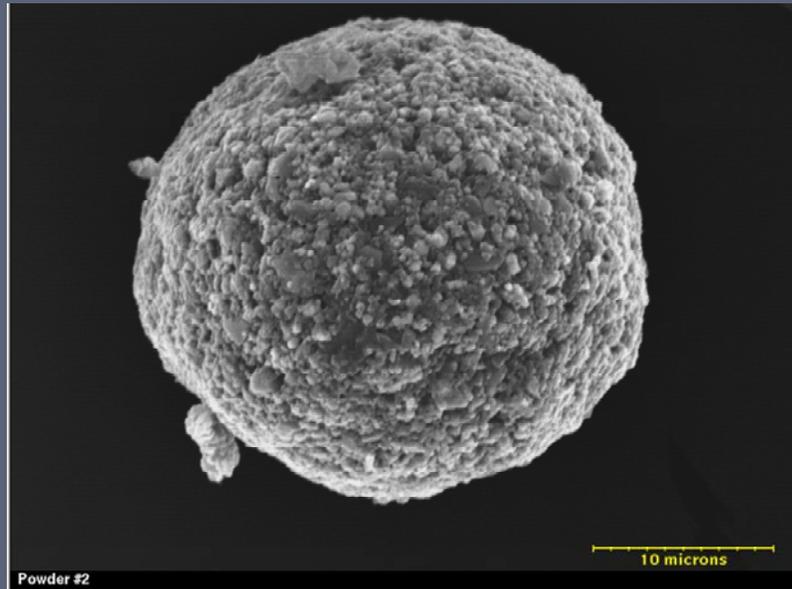


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Advantages of PComP™

- Get a combination of hardness and toughness from the reinforcement and matrix phases respectively
- Higher hardness than Cr, or even WC-Co, results in less wear
- Improved surface quality results in lower corrosion rates
- Can achieve densities $<4 \text{ g/cm}^3$ resulting in an overall decrease in weight

Micro-/Nano-Composite Coatings



What are the Tradeoffs?

- Hazards
 - Waste cycle
 - Solvent waste from the milling process
 - Collected and recovered for re-use and recycling
 - Hydrocarbon and acid production during coating and synthesis processes
 - Collected and recycled
 - Nano-sized powders
 - Fire hazard – rapid oxidation
 - Health risk – the smaller a powder is, the more reactive it will be
 - Contact with nano-powders mitigated through the process, nano-materials are contained within micro-powders that are easier to handle

Conclusions

- Hard CrVI coating limited to critical applications
- Other technologies available to replace CrVI
- PComP™ offers unique advantages
- PComP™ can be produced using safer methods and reduce worker exposure to unsafe materials
- PComP™ offers additional materials compatibility

Questions?

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