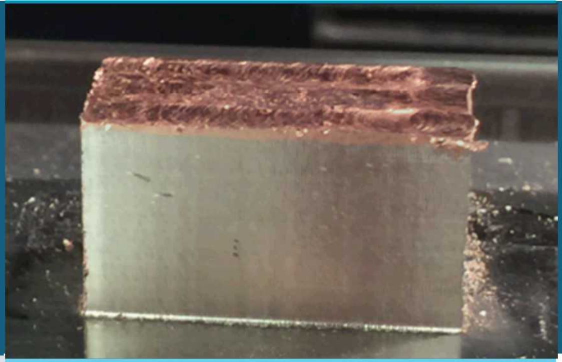
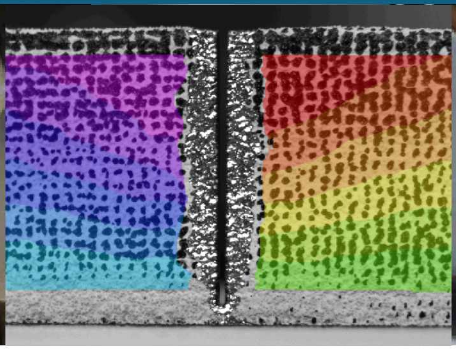
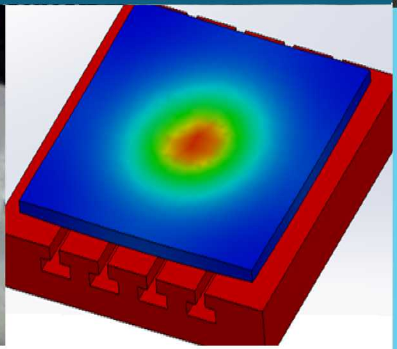
SAND2020-0687PE

Process Development for the In-Situ Mixing of Multi-Material Feed Stock in Additive Manufacturing







PRESENTED BY

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Raymond Puckett, Dylan Casey, Michael Melia, Andrew Kustas

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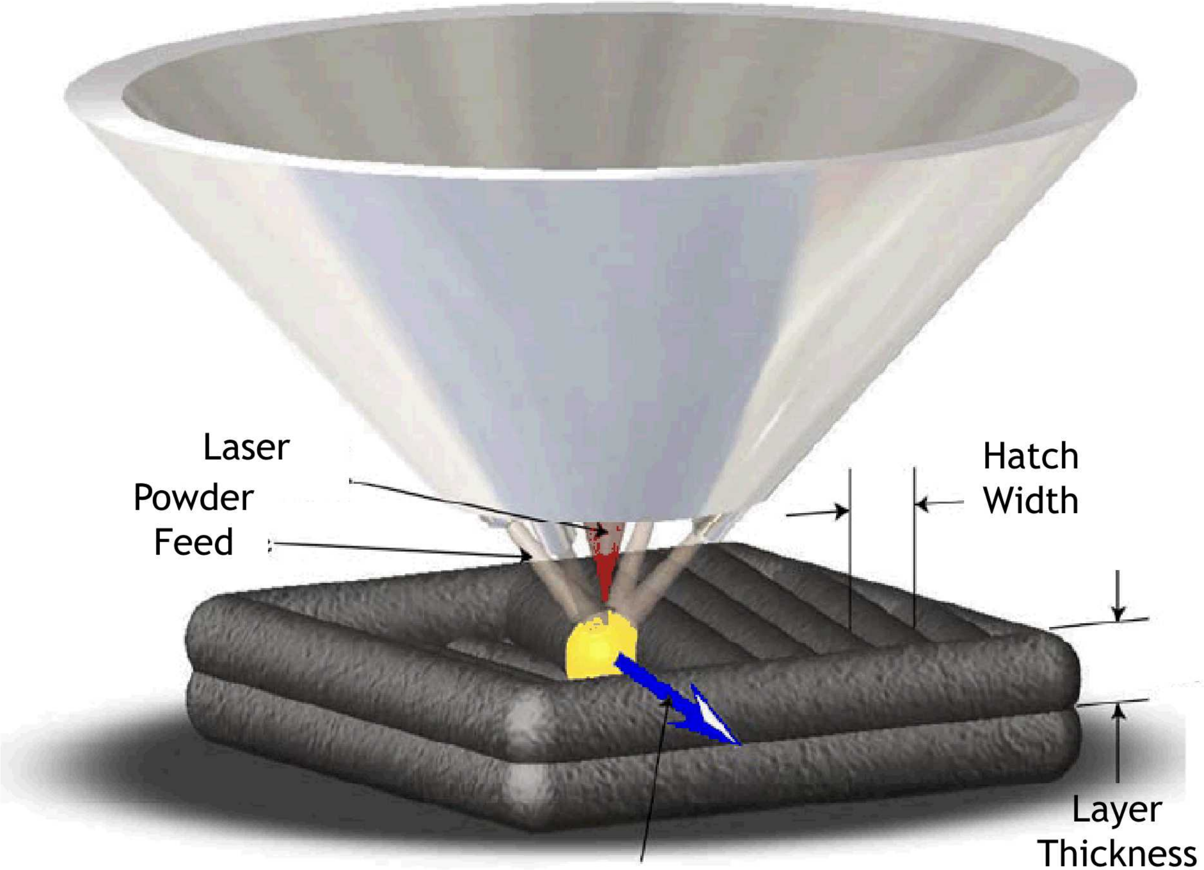
LENS (Laser Engineered Net Shaping)

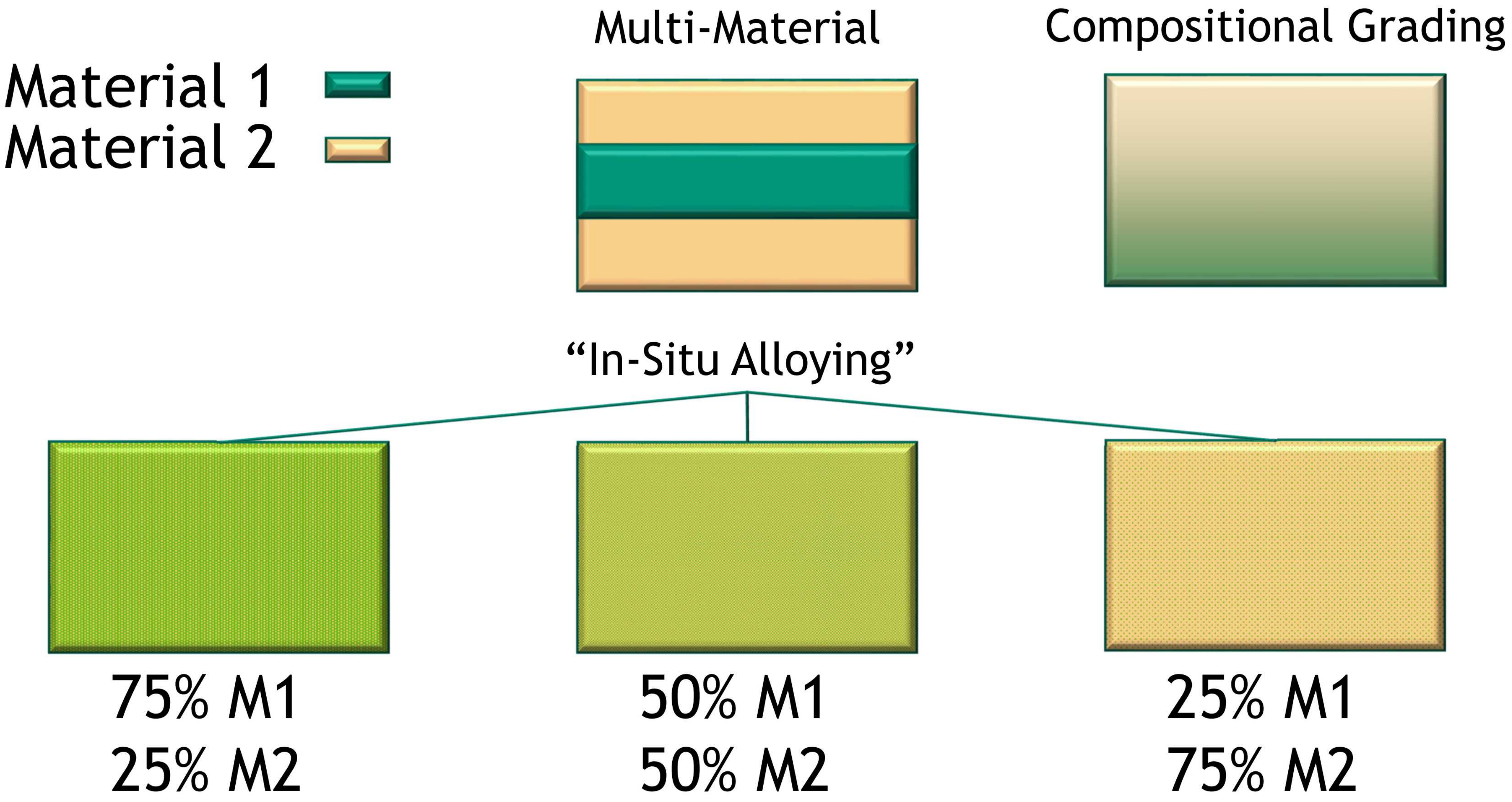
- Laser beam coaxial to print head
- Fluidized powdered metal is blown into laser melt pool
- Beads of material are formed as deposition nozzle and substrate are moved relative to each other



Schematic of LENS 3D printer [1]

[1]Smugeresky, J.E., *On the interface between LENS deposited stainless steel 304L repair geometry and cast or machined components.*

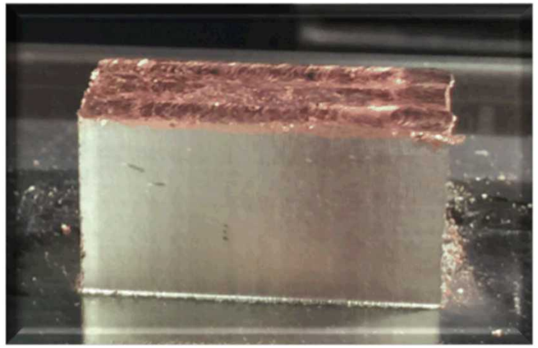
Uses For Multiple Powder Feeders



Advantages of LENS (DED)

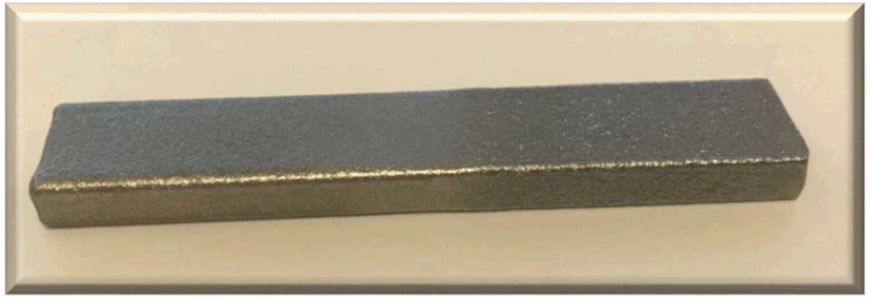
- Functionally graded
- Multi material
- Size of parts
- Hybrid additive subtractive
- High deposition rate
- Repair of parts
- In-Situ Alloying

Hybrid Additive Subtractive
Ti6Al4V



Multi-material and Hybrid
Cu Core with SS304L Shell

Repair of worn parts [1]



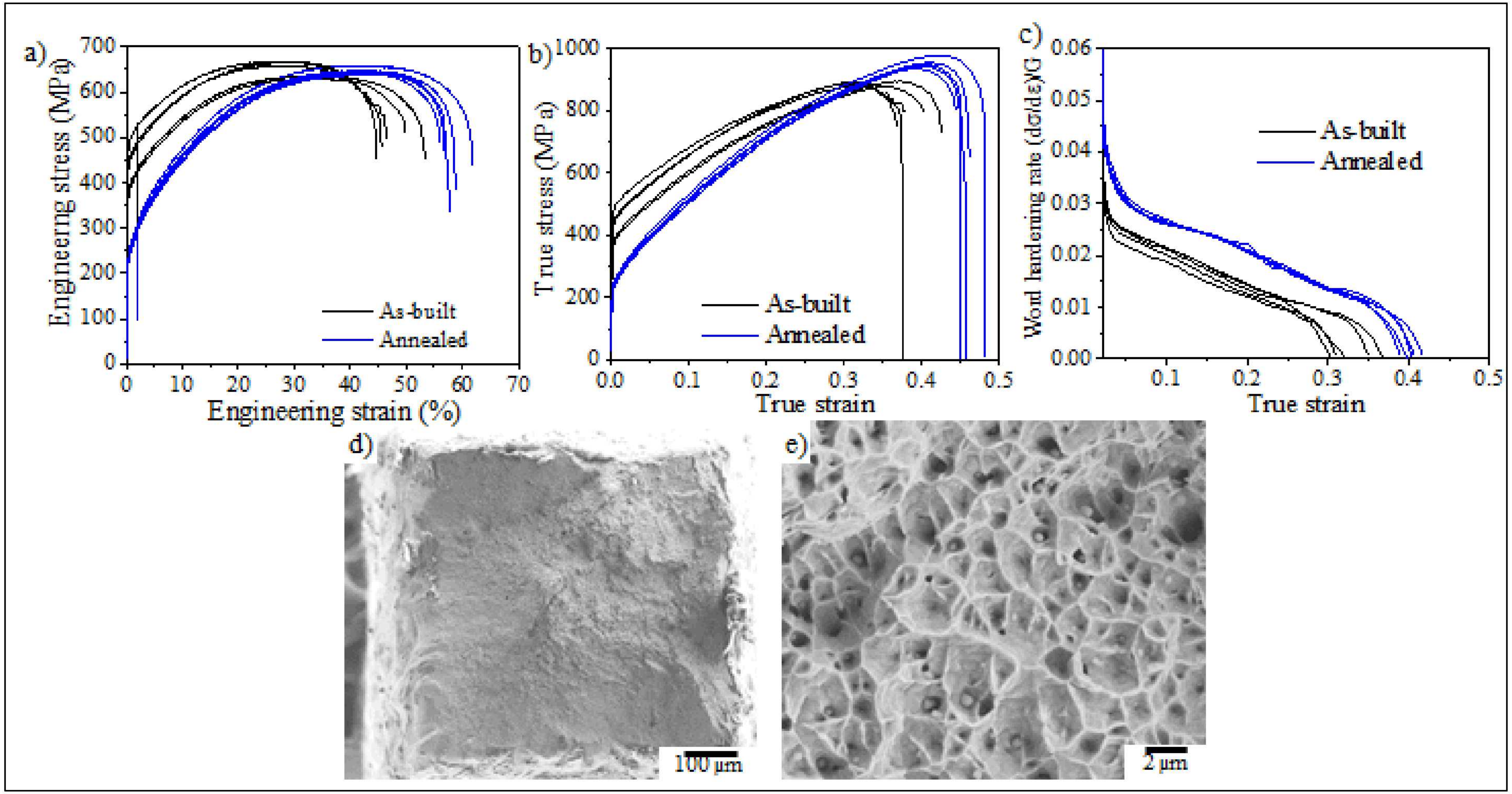
Multi-material
½ magnetic steel ½ non-magnetic steel

Multi-material and Hybrid
Hiperco core with SS304L Shell

[1] RPM Innovations, Inc. Laser Deposition Technology For Additive Manufacturing and Repair

High Entropy Alloys (HEAs)

- Mechanical testing of pre-alloyed HEA powder
- High strength and ductility with desirable performance shown in AM HEAs



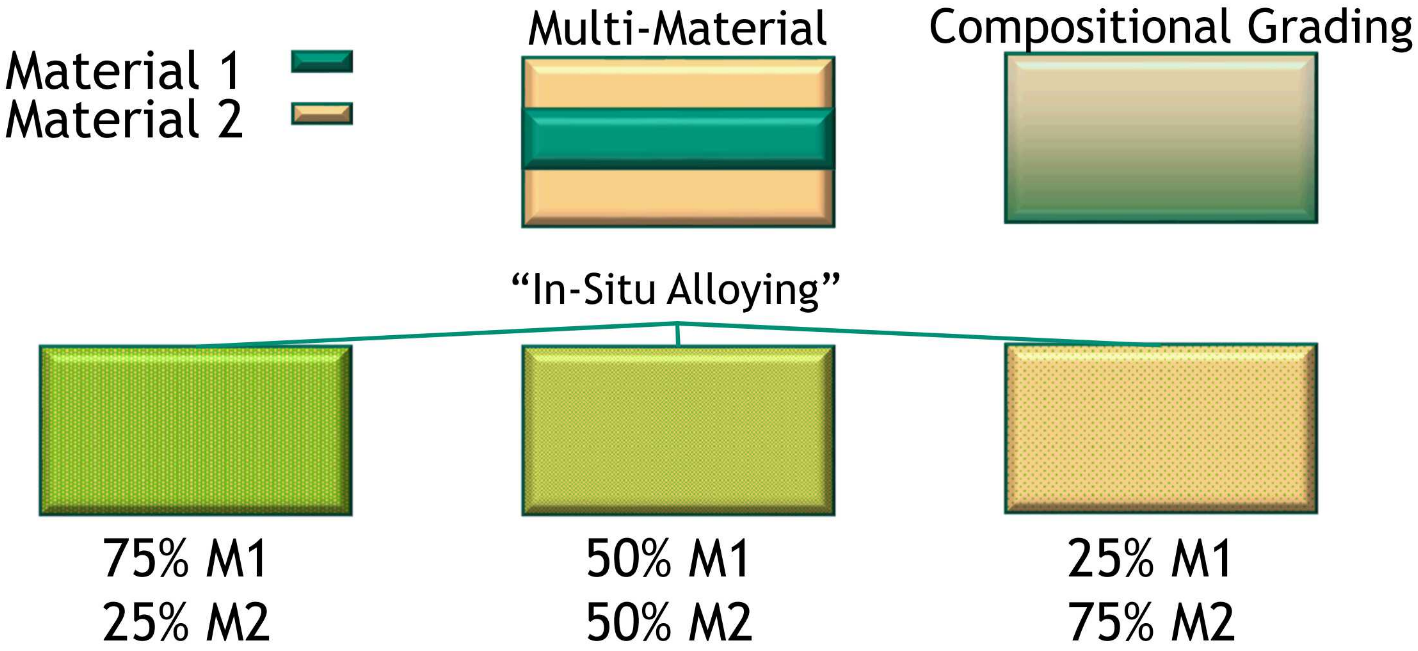
We need more powder feeders!!

What if I didn't have to have custom powders made for every project?

What if I could put ingredients and an "alloy recipe" into the printer and push print?

What if I could change alloy composition from coupon to coupon?

What if I could change alloy composition within a coupon?



LENS Powder Feed Upgrade

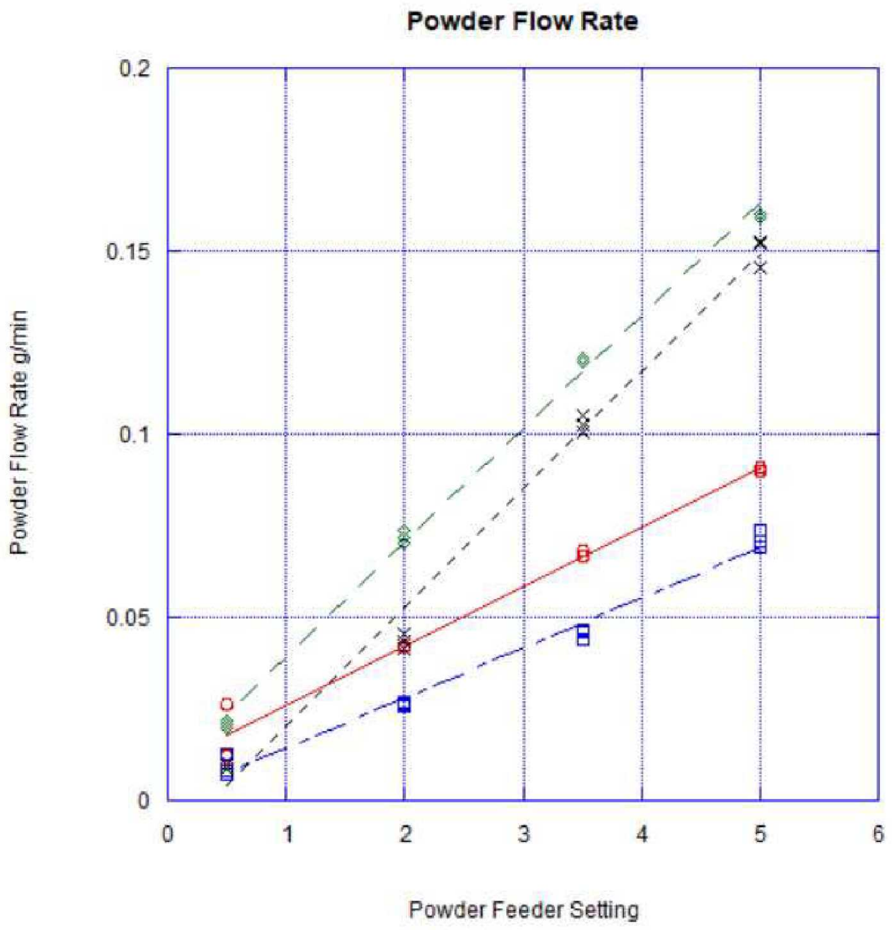
- Up to 5 component compositional grading
- Up to 5 component multi material
- In-Situ alloying of up to 5 "Ingredients"
- HEA's

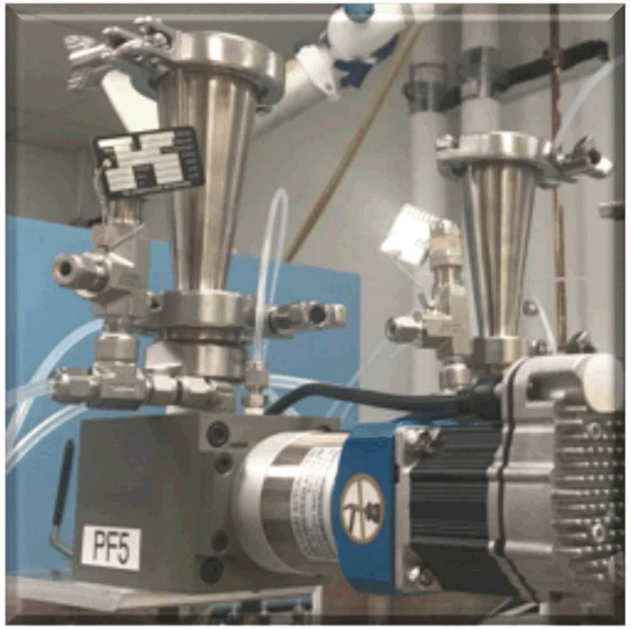
Additional new powder feeders

Original two powder feeders

Characterizing Powder Flow Rate

- Necessary to know how much of each powder is going into the sample.
- Approach:
  - Flow powder at various feeder settings
  - Create flow curves
  - Use flow curves to calculate settings needed for desired alloy composition
  - Verify composition using metallurgical methods.





y = 0.00937 + 0.016353x R= 0.99243

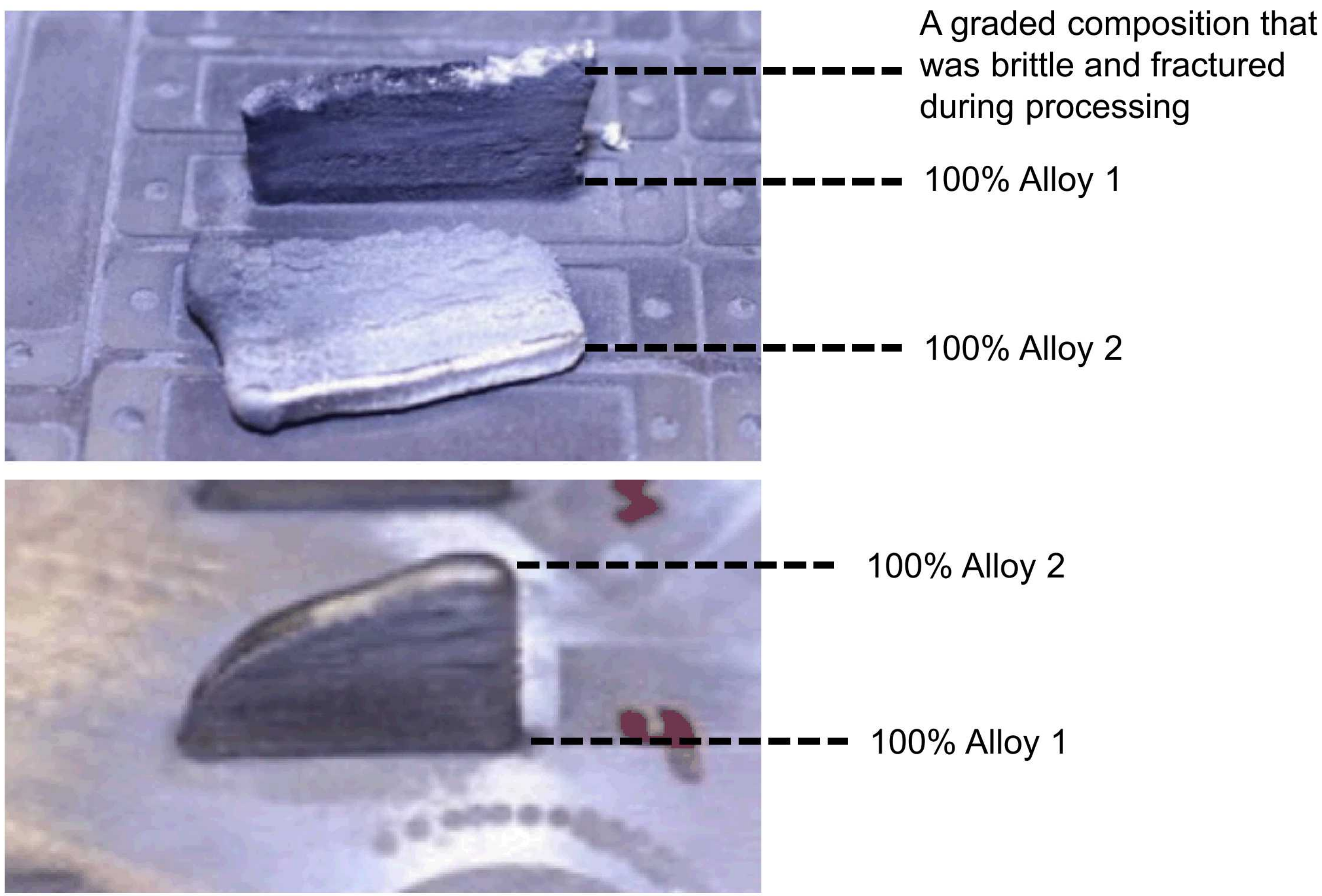
y = 0.00043111 + 0.013698x R= 0.99277

y = 0.0078944 + 0.031011x R= 0.99821

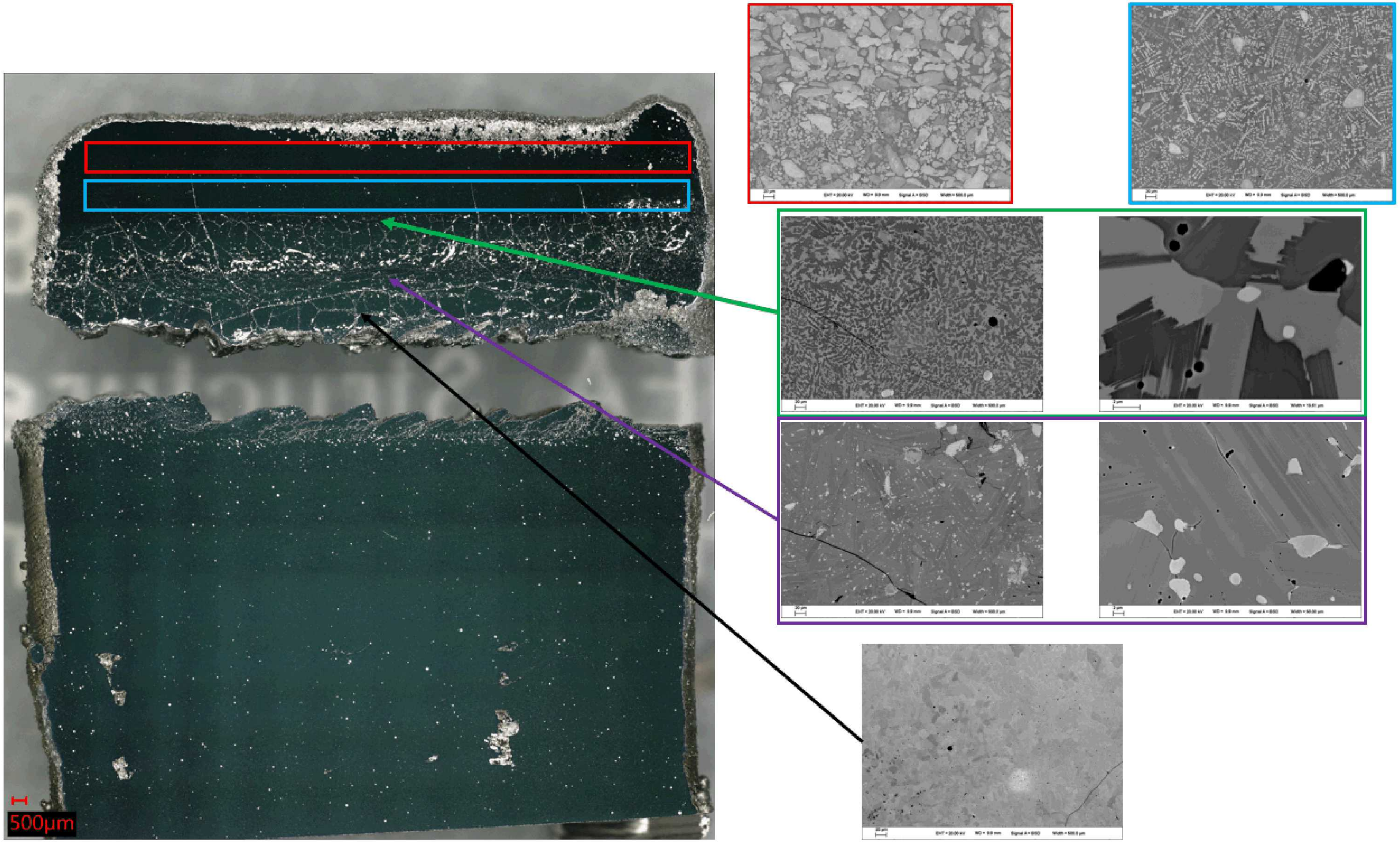
y = -0.012124 + 0.032184x R= 0.99466

Compositionally Graded Thin Walls

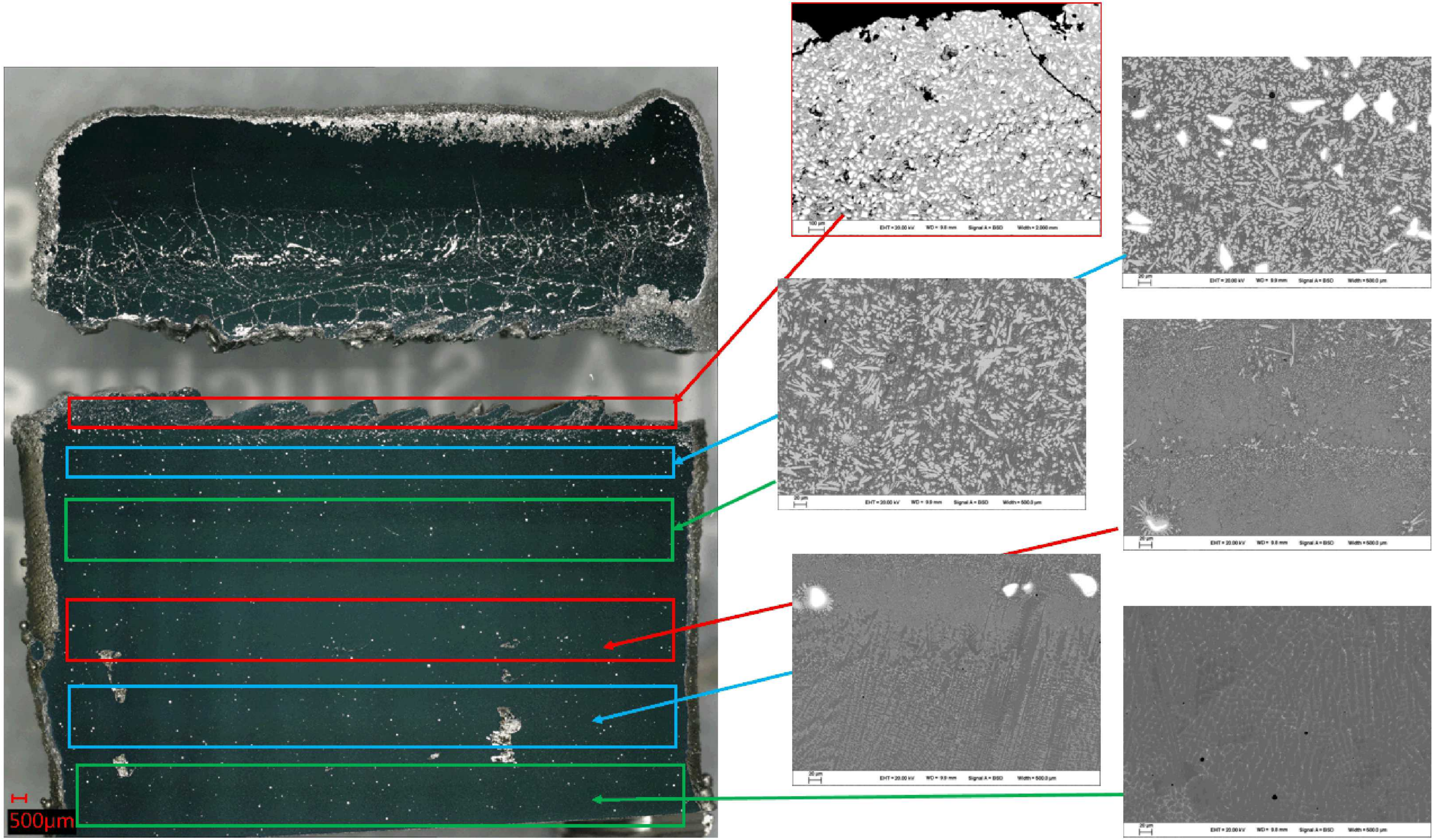
- Using functional grading to targeting high strength eutectic HEA's
- Goal: to connect experimental work with atomistic computational modeling work.



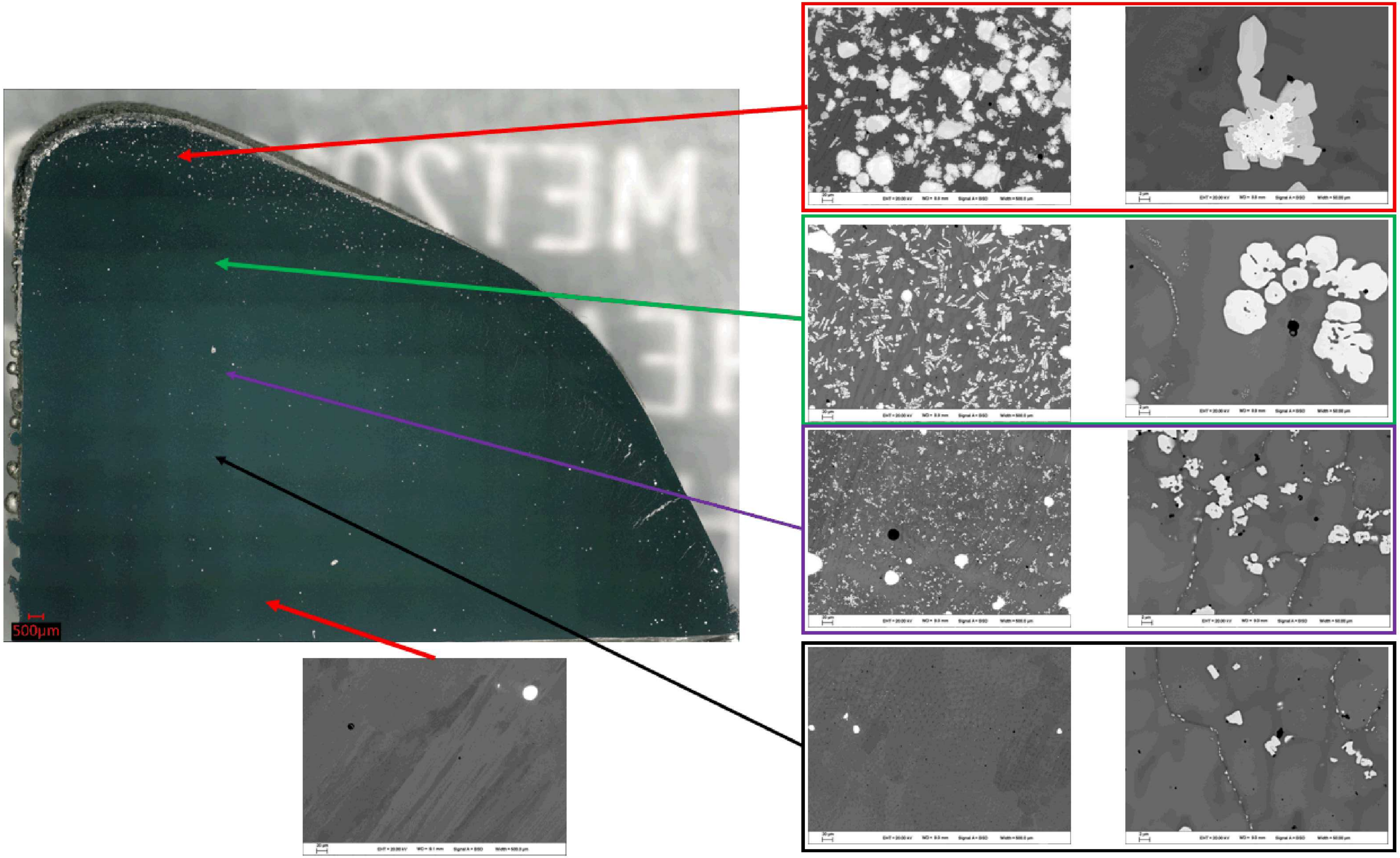
Compositionally Graded Thin Wall Case Study 1



Compositionally Graded Thin Wall Case Study 1



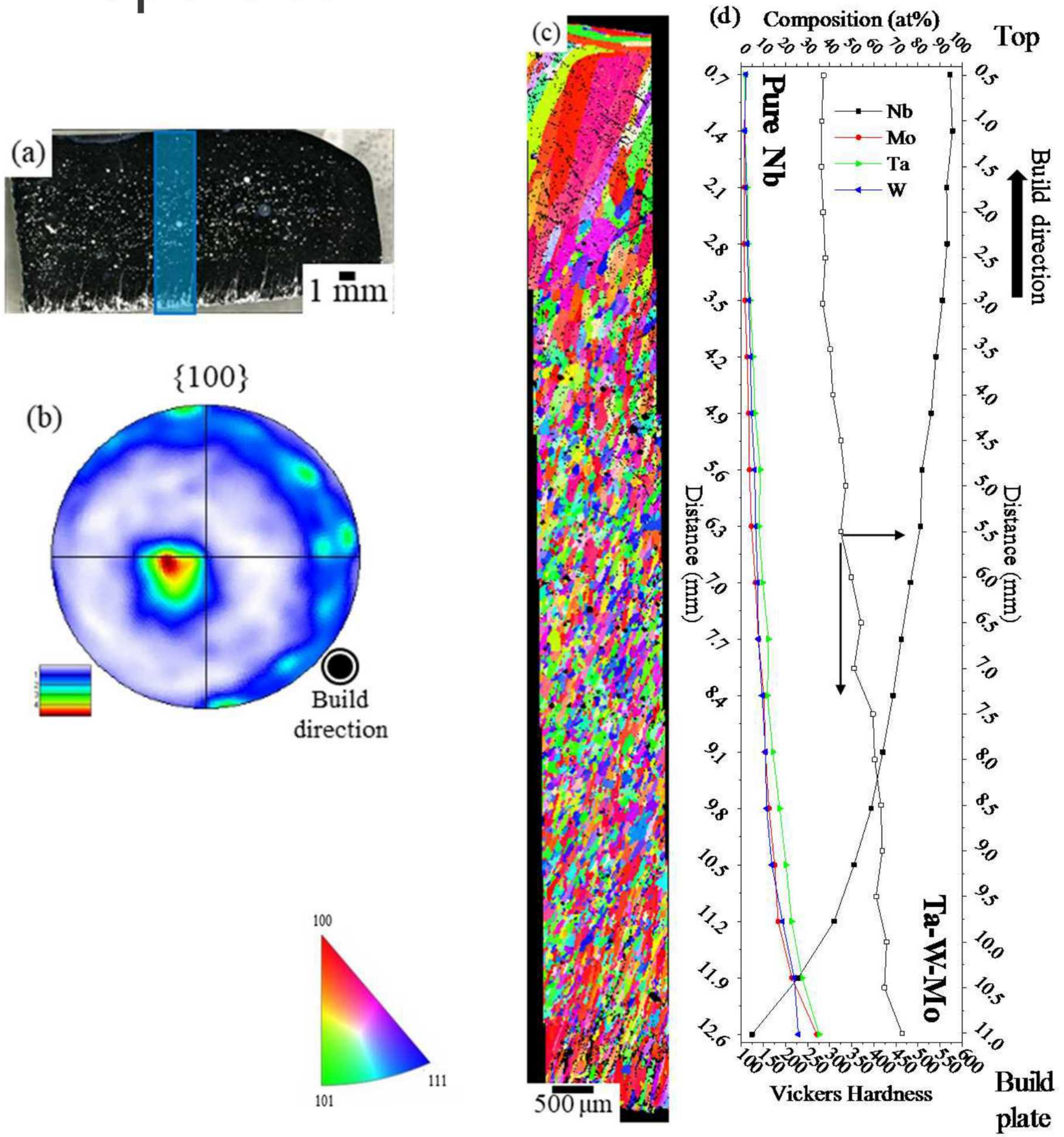
Compositionally Graded Thin wall Case Study 2



Composition and Various Properties

Analysis of the AM-processed $(MoTaW)_x(Nb)_{1-x}$ compositionally graded part that was manufactured using LENS in-situ alloying.

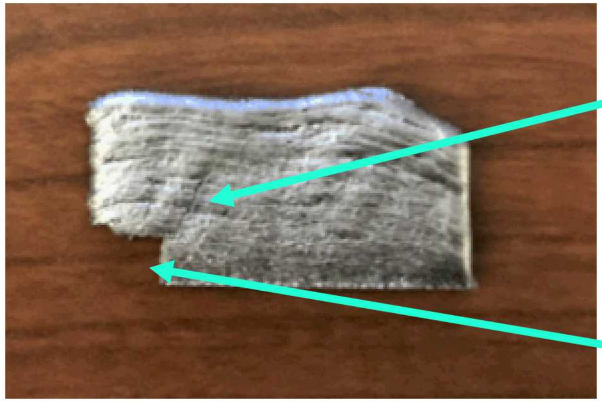
a) An optical image of the 3D printed thin wall
b) {100} pole figure oriented parallel to the build direction
c) IPF map
d) Composition and hardness gradients along the height of the 3D printed thin wall



In Situ Alloyed HEAs

- Using In Situ alloying to create High Entropy Alloys from elemental powders
  - Reduce time to make custom powders
  - Reduce cost to make custom powders
- Goal: use powder feeder settings to accurately meter desired composition of powder and then mix and alloy during printing process

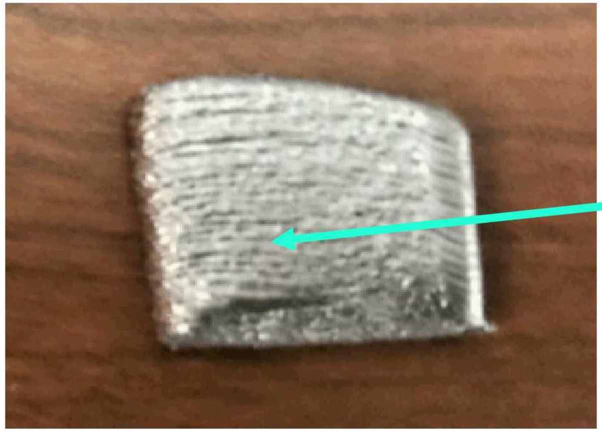
Alloy Composition #1



Brittle alloy composition with cracks from printing process

Chunk of sample that fell off during removal from substrate

Alloy Composition #2



Less brittle alloy that shows no visible signs of cracking

Conclusions

- Successfully installed a 5 hopper powder feed system on Sandia National Labs Material Sciences Center LENS printer
- Demonstrated powder control for:
  - Compositionally graded thin wall structures
  - In-Situ alloying of custom alloys from elemental powders
- More work needed to verify and tune for desired material composition.

Questions?

Contact Information

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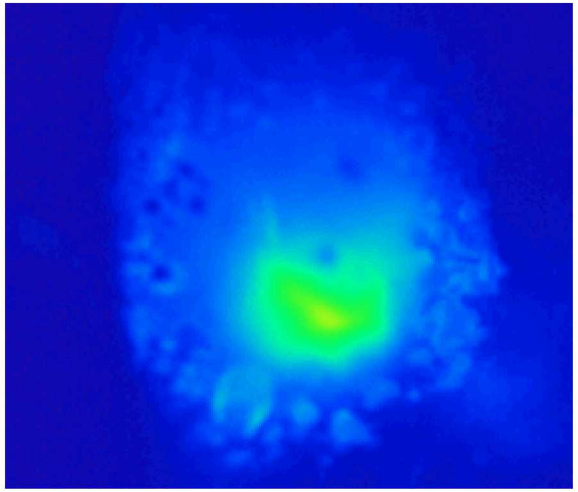
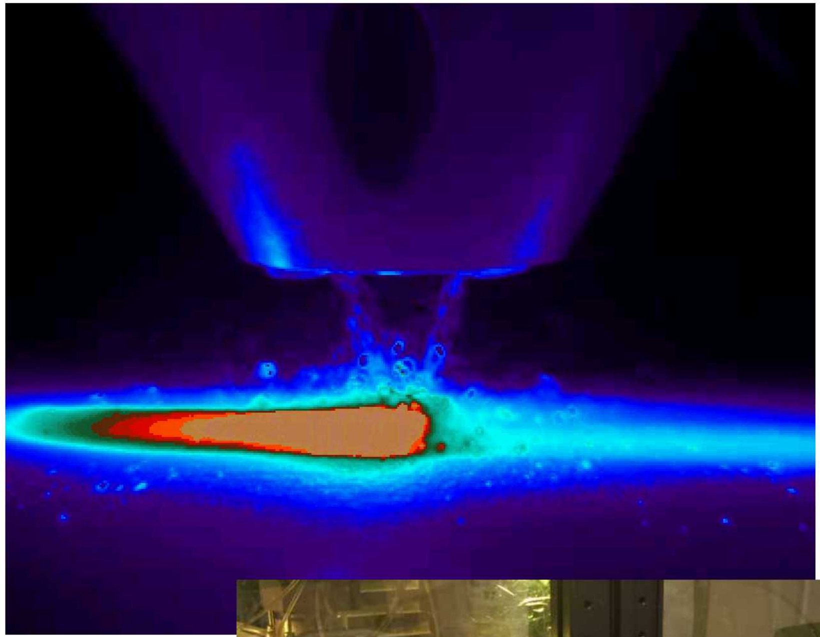
Other Features of SNL's LENS

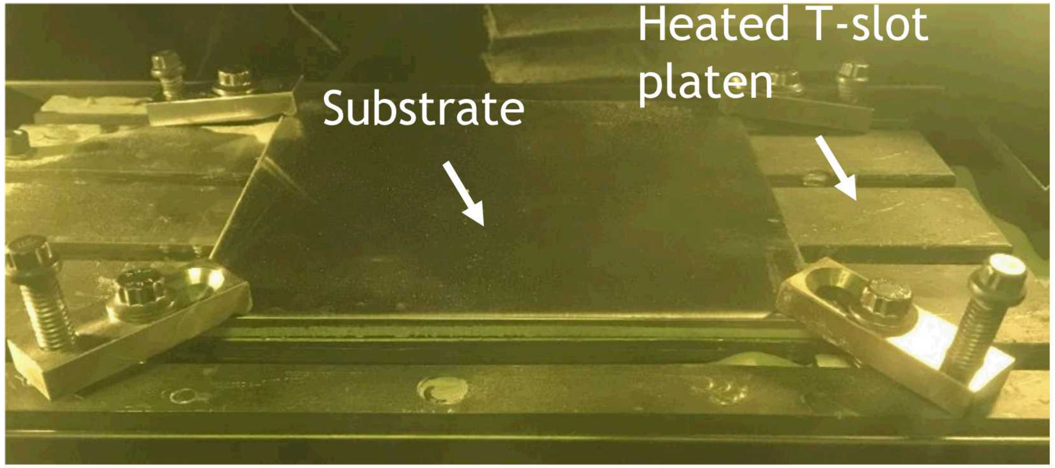


2- Color Pyrometer

Adjustable Spot Size



Flir IR Camera



Heated Print Bed