

**POWDERMET INC.**

*The Cutting Edge in Metal Powder Technology*

***PComP™: Nano-Composite Thermal Spray  
Alternative to Cd and Cr***

***SERDP/ESTCP Workshop  
Tempe, AZ***

***February 26-28, 2008***

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# Report Documentation Page

*Form Approved  
OMB No. 0704-0188*

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1. REPORT DATE <b>FEB 2008</b>	2. REPORT TYPE	3. DATES COVERED <b>00-00-2008 to 00-00-2008</b>			
4. TITLE AND SUBTITLE <b>PComPtm: Nano-Composite Thermal Spray Alternative to Cd and Cr</b>		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Powdermet Inc,24112 Rockwell Dr,Euclid,OH,44117</b>		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Surface Finishing and Repair Issues for Sustaining New Military Aircraft Workshop, February 26-28, 2008, Tempe, AZ. Sponsored by SERDP/ESTCP.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>18</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

## Acknowledgments

- EPA Phase I SBIR CONTRACT # EP-D-06-053
  - *Metastructured Cermets for Hard Chrome Replacement*
- Ohio Third Frontier Grant ORCGP-04-063
  - *Commercialization of MicroComposite Powders*
- NASA SBIR Grant NNC07QA06P
  - *Erosion Resistant Compressor Blade Repair Technologies*
- National Science Foundation 637502
- Boeing –Fatigue testing and data
- PTI –HVOF Coating Services

- Introduction to Powdermet
- Hierarchically Structured Materials
- PComP™
- Work Plan
- Testing
- Conclusion

- Application Driven Powder Development Company
- Specializing in Powder Modification
  - Particle Size Engineering
    - Bottom up/Top Down
  - Compositing
  - Agglomeration
  - Particle Coating
- Develop Powders to Meet Specification

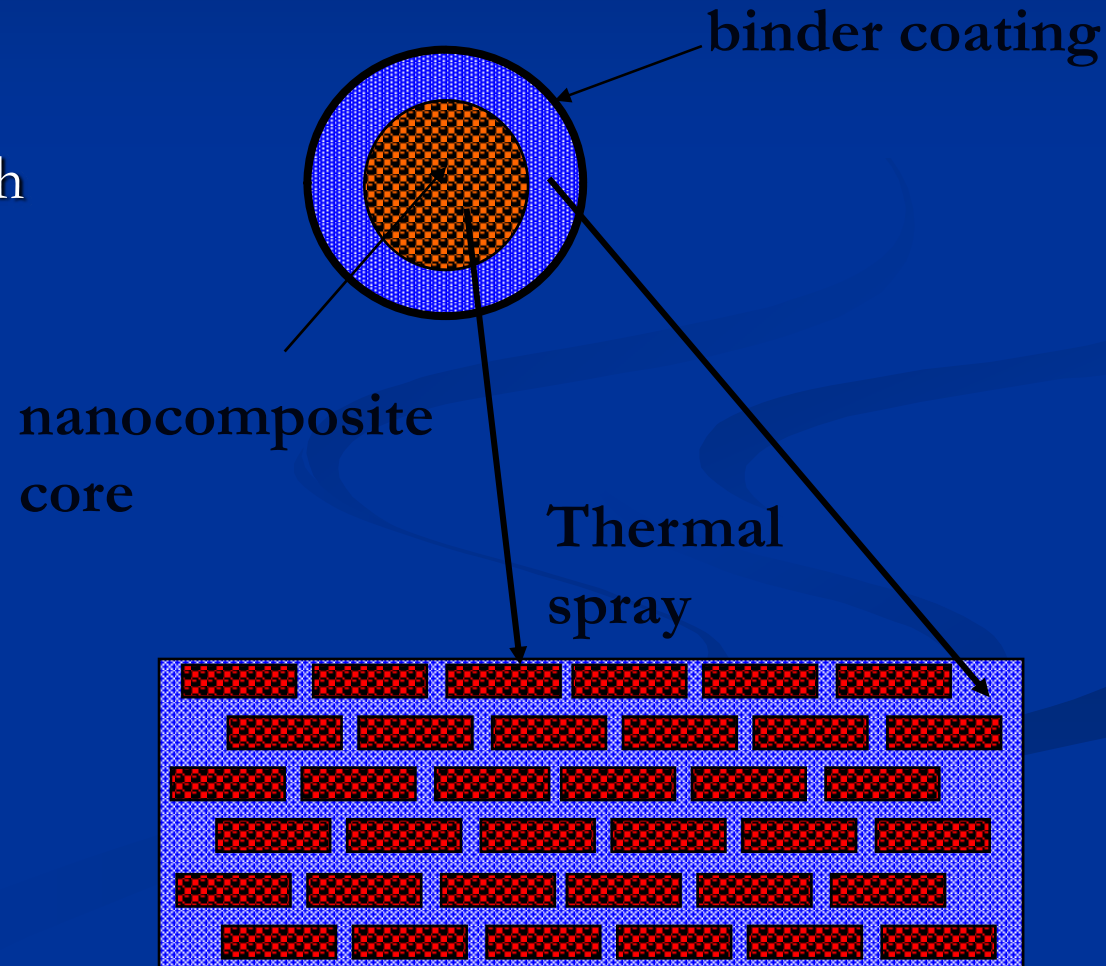


# Microcomposite coating Materials Approach

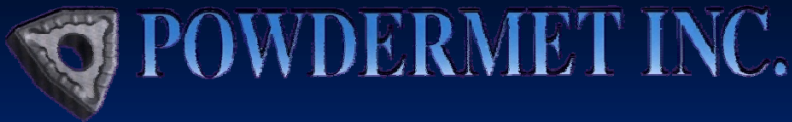
- Combine hardness of lightweight ceramic with ductility and toughness of metal
  - Start with low cost, lightweight ceramic ( $\text{Al}_2\text{O}_3$  or SiC, -Si<sub>3</sub>N<sub>4</sub> for low friction). 3-4g/cc, 0.1-1 micron particle size
  - Blend and Spray-dry with corrosion resistant ductile metal alloy binder (Ni baseline)
    - Keep structure nanocrystalline, high hardness, corrosion resistance, and strength
  - Encapsulate with additional matrix for toughness/ductility
    - Micron-scale “lamella” in coating to allow for dislocation motion (ductility)
  - Thermal spray to form ductile wear and corrosion resistant coatings.
    - Laser fuse, cold-spray alternatives
  - Patent-pending materials technology

# The Micro/Nanocomposite solution

- nanocomposite provides high wear resistance, low friction
- Ductile binder provides ductility and toughness
- Working on HVOF, laser cladding, cold spray, and fuse powder designs







# Microcomposite coating features

	<b>Micro-Composite Coatings</b>	Chrome Plate	WC-Co-Cr thermal spray
Coating density	<b>4-5g/cc (low)</b>	9g/cc (medium)	17g/cc (very high)
Total coating cost	<b>Less than 1X</b>	Baseline (1X)	2X
modulus	<b>20-30MSI</b>	0 (cracked)	65 MSI
Gun throughput	<b>&gt;3X</b>	Days to coat	1X
Surface finishing costs	<b>SiC or alumina wheel</b>	Alumina wheel	Diamond wheel
Ductility	<b>4%</b>	<0% (cracked)	<1%
Wear Performance	<b>10X chrome</b>	1X chrome	3X chrome
Thickness limitations	<b>&gt;40 mils</b>	3-5 mils	10-20 mils



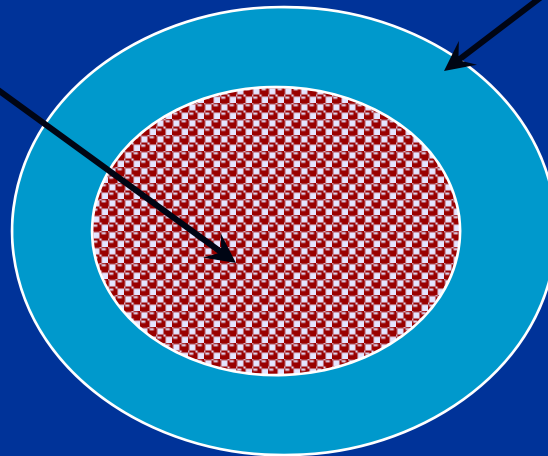
- Drop-In Replacement for Thermal Spray Materials
- Reduced Density (3.5-6.5 g/cm<sup>3</sup>)
- Doesn't Require Special Tooling
  - No Diamond/CBN Grinding
- Low-
  - Density, Friction, Stiffness

- **WC-Co**
  - Applied by PTI
  - Tested by Boeing
- **Core Reinforcements**
  - TiN, Si<sub>3</sub>N<sub>4</sub>, TiC, Al<sub>2</sub>O<sub>3</sub>
- **Metal Binders**
  - Ni, Ni-Cr, Ni-Cr-Mo

# Powder design variables

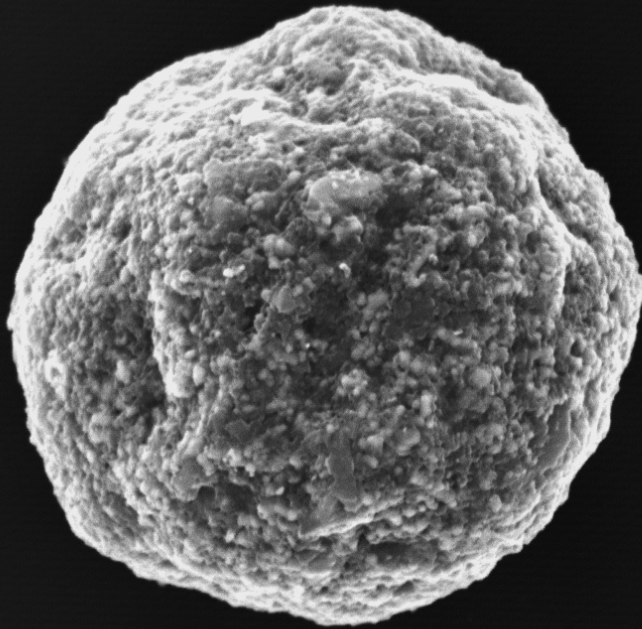
Core: diameter, density, grain size, pore size, metal/ceramic V%

Coating: composition, thickness



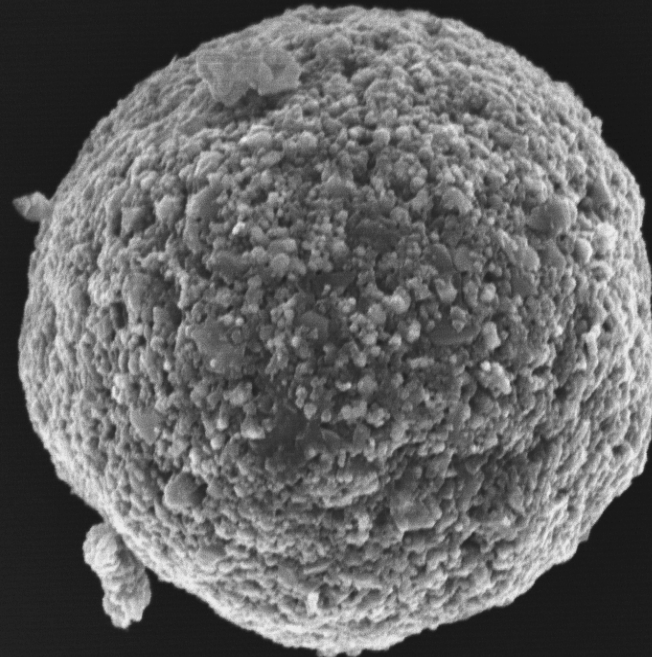


# Nanocomposite Powders Developed



25 microns

Powder #1

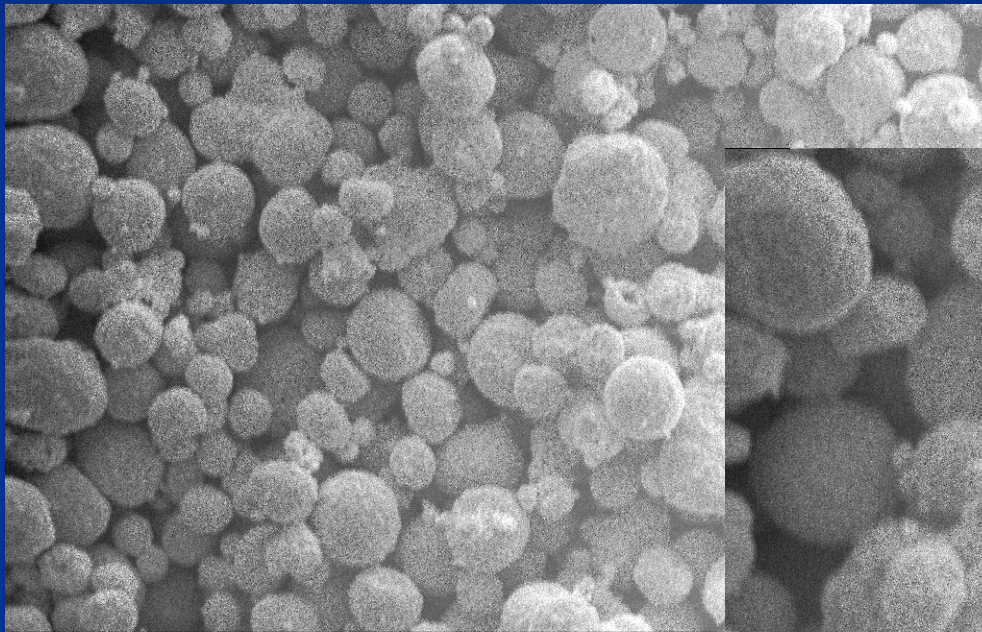


10 microns

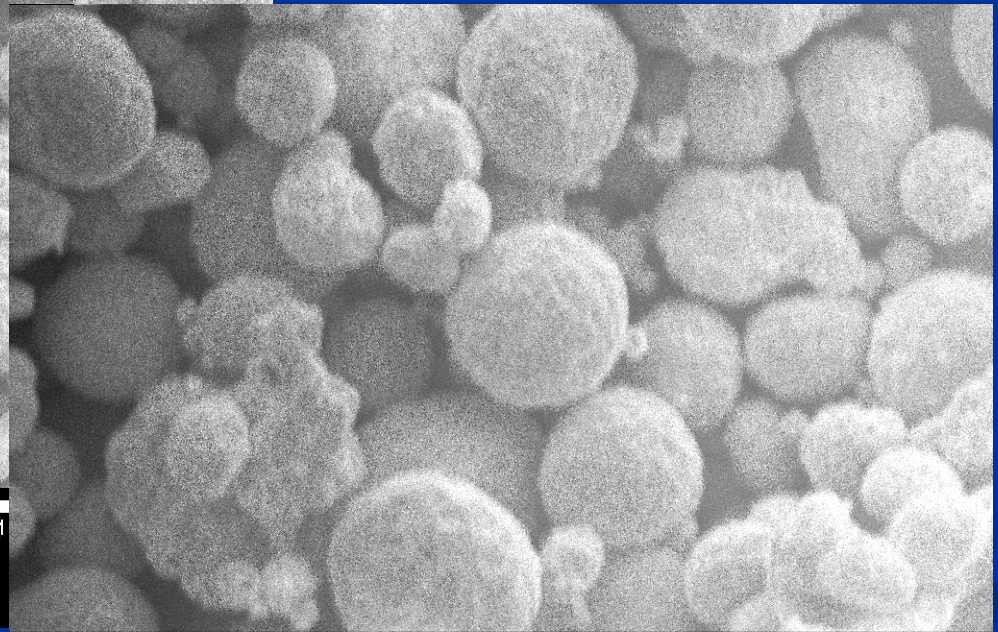
Powder #2



## DJ- Cut, HVOF powders

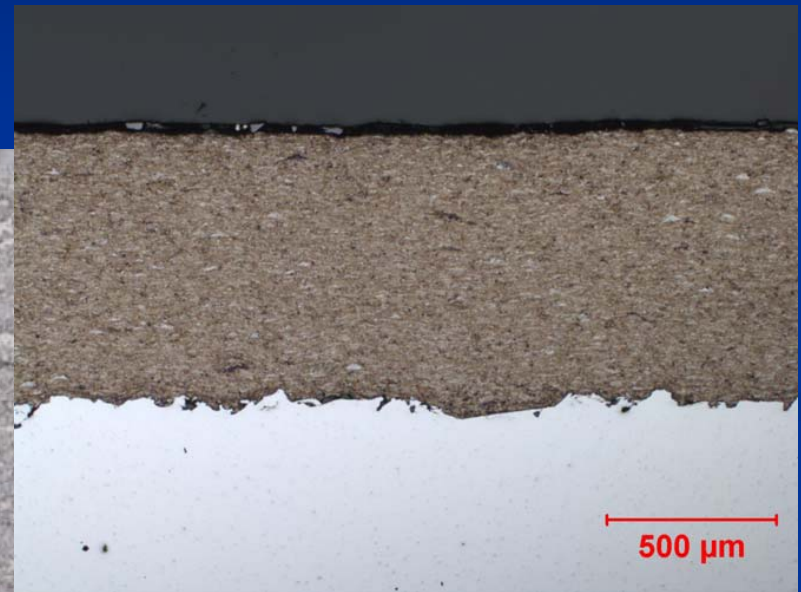
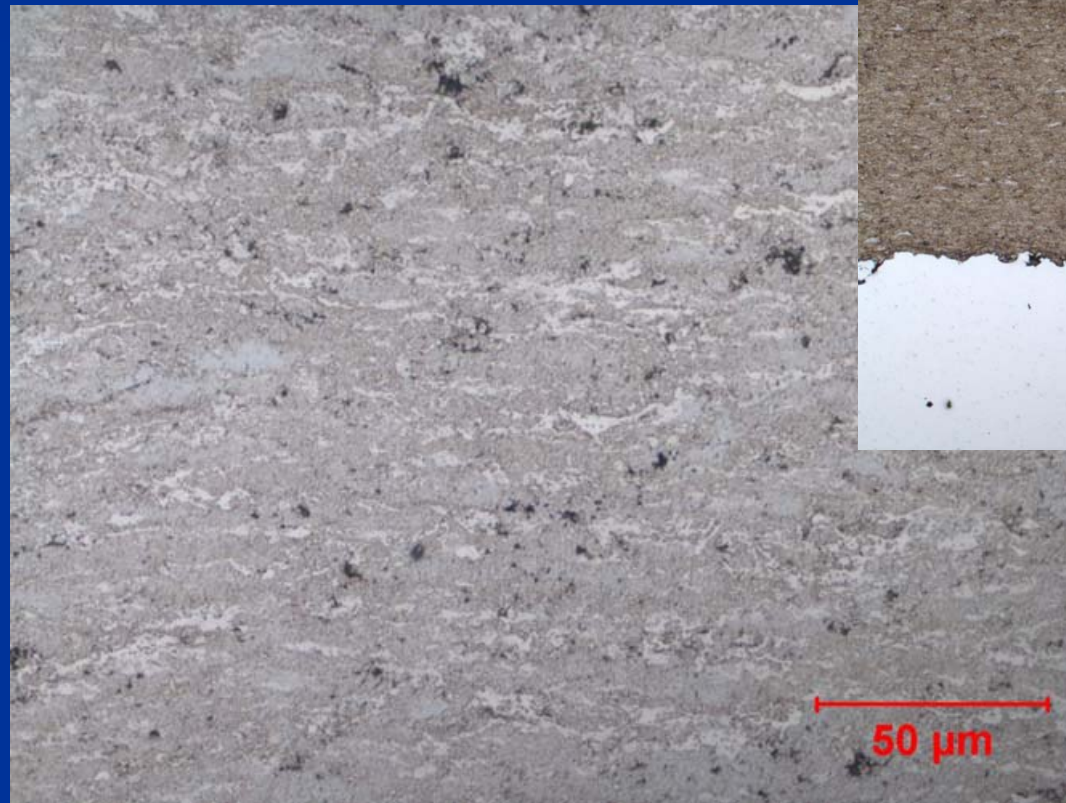


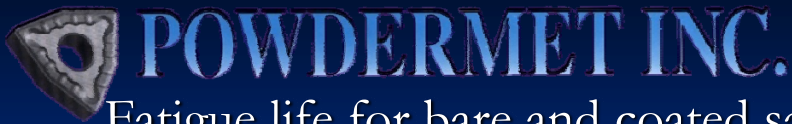
20KV X 00 100U 127 0



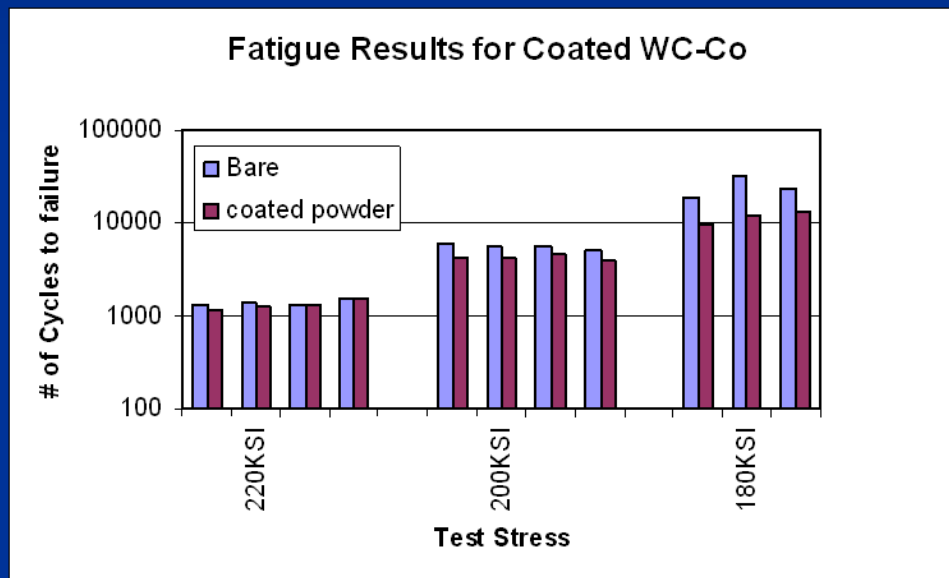
20KV X 000 10U 127 00001 LMA

# Composite Structure





## Fatigue life for bare and coated samples at different test stress conditions



Axial tension-compression fatigue ( $R = -1.0$ ), in room temperature air, at 2 Hz. Fatigue specimens were cylindrical bar 8 inches long, 0.75 inches in diameter, with an hourglass shape narrowing to a minimum of 0.3 inches. The fatigue debit as a result of coating is less than a factor of 2.



## Fatigue Data Observations: Notes from Test Operator

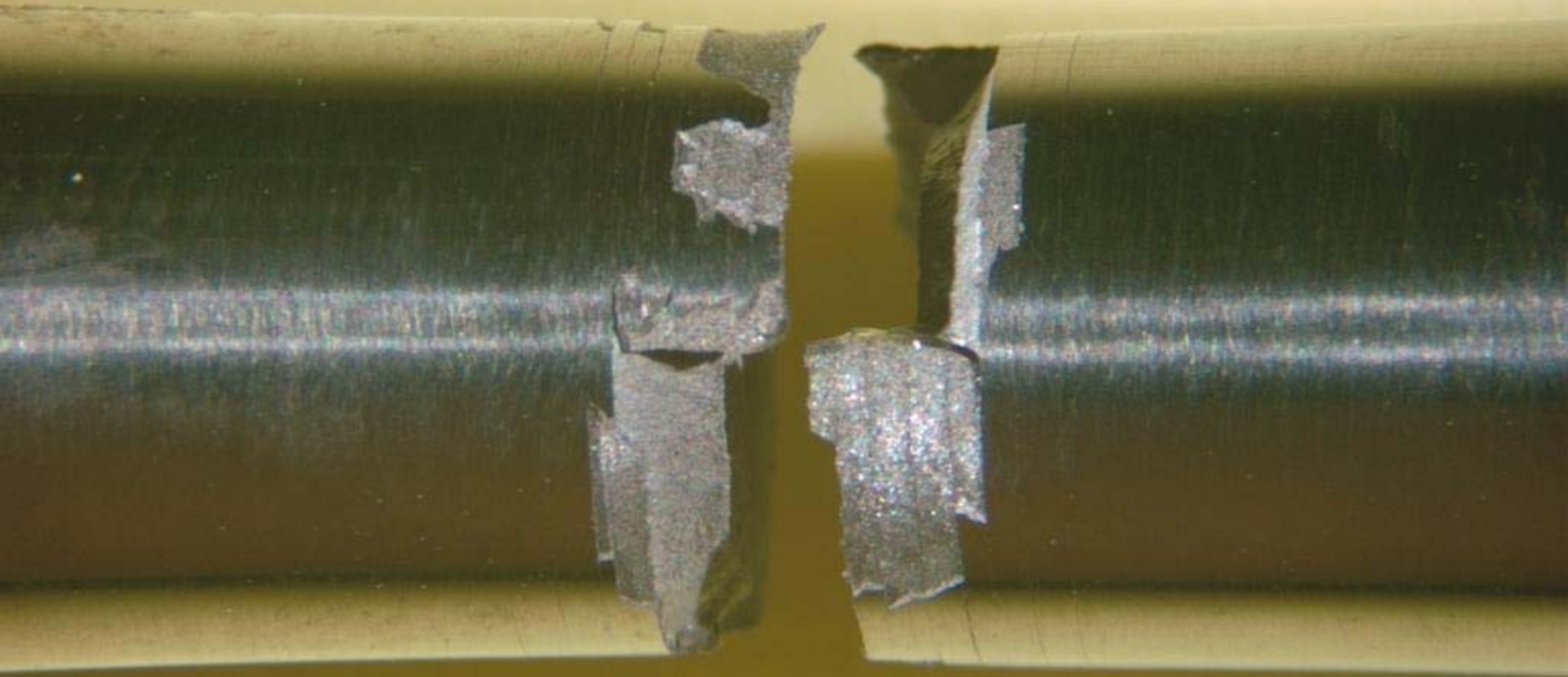
Specimen Number	Cycles to Failure	Notes
7604-10 C	2,120	No spalling before failure
7604-12 C	2,129	Crack in coating at 750 cycles. Spalling at 1500 cycles.
7604-13 C	2,258	No spalling before failure
7604-14 C	1,949	No spalling before failure



**5X Magnification**

**Left side**

**Right side**



- Hierarchically Structured Coatings Offer Numerous Advantages
- PComP™ Improves on Meso-Structured Composite Materials
- PComP™ Can Meet Rigorous Landing Gear Requirements (AF/Navy/Civilian)
- Need Specifications for Materials Design



**QUESTIONS?  
COMMENTS**