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The Development of a Capillary Cold Spray System

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Write by Capillary Cold Spray

What is it?

- Capillary Cold Spray (CCS) injects a gas-particle suspension into a capillary tube
- The gas exits the capillary at sonic velocity, with the particles at a lower velocity
- The sonic velocity of helium gas can yield higher than critical velocities for the particles
- The small diameter of the capillary yields a very fine deposition
- In addition, the Saffman Force further narrows the particle beam

Why do it?

- CCS write of copper can replace lead-based solder
- CCS write is additive technology – replaces conventional etching
- MEMs circuitry requires circuit paths of micrometer dimensions
- Strong bonds to the substrate are produced for high-G tolerance

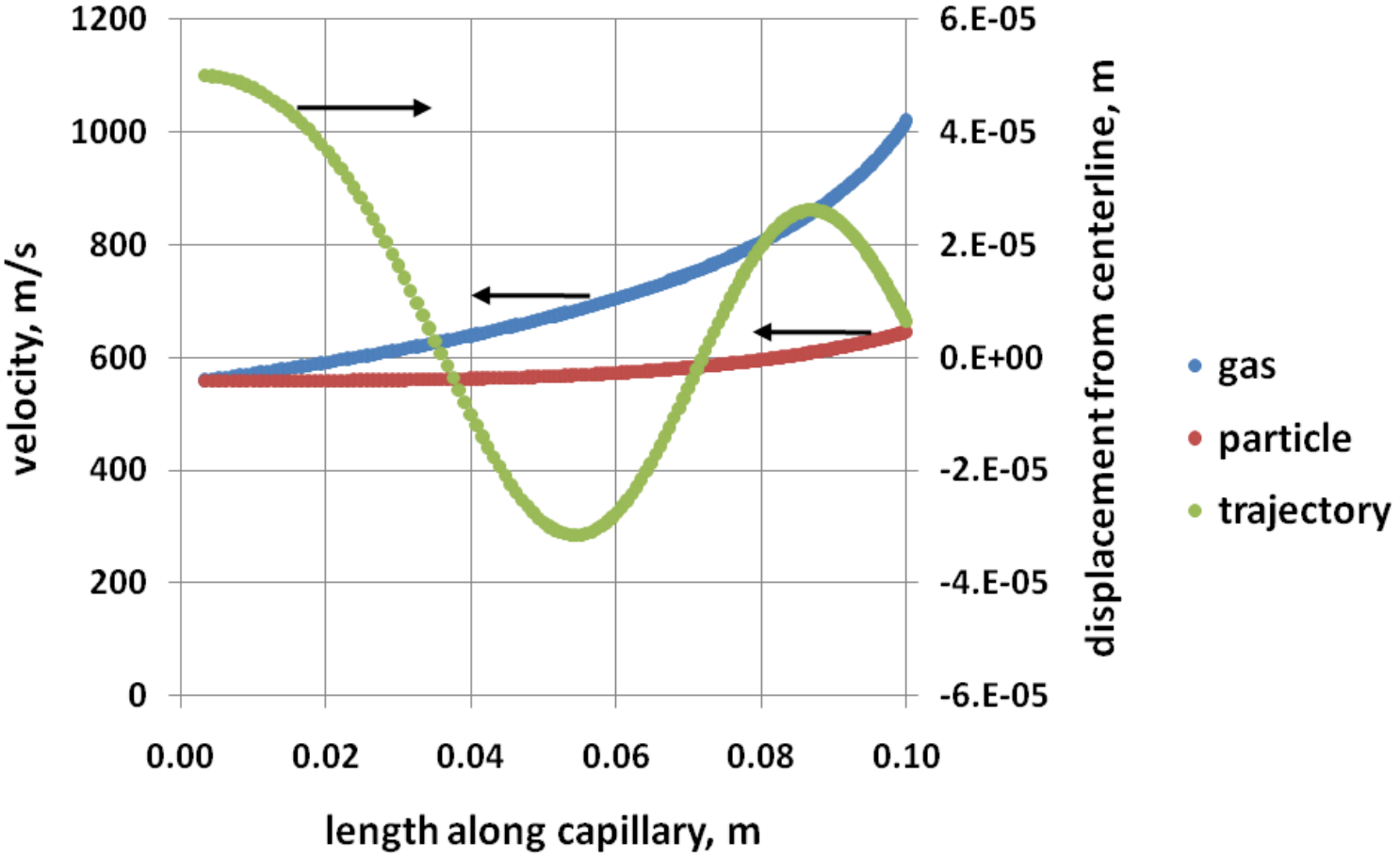
Calculations

- The constant Reynolds number procedure developed by Cheng & Dahneke is used to define the capillary gas flow.
- The conventional particle drag equation is used to describe particle motion.
- The Saffman Force equation, which moves particles toward the centerline, is used to calculate the particle radial position as it moves along the capillary.

The equations, described above, solved through finite difference, yield velocities and trajectories.

Cheng & Dahneke, J. Aerosol Sci., Vol 10, p 363

Calculation Result

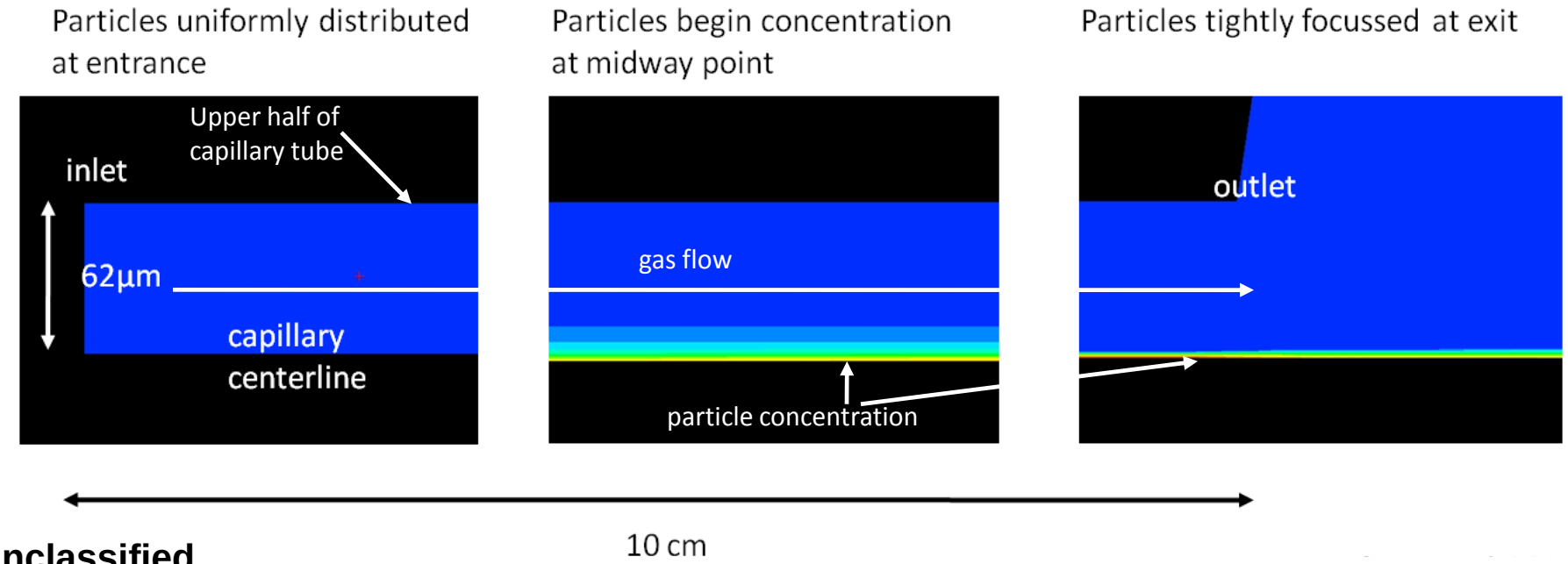


2-D CFD Calculation

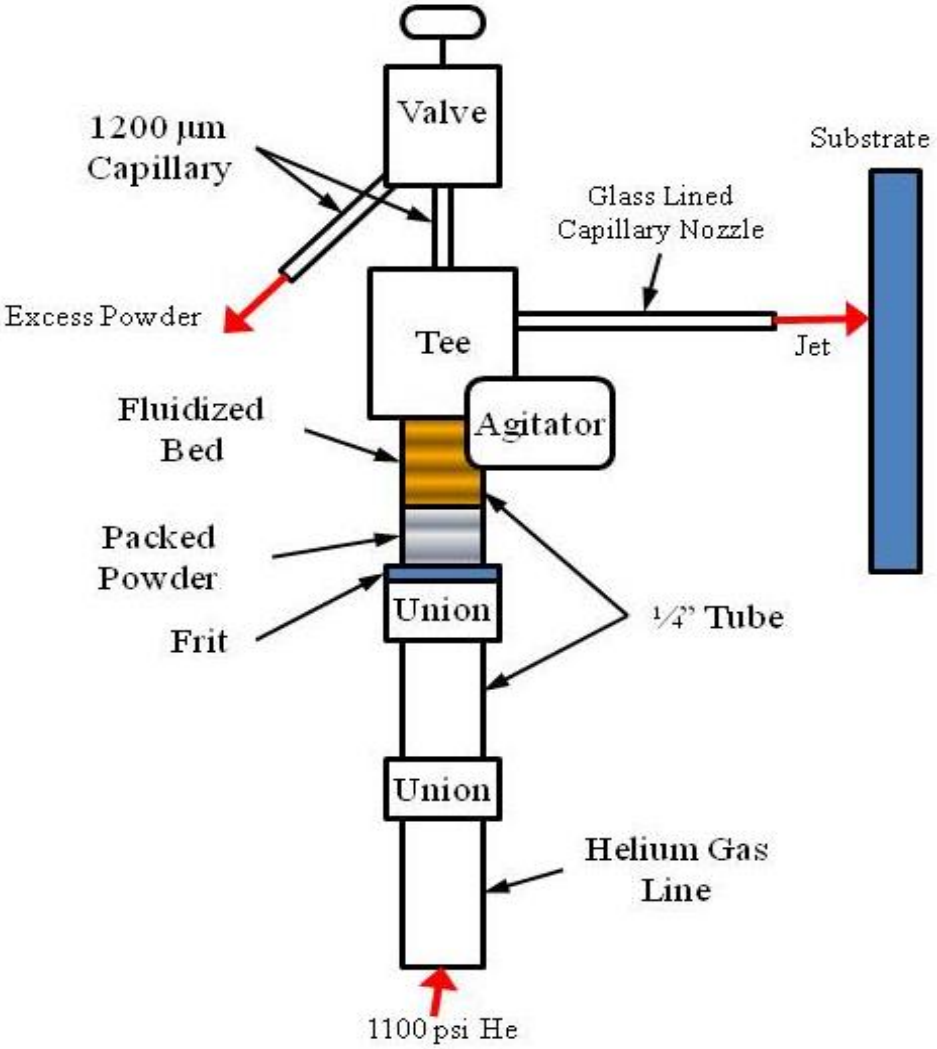
A 2-D CFD calculation shows how the particles in shear flow are concentrated to the centerline by the Saffman force.

1000 psi helium, 20 degree C, 5 µm copper particles.

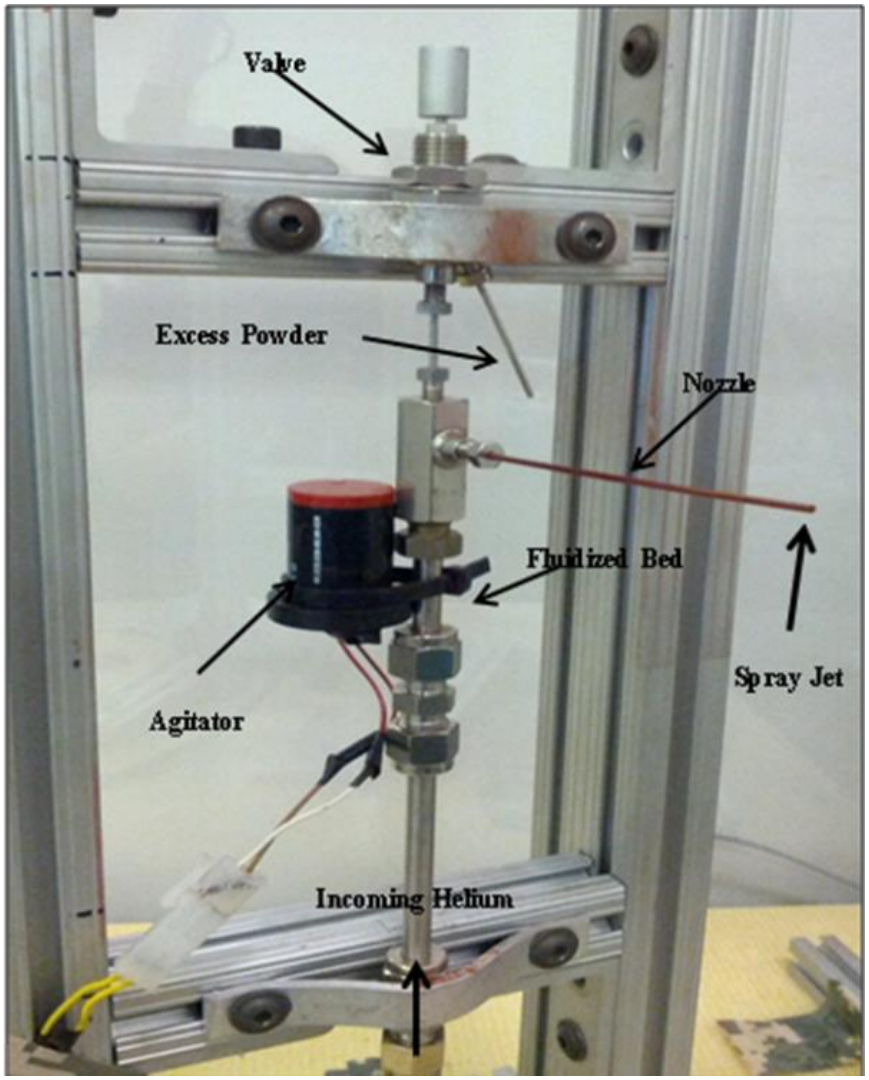
Particle beam approximately 10 µm in diameter.



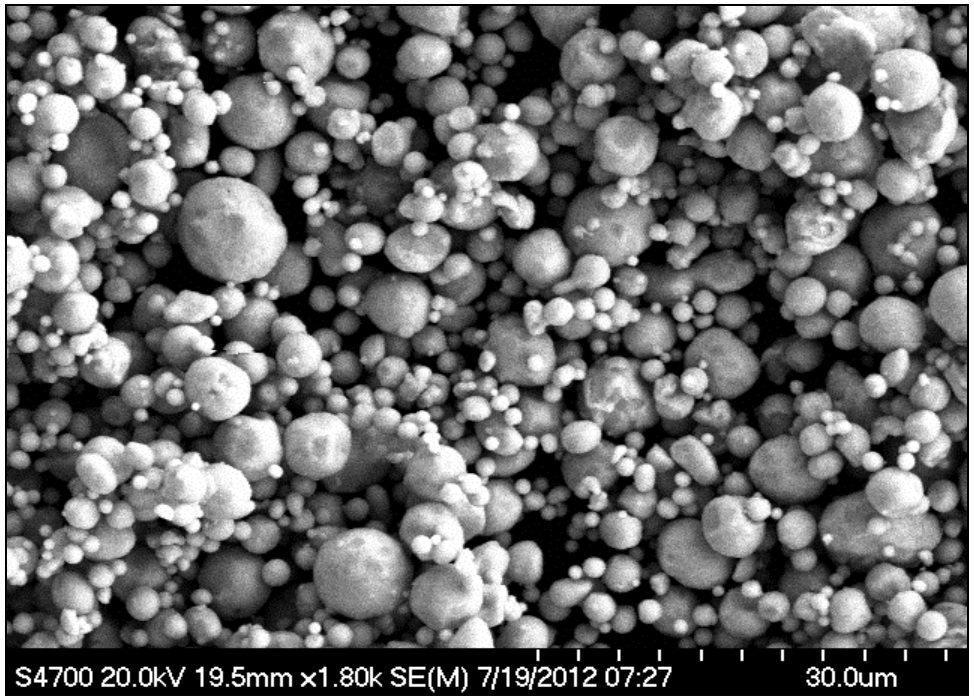
System Assembly



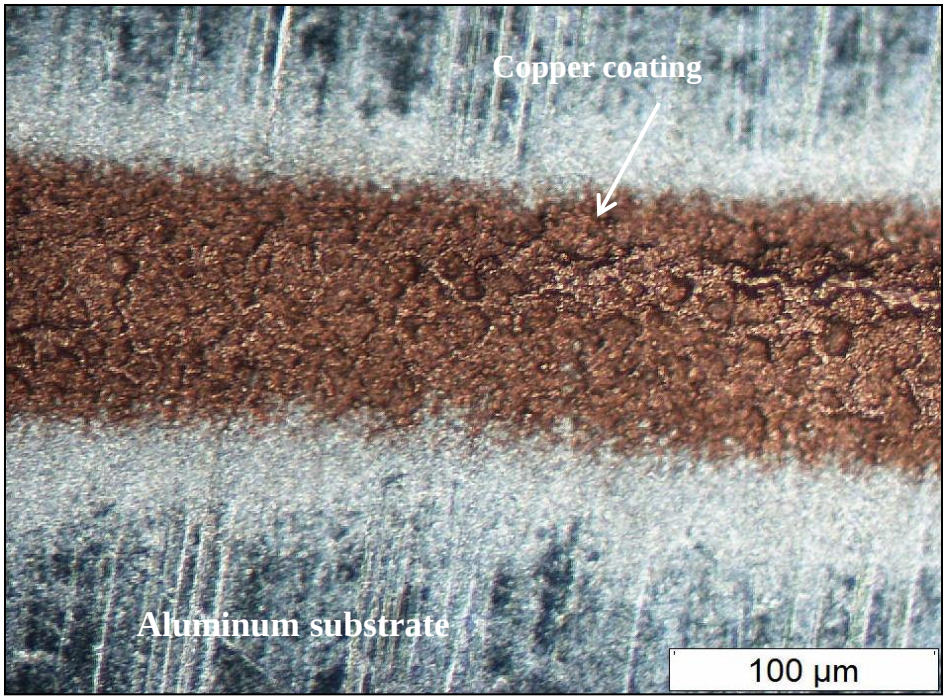
Equipment Set-Up



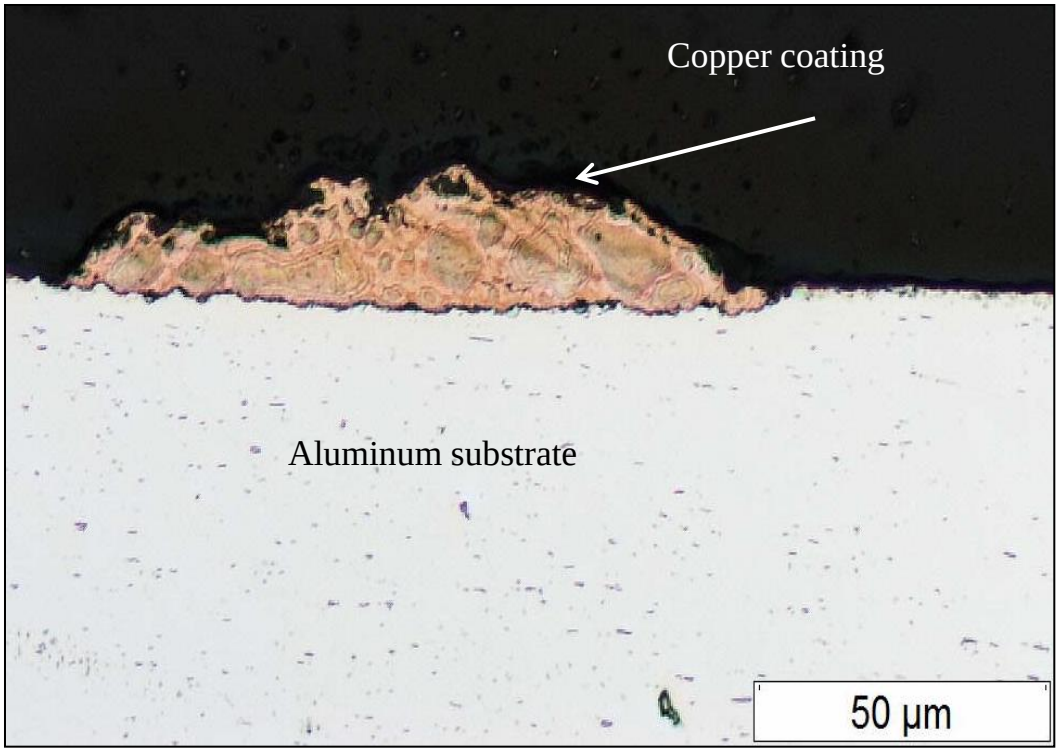
Copper Powder



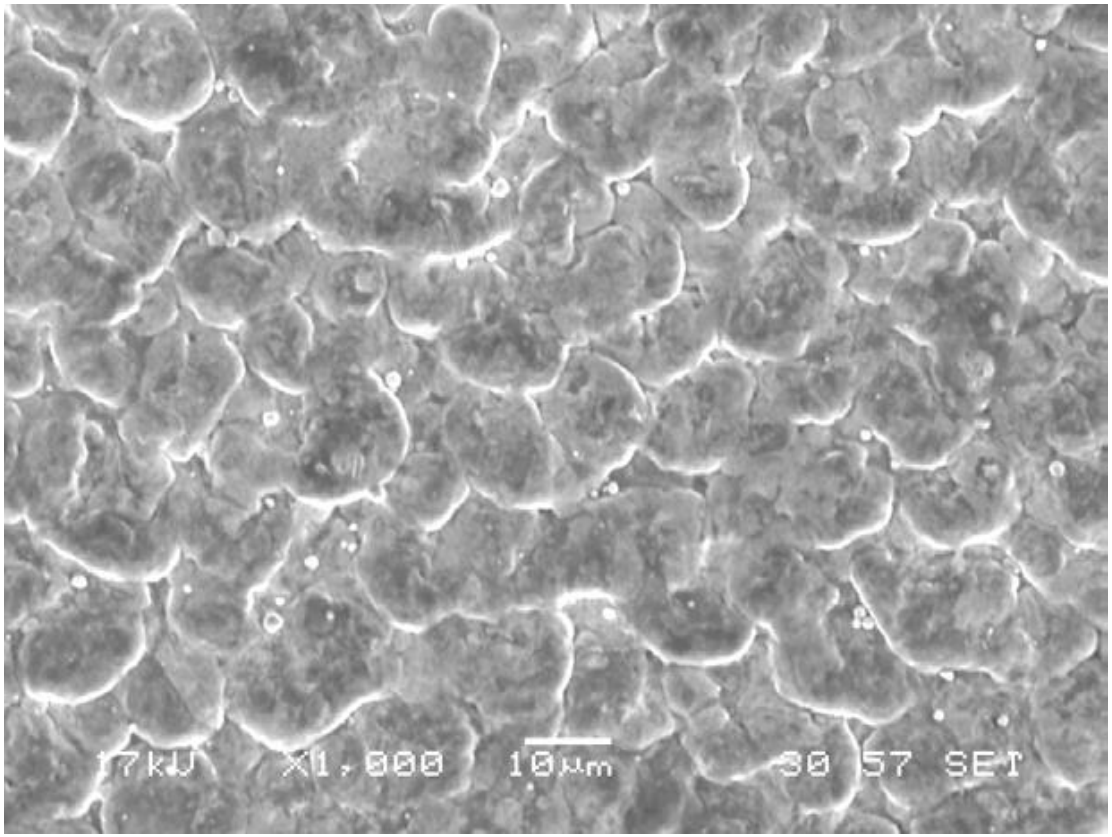
Copper Deposit



Copper Deposit Cross Section

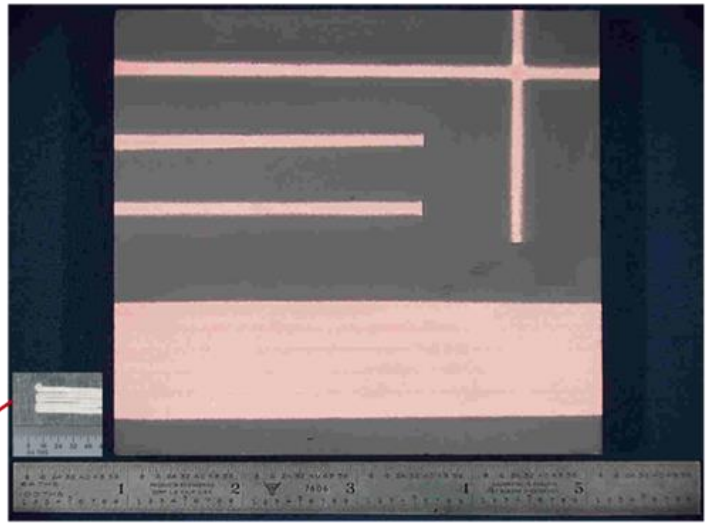


Copper Deposit Magnified

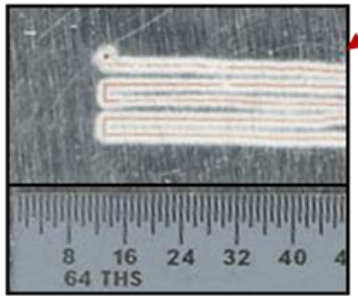


Copper Deposited by Conventional and Capillary Cold Spray

Copper on SiC
conventional cold spray capability



Copper on Al
capillary deposition capability



Future Work

- Improve the feed mechanism
- Heat the gas
- Smaller diameter capillaries
- Measure particle velocity
- Better powder & powder conditioning
- Other metals

? Questions ?