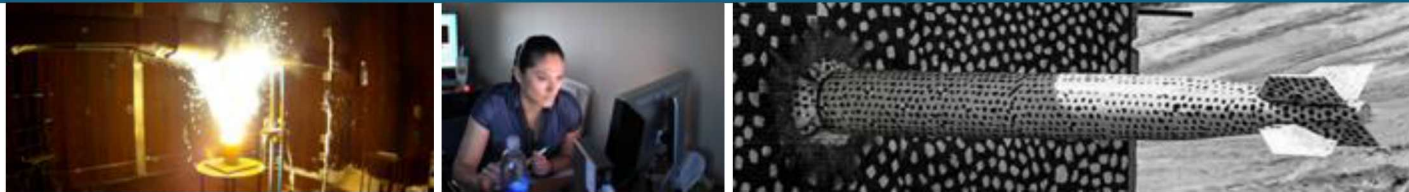




Sandia
National
Laboratories

SAND2020-3244C

Leveraging and Developing Additive Technologies at Sandia National Laboratories



Dale Cillessen

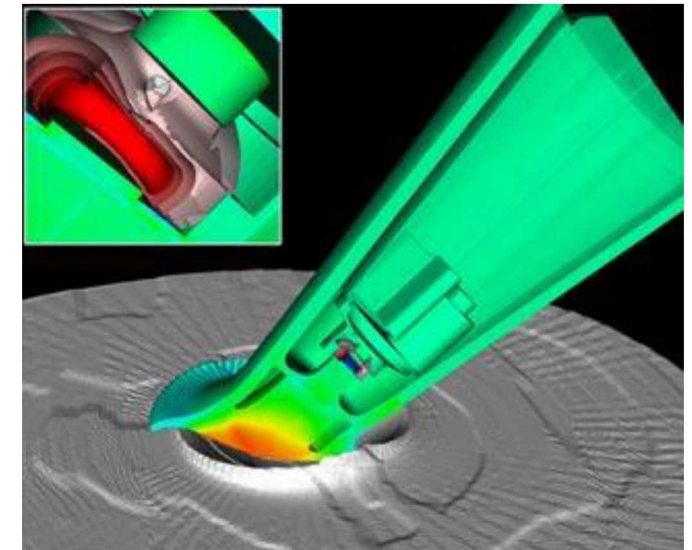
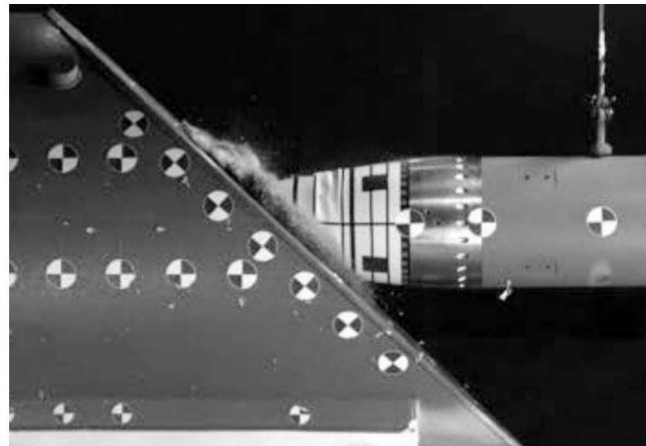
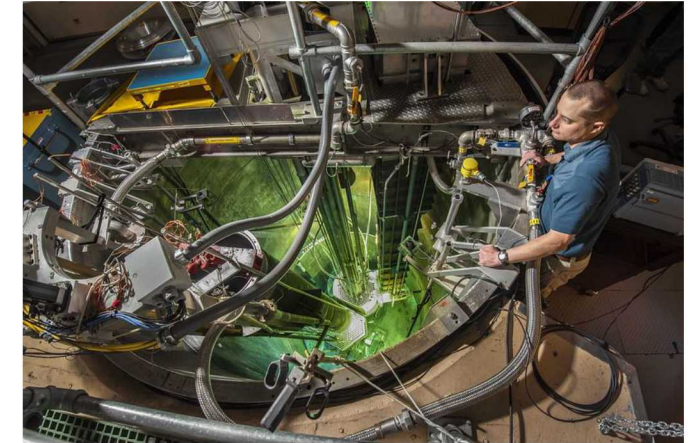


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“Exceptional service in the national interest”

A National Security and Engineering Laboratory

- Nuclear Weapons
- Defense System and Assessments
- Energy and Climate
- International, Homeland, and Nuclear Security



Sandia's History Additive Manufacturing

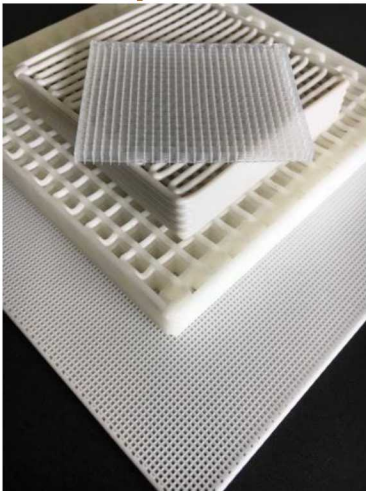


FastCast*

prototype test unit

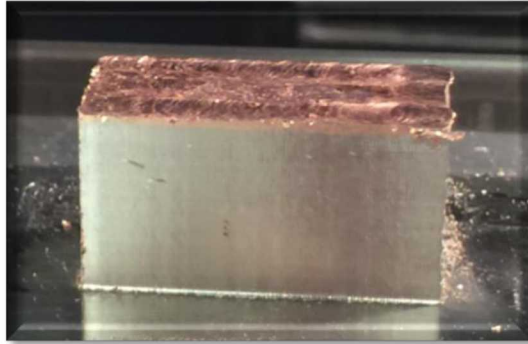


Compression pad



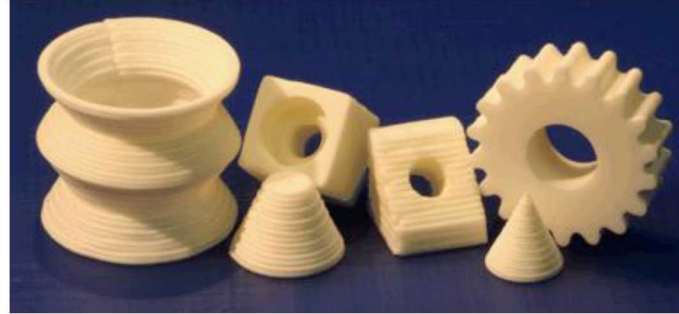
LENS®*

Multi-material print



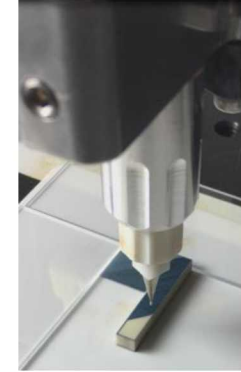
RoboCast*

ceramic parts

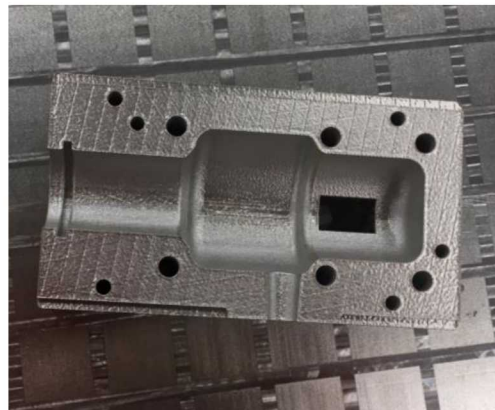


IDS, Inc.*

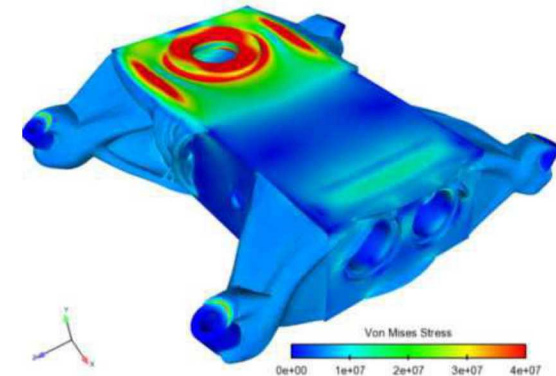
Aerosol-based AM



Laser Powder Bed Fusion



Topology Optimized



* licensed/commercialized technology

Laser Powder Bed Fusion

Across Sandia there are 5 Laser Powder Bed Fusion machines in operation.

Newly renovated lab space brings additional capability!

The laboratory was renovated and now meets Class 2 Division 2 electrical requirements. Making it capable of handling reactive metals (Ti & Al) internal to Sandia.



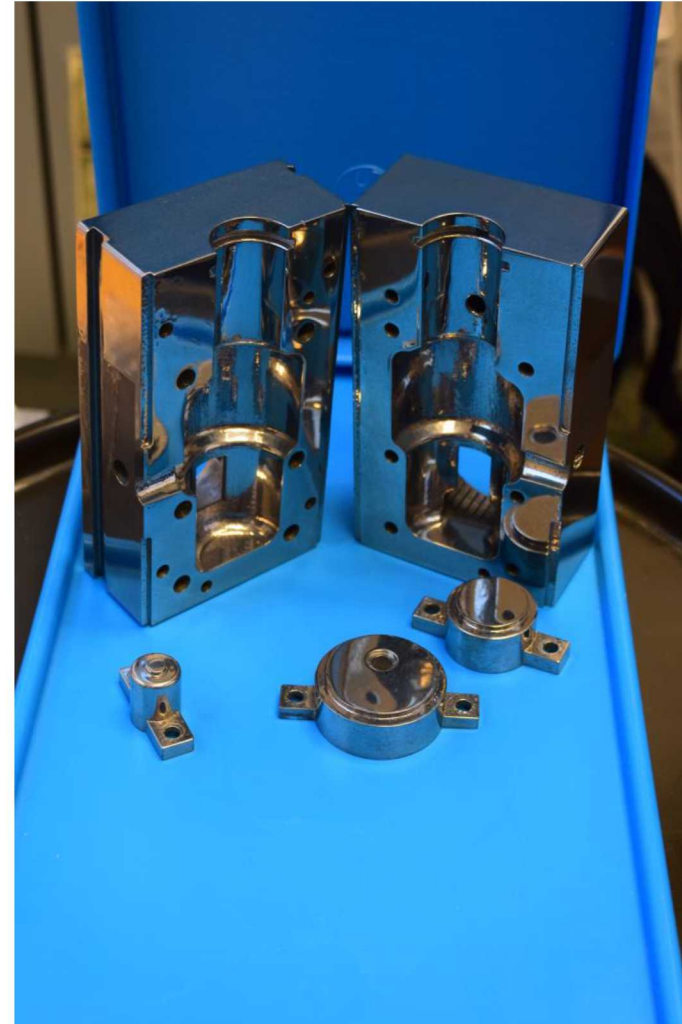
Leveraging Powder Bed for mold manufacturing



As printed



Post Electro Finish



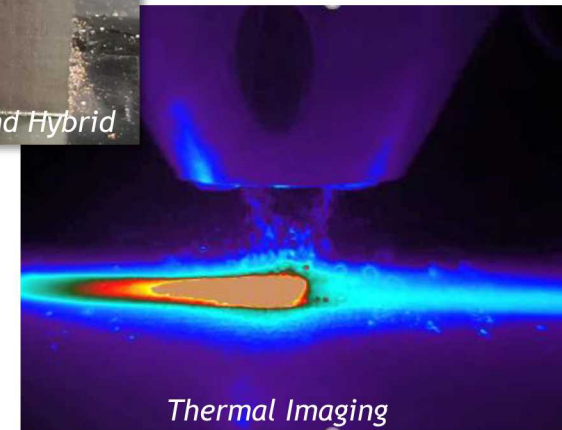
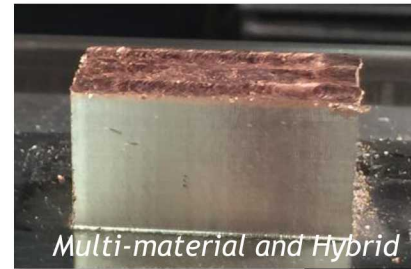
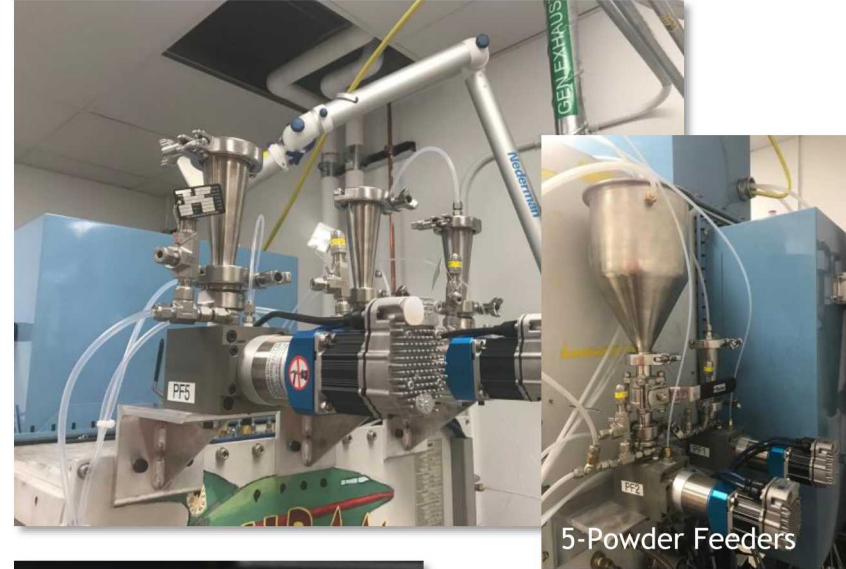
6 LENS® (Laser Engineering Net Shaping)

Operation and research continues with Sandia's LENS machine

Sandia's LENS machine was upgraded from 2 to 5 powder feeders.

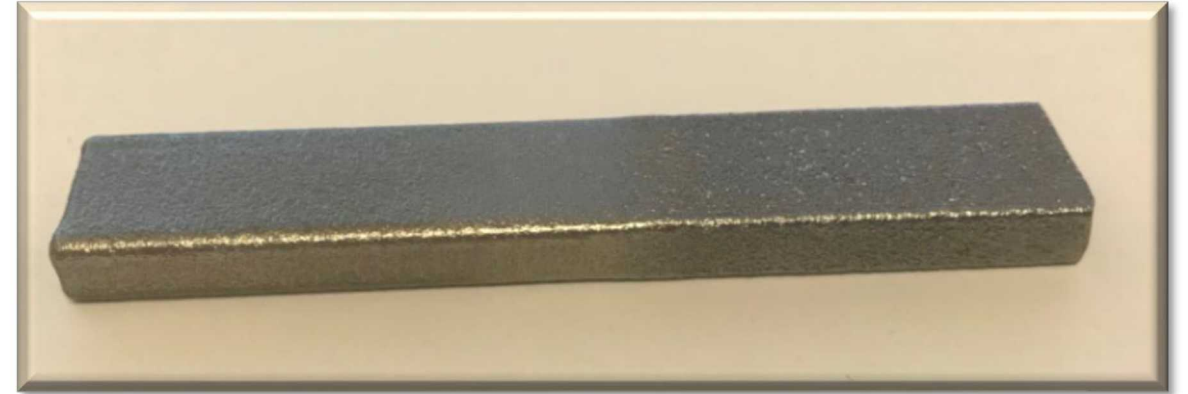
Areas of research

- Multi Material
- Functionally grading
- In-Situ Alloying
- Refractory metals
- Titanium
- High Entropy Alloys
- Magnetic Alloys
- Variable laser Spot size

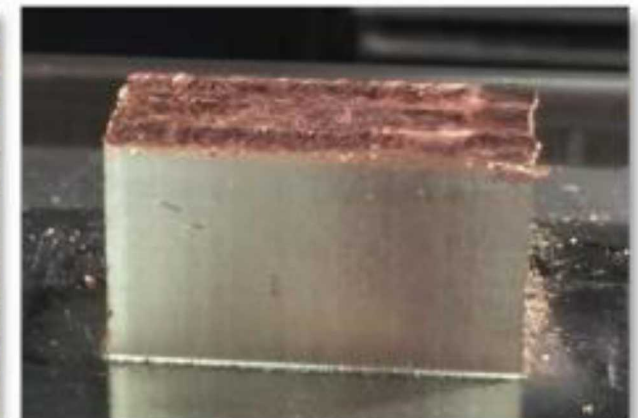




*Multi-material and Hybrid
Hiperco core with SS304L Shell*



*Multi-material
 $\frac{1}{2}$ magnetic steel $\frac{1}{2}$ non-magnetic steel*

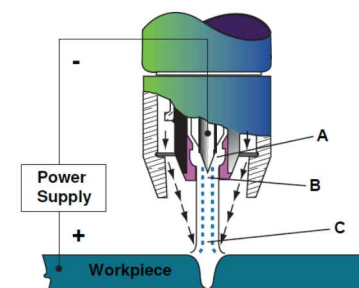
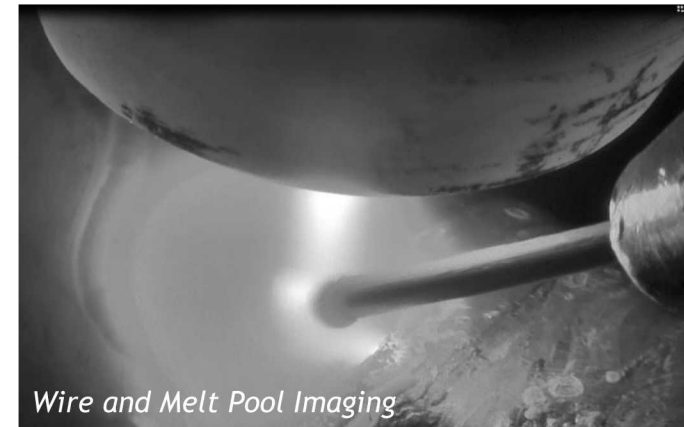


304L SS / Cu multi-material thermal concentrator

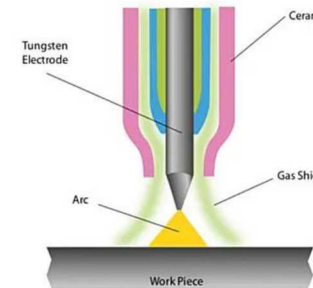
Wire Feed AM

Capabilities of Plasma Arc Welding (PAW) wire feed

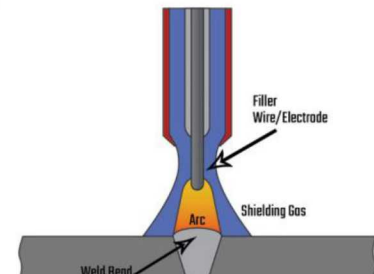
- 5 axis hybrid additive/subtractive manufacturing platform
- Materials to date
 - Low Carbon steel
 - Ti-6Al-4V
 - Copper
- Other material candidates
 - Refractories
 - Other metals that are weldable and come in wire form.
- 3 arc based deposition torches
 - Plasma Arc Torch (small part, higher resolution)
 - Gas Tungsten Arc Torch (medium part, TIG)
 - Gas Metal Arc Torch (large part lowest resolution, MIG)
- Acceptable Wire Sizes - 0.4mm to 2.0mm
- Weld bead width from 2mm to 6mm



Plasma Arc



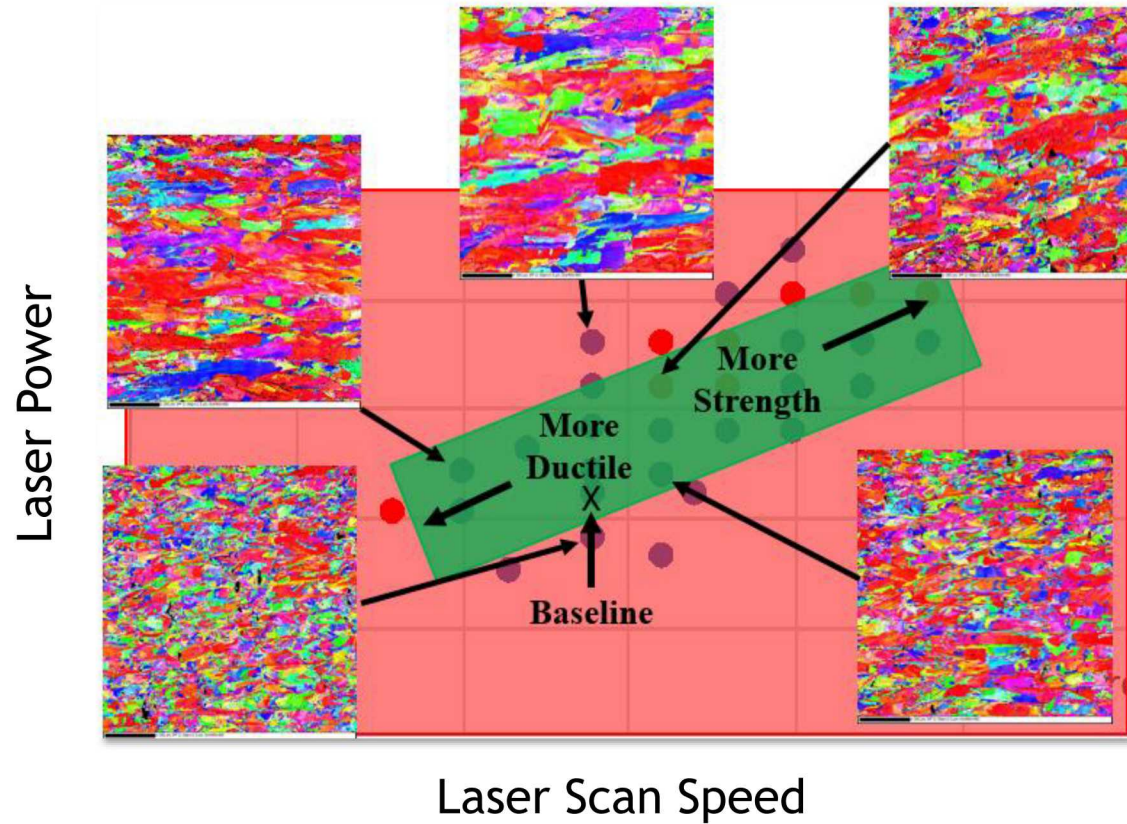
Tungsten Arc



Metal Arc

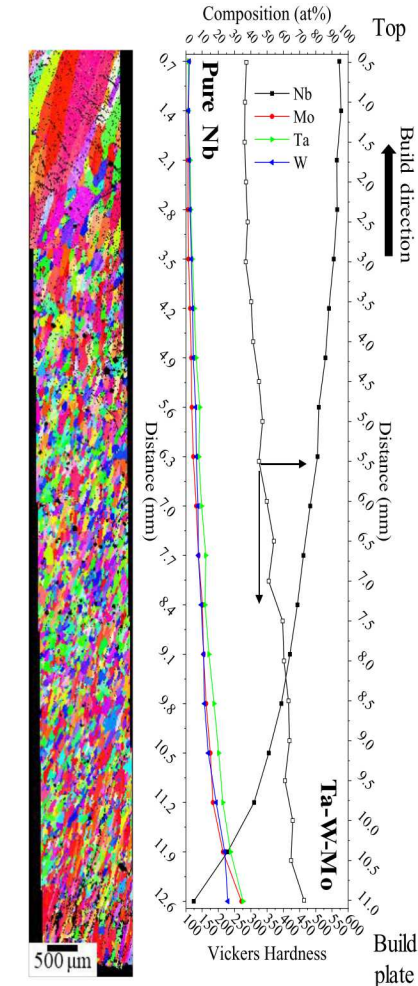
Metal Additive Research

Optimal powder bed print setting might not be what you think.



Research performed by Dr. Bradley Jared
Josh Koepke, MS Thesis, UNM Dept of ME, 2019

Thin wall cross section Nb to Ta-W-Mo



Research performed by and published
Dr. Andrew Kustas

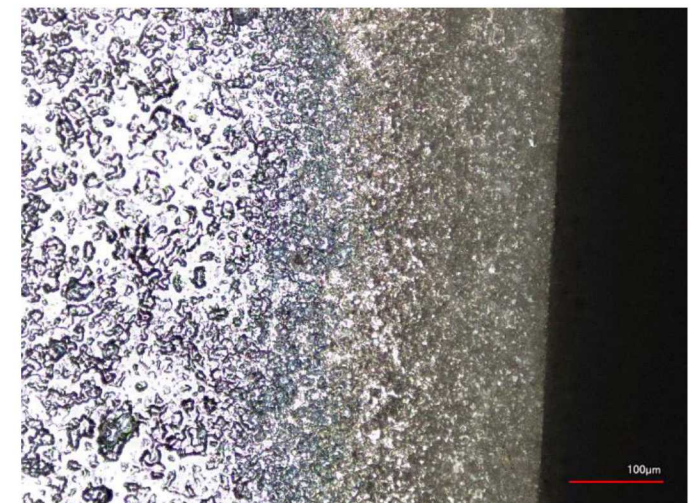
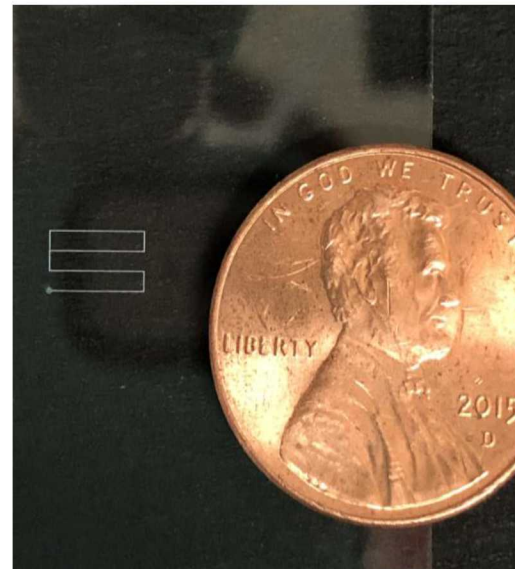
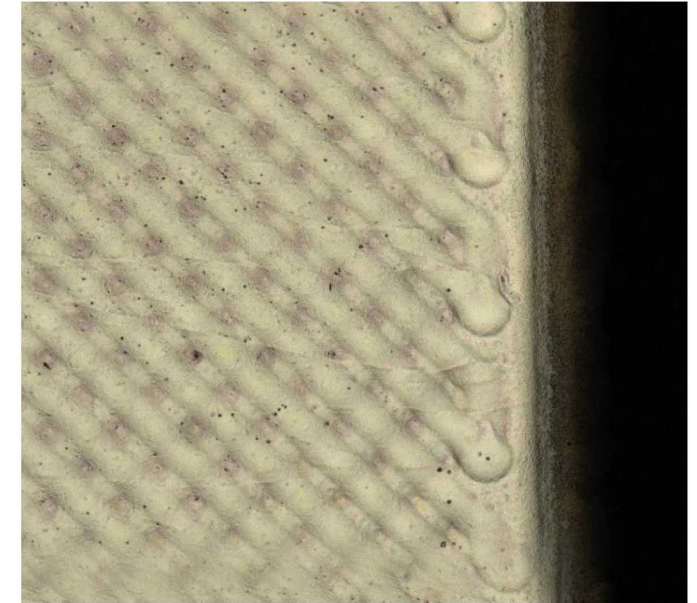
Creating Silver Electrodes using Aerosol Printing



Sandia is evaluating the application of nano-particle silver on a ceramic substrate.

Working with IDS NanoJet, conductive electrodes are applied and sintered onto ceramic substrates.

The application is done by spraying a silver nanoink (UT DOTS) through an IDS NanoJet head attached to a motion platform. The IDS NanoJet head is capable of line with as small as 10 microns.



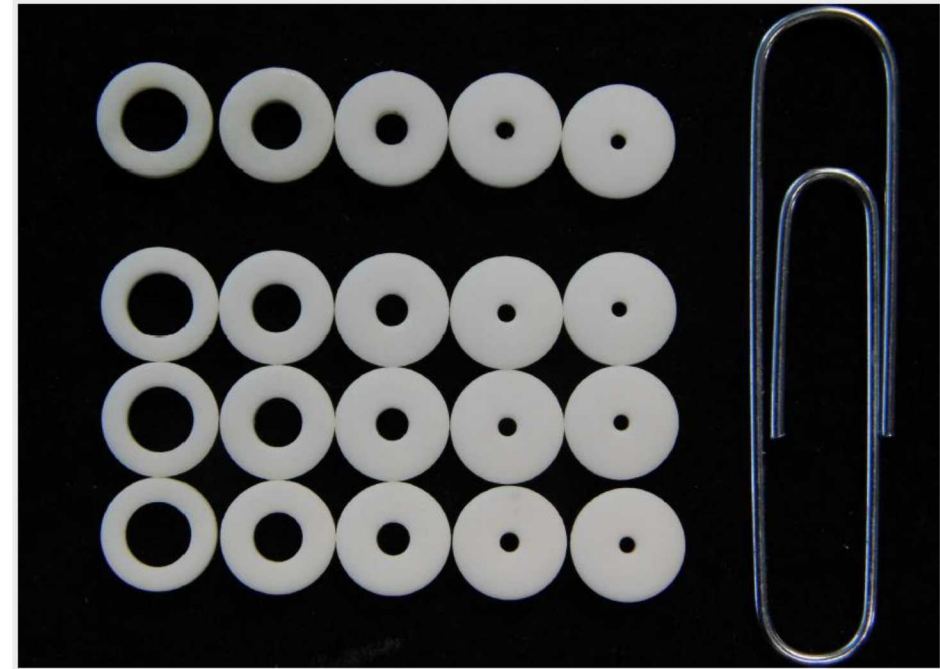
Lithoz Ceramic Printing at Sandia

Sandia desired a high tolerance fully dense solution to additive ceramic manufacturing.

Lithoz America LLC. was capable of developing custom slurries and manufacturing components for Sandia's evaluation.

Based on these components, Sandia purchased the Lithoz CeraFab printer.

With internal access to ceramic manufacturing we estimate our production/development time can be reduced from 4 - 6 months to weeks.



Geometry		Value	Goal	Assessment
Height		Average: 1.57 ± 0.02 mm	1.52 mm	Within tolerance
Outer Diameter		Average: 5.45 ± 0.02 mm	5.43 mm	Within tolerance
Inner Diameter	0.125"	Average: 0.121" *	0.120"	Edge of tolerance – big
	0.095"	0.091"	0.090"	Within tolerance
	0.065"	0.059"	0.060"	Within tolerance
	0.040"	0.034"	0.035"	Out of spec – too big
	0.035"	0.028"	0.030"	Edge of tolerance - small

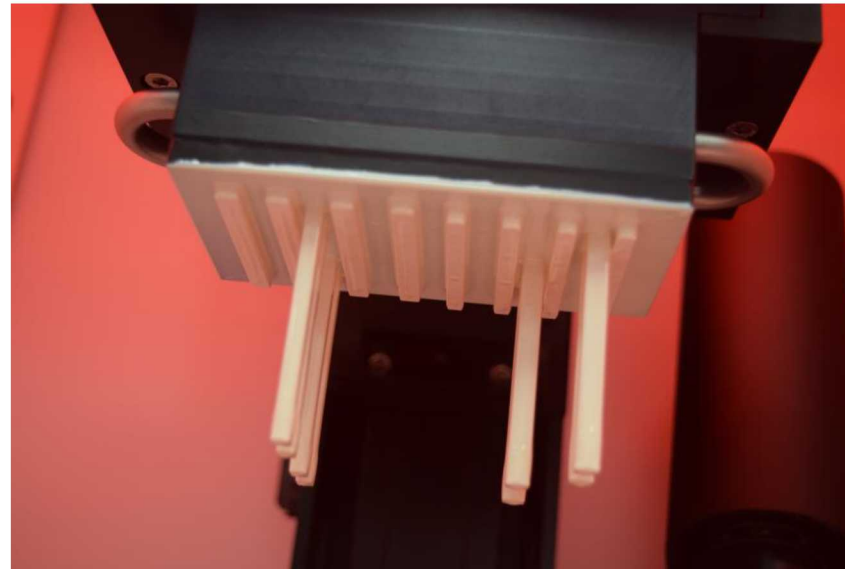
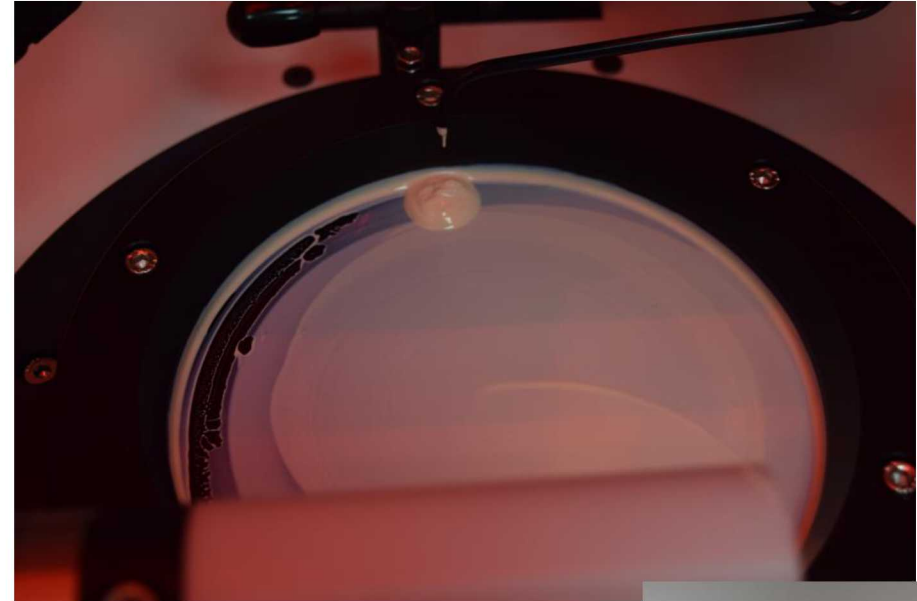
Custom Slurry development

Custom Sandia ceramic component resulted in like-for-like results compared to traditional manufacturing creating a drop-in component.

The drop-in component required a dissimilar braze (metal-braze-ceramic) and a hermetic seal.

Sandia and Lithoz are working together on production ready slurry.

The Lithoz printer was placed in service and started printing February 25th



2021 Additive Ceramic Effort



- Five research topics were submitted that will utilize Lithoz ceramic additive manufacturing technology.
- Characterization of Sandia's customer slurry.
- Providing internal researchers at Sandia the ability to have custom manufactured ceramic components while minimizing manufacturing time.
- Data management and tracking of manufactured components.