Comparison of Vacuum Plasma Spray (VPS) and Low Pressure Plasma Spray (LPPS) for Deposition of Yttria-stabilized Zirconia (YSZ)

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Nicholas Spinhirne, Deidre Hirschfeld
New Mexico Institute of Mining and Technology
Aaron Hall, Rodney Williamson
Sandia National Laboratories

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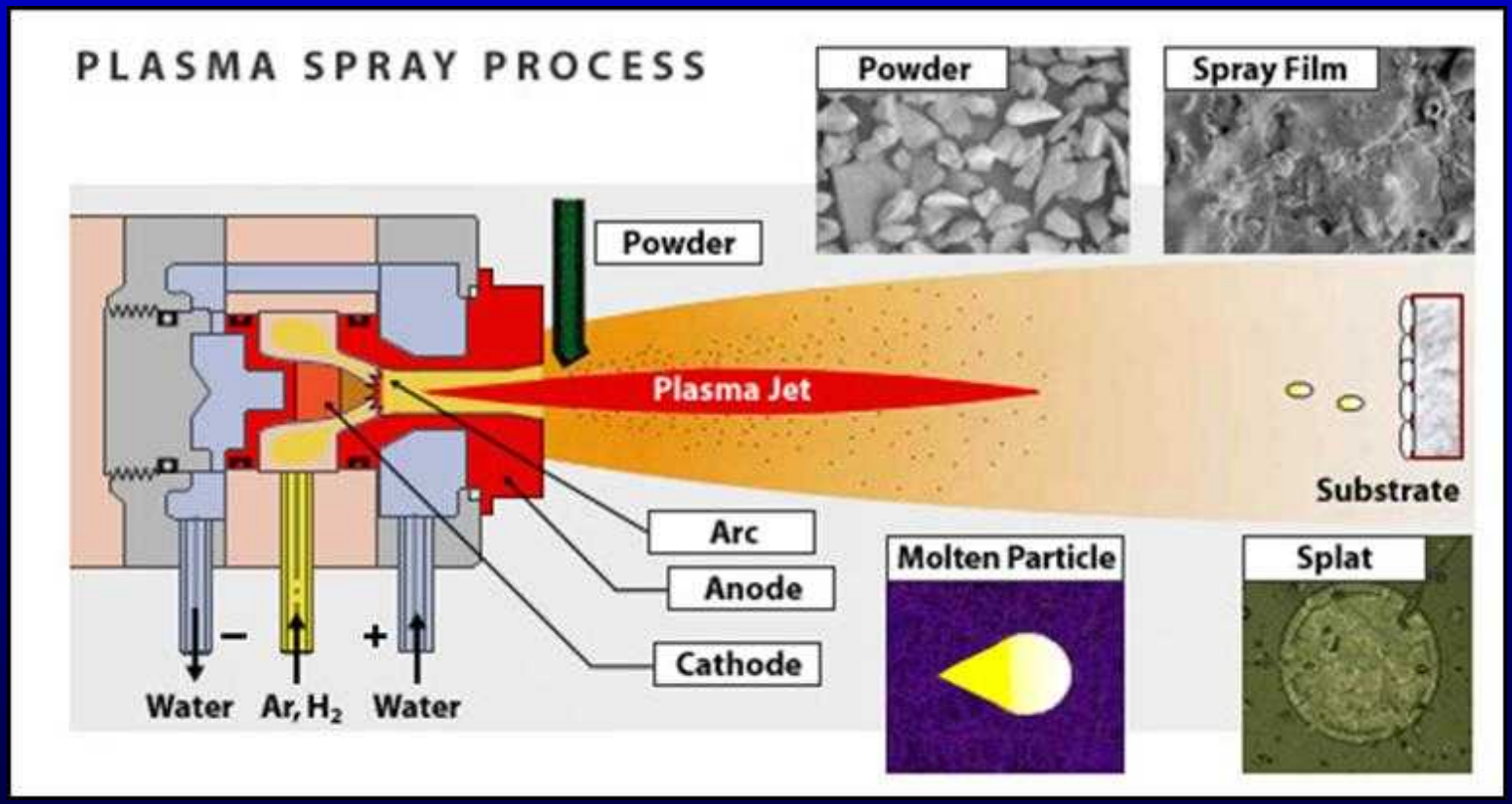
Purpose of Research

- Investigate effect of coating microstructure on mechanical and electrochemical properties of very low pressure plasma spray (VLPPS) YSZ
- Determine which microstructure is best suited for SOFC electrolyte applications

Basics of Plasma Spraying

- Line of sight process to deposit coatings using powder feedstock



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Advantages of LPPS/VLPPS

- Deposit thin, dense coatings over large surface areas
  - Homogeneous coatings
- Reduced oxide inclusions
- Increased particle temperature and velocity – to a limit
- Comparatively fast process – 1 micron per minute

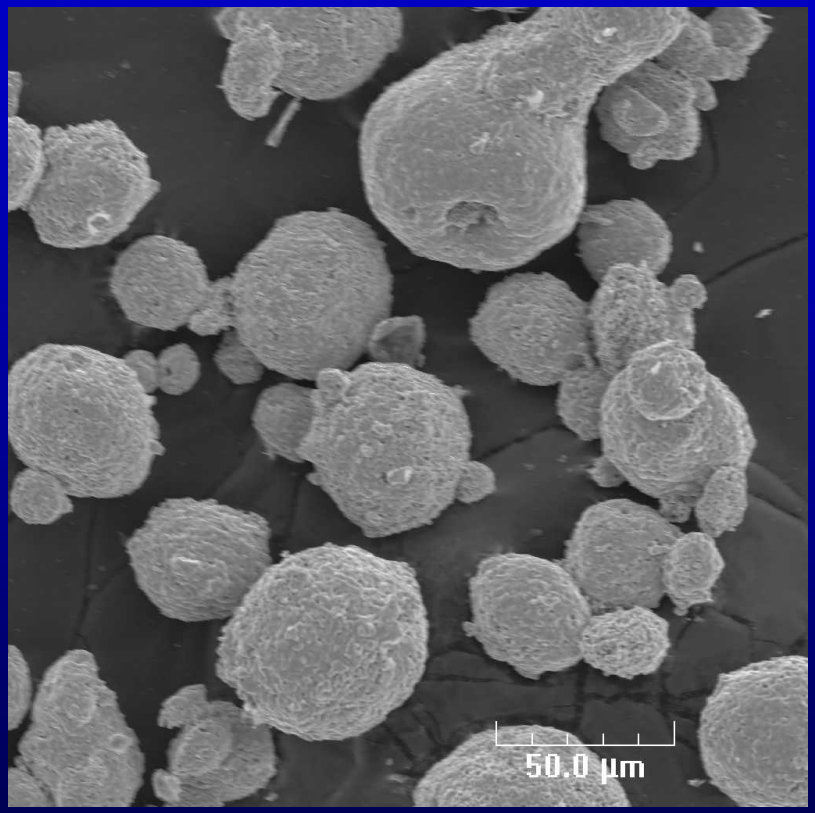
Controlled Atmosphere Plasma Spray (CAPS) System

- 5 cubic meter chamber
- 3-axis robotic manipulator
- LabVIEW based control software
- Operating pressures below 2 torr

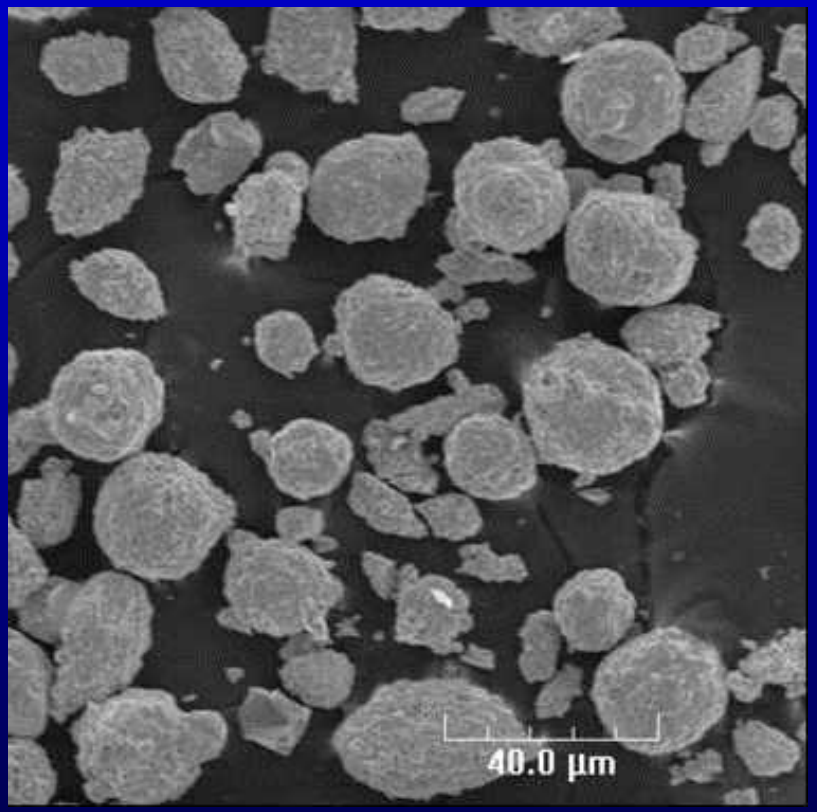
Powder Analysis Results

Powder	Mean (um)	Standard Deviation	Morphology
487	41.4	19.7	Spherical
556	24.0	19.5	Spherical

Micrographs of Powder Feedstock

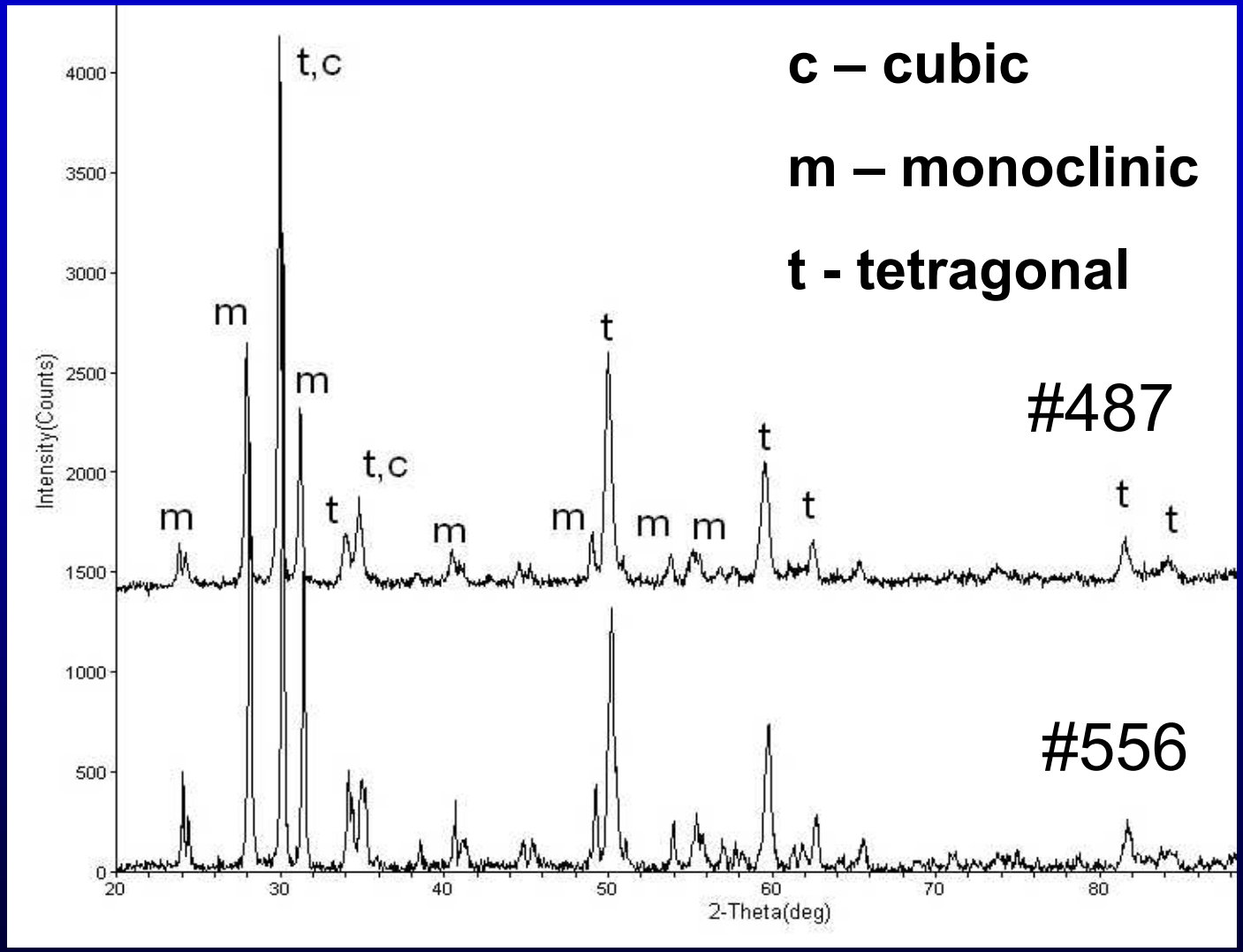


Powder 487

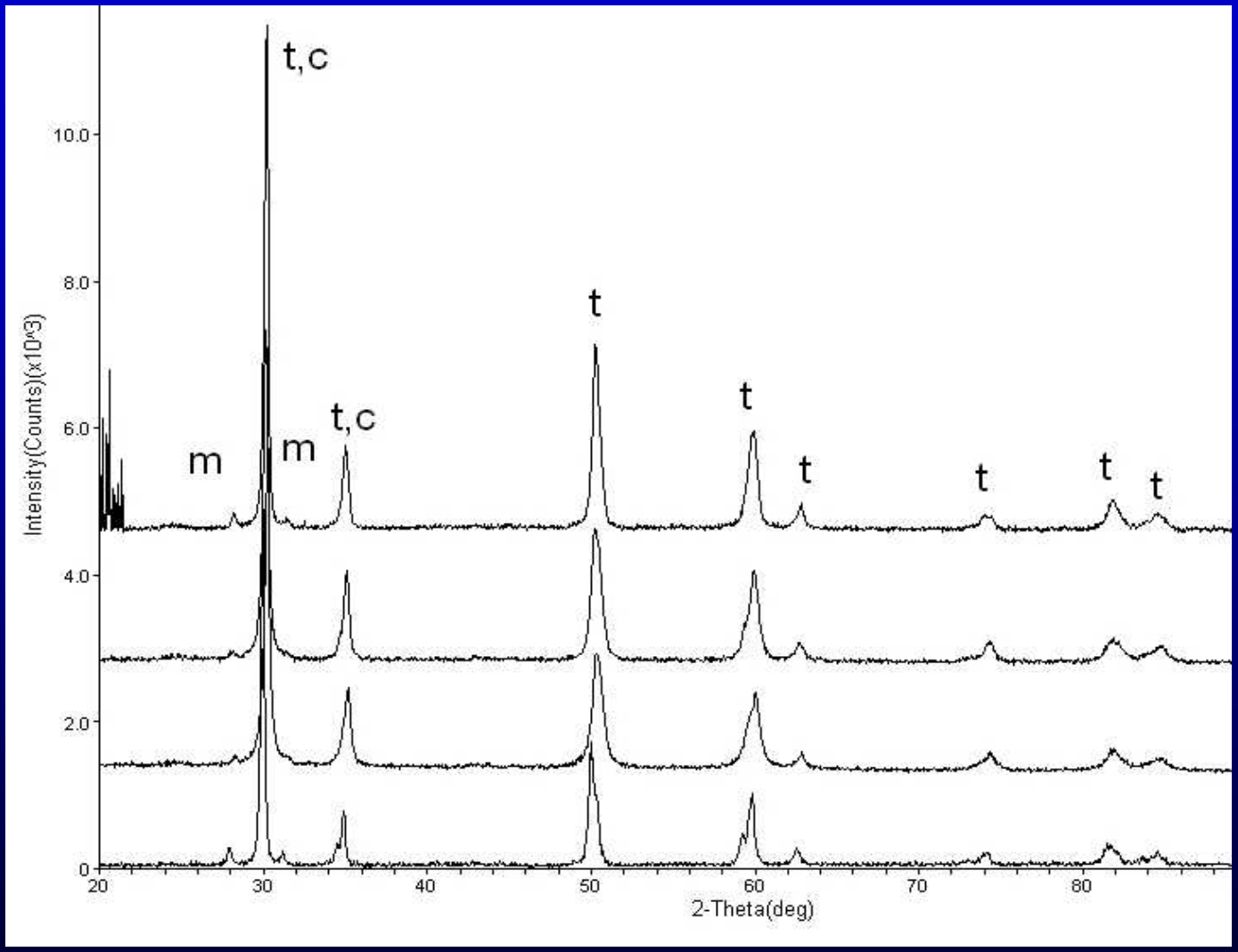


Powder 556

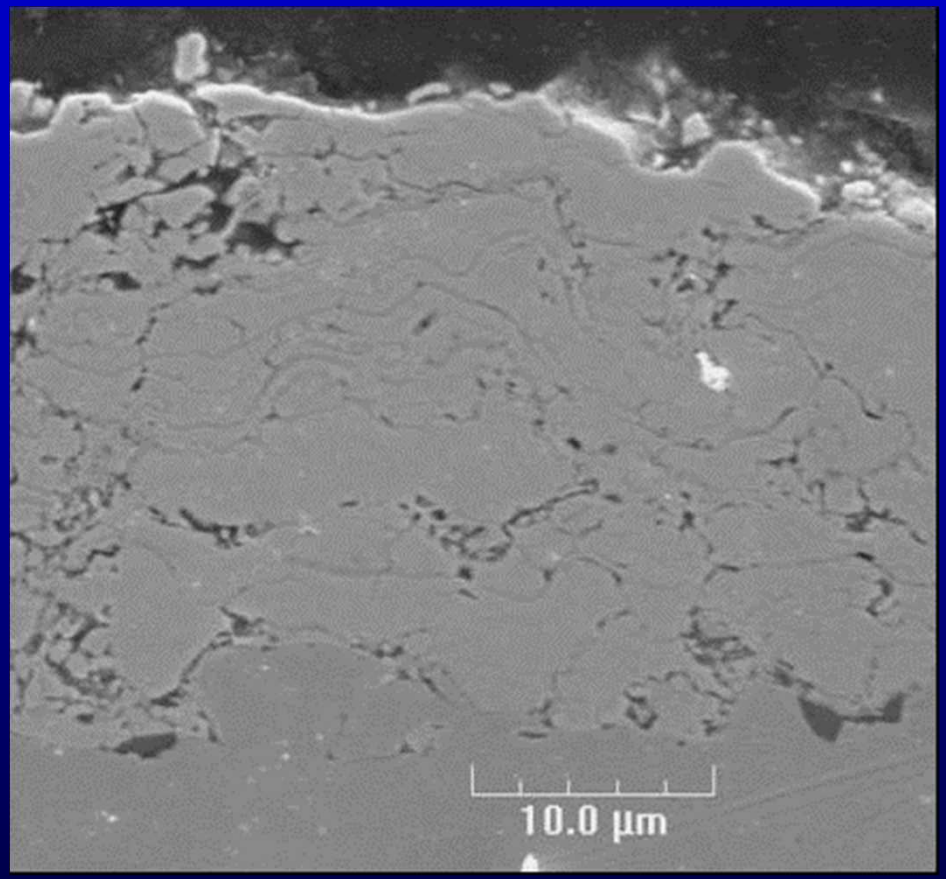
Powder XRD Analysis



Coating XRD Results

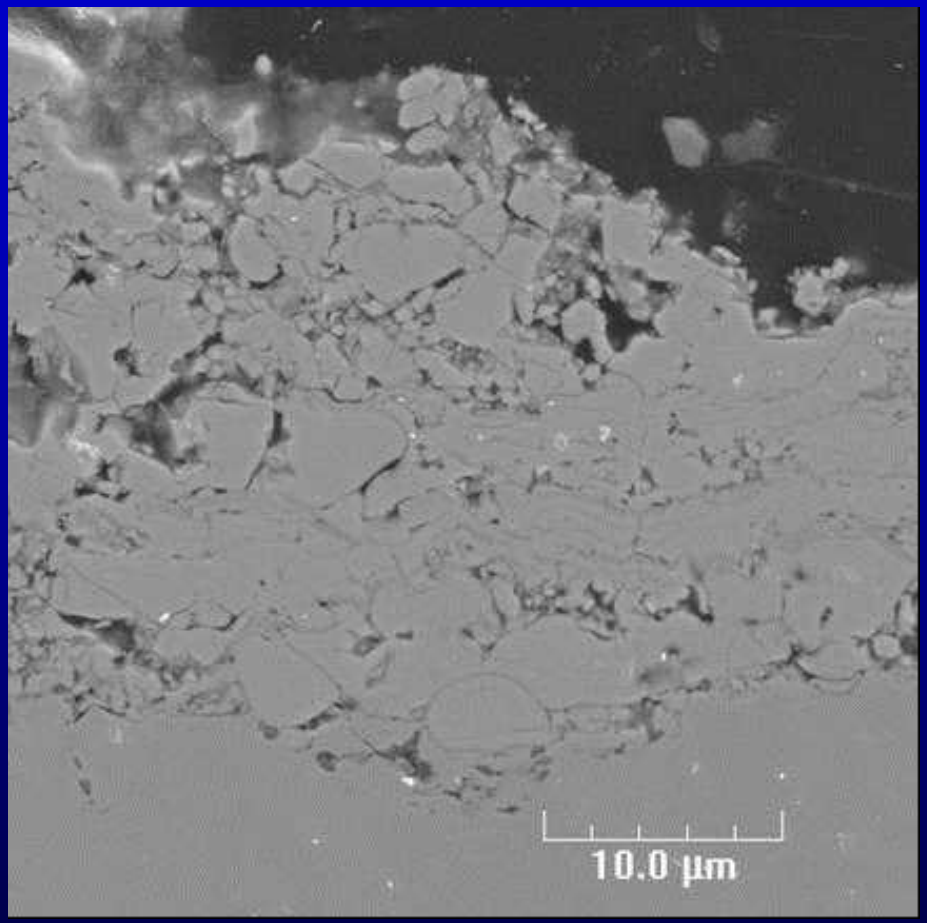


Typical Lamellar Coating



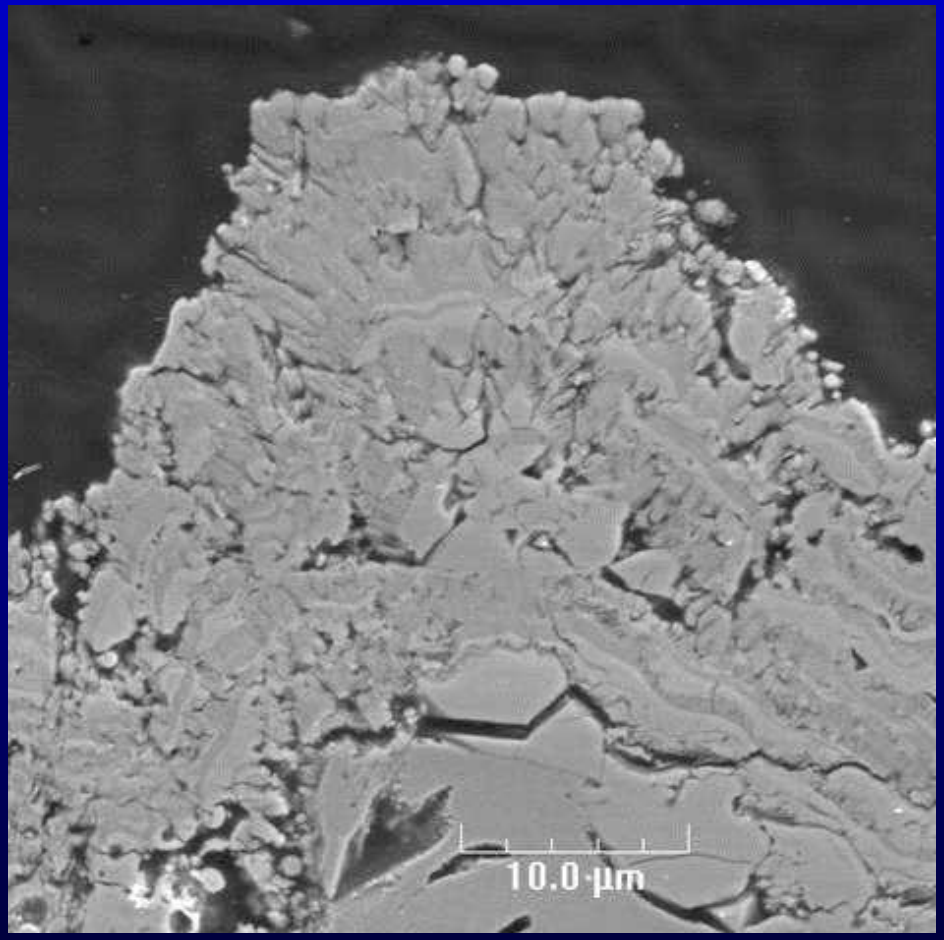
Current (A)	1750
Voltage (V)	51
Ar flow (slpm)	59
Hydrogen flow (slpm)	7
Helium flow (slpm)	~70
Chamber (torr)	2.40
Substrate	stainless
Preheat passes	none
Number of passes	400
Gun speed	150
Standoff (in)	36
Powder	#556
Hopper rpm	1
Ar powder gas (slpm)	6.0

Highly Porous Coating



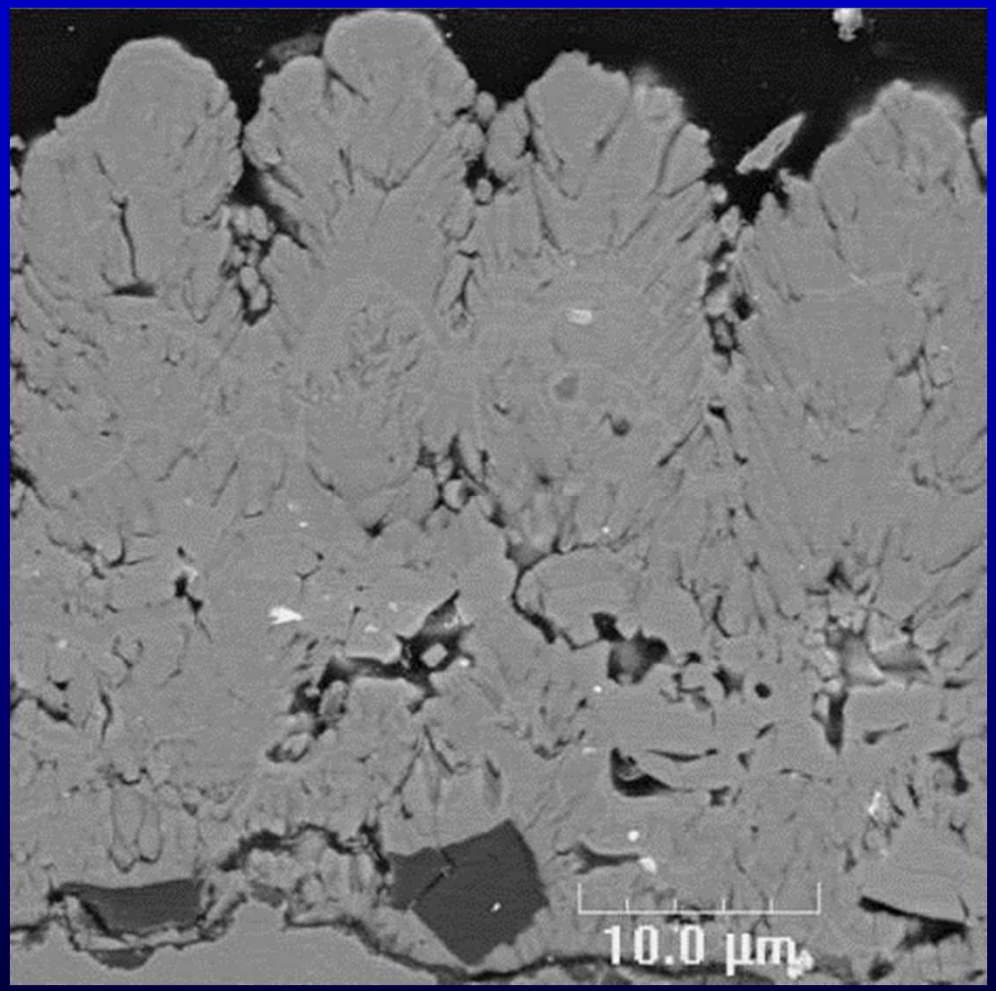
Current (A)	1700
Voltage (V)	49
Ar flow (slpm)	59
Hydrogen flow (slpm)	7
Helium flow (slpm)	~45
Chamber (torr)	2.2
Substrate	stainless
Preheat passes	50 w/He
Number of passes	600
Gun speed	100
Standoff (in)	25
Powder	#487
Hopper rpm	0.6
Ar powder gas (slpm)	12.5

Partial Columnar Microstructure Coating



Current (A)	1800
Voltage (V)	52
Ar flow (slpm)	59
Hydrogen flow (slpm)	7
Helium flow (slpm)	~70
Chamber (torr)	2.55
Substrate	stainless
Preheat passes	none
Number of passes	400
Gun speed	100
Standoff (in)	30
Powder	#487
Hopper rpm	1
Ar powder gas (slpm)	12.5

Beginning of Columnar Structure



Current (A)	1800
Voltage (V)	52
Ar flow (slpm)	59
Hydrogen flow (slpm)	7
Helium flow (slpm)	~70
Chamber (torr)	3.65
Substrate	stainless
Preheat passes	~135
Number of passes	~465
Gun speed	100
Standoff (in)	30
Powder	#487
Hopper rpm	1
Ar powder gas (slpm)	12.5

Conclusions

- Sprayed coatings consist primarily of tetragonal and cubic phases
- Large helium flow rate required to melt particles
- Formation of columnar structure requires further investigation
  - Substrate temperature
  - Vapor or liquid deposition
  - Solidification rate

Acknowledgements

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