

AM Product Development and Future Research Opportunities



PRESENTED BY

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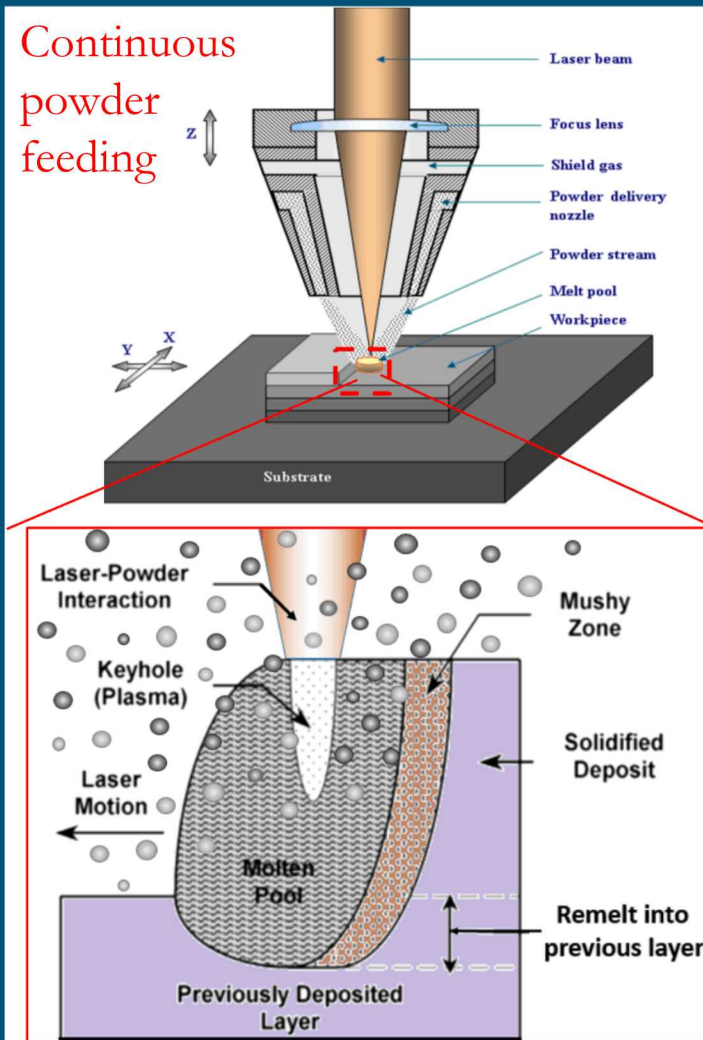
Technical Contributors:

Nancy Yang, Jonathan Noland, Wei-Yang Lu

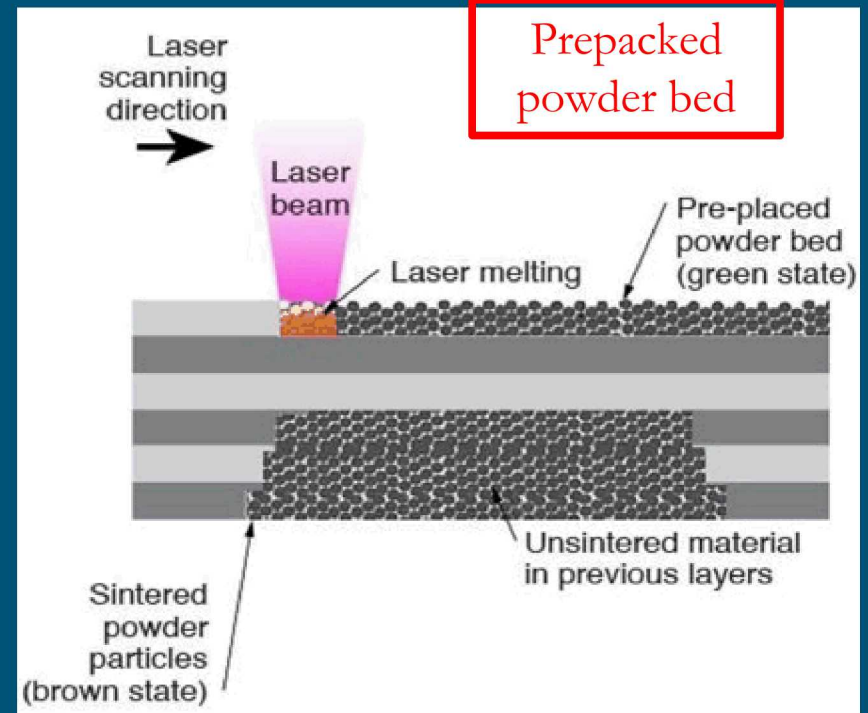
- Baseline Technologies
- Qualification Roadmap
- S&T Maturation Efforts
- Component prototyping
- Future Research Opportunities

Baseline Technologies

3-D LENS



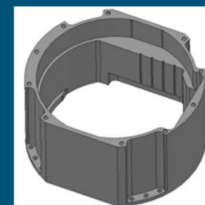
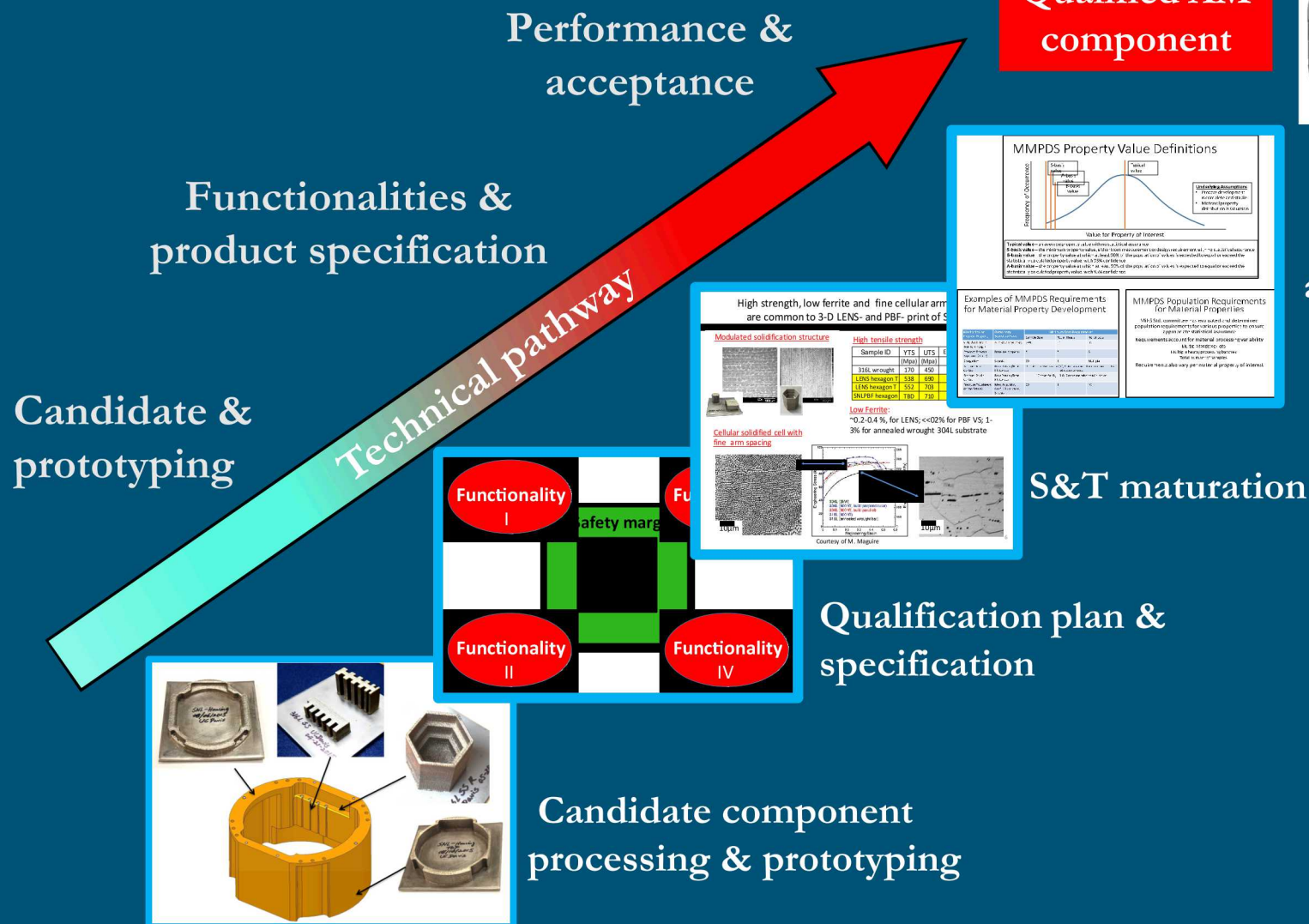
(3-D EPBF) 3-D LPBF



Common printing steps

- Powder melting
 - Molten metal fusion
 - Molten metal solidification
- Accompanies by metallurgical reaction

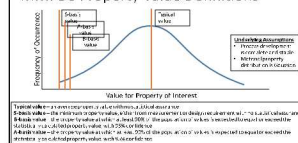
Metal AM Component Qualification Roadmap



Material assurance

Qualified AM component

MMPDS Property Value Definitions



Examples of MMPDS Requirements for Material Property Development

Property	Requirement	Notes
Tensile Strength	≥ 1000 MPa	Minimum
Yield Strength	≥ 800 MPa	Minimum
Elongation	≥ 10%	Minimum
Reduction of Area	≥ 30%	Minimum
Impact	≥ 10 J	Minimum

MMPDS Population Requirements for Material Properties

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Requirements for Material Properties

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High strength, low ferrite and fine cellular arm are common to 3-D LENS- and PBF- print of S

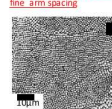
Modulated solidification structure



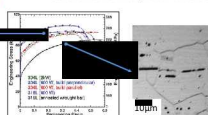
High tensile strength

Sample ID	YTS	UTS	EL
310L wrought	170	450	10
LENS hexagon T	538	600	10
LENS hexagon T	552	700	10
310L wrought	180	710	10

Cellular solidified cell with fine arm spacing



Low Ferrite
 <0.2-0.4% for LENS; <0.2% for PBF VS 1-3% for annealed wrought 304L substrate



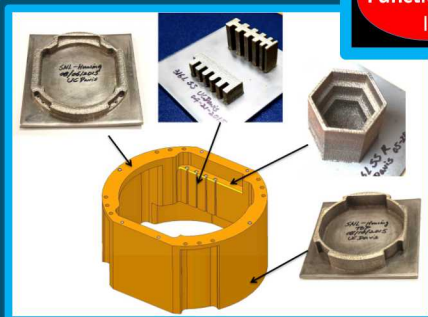
Courtesy of M. Maguire

Functionality I

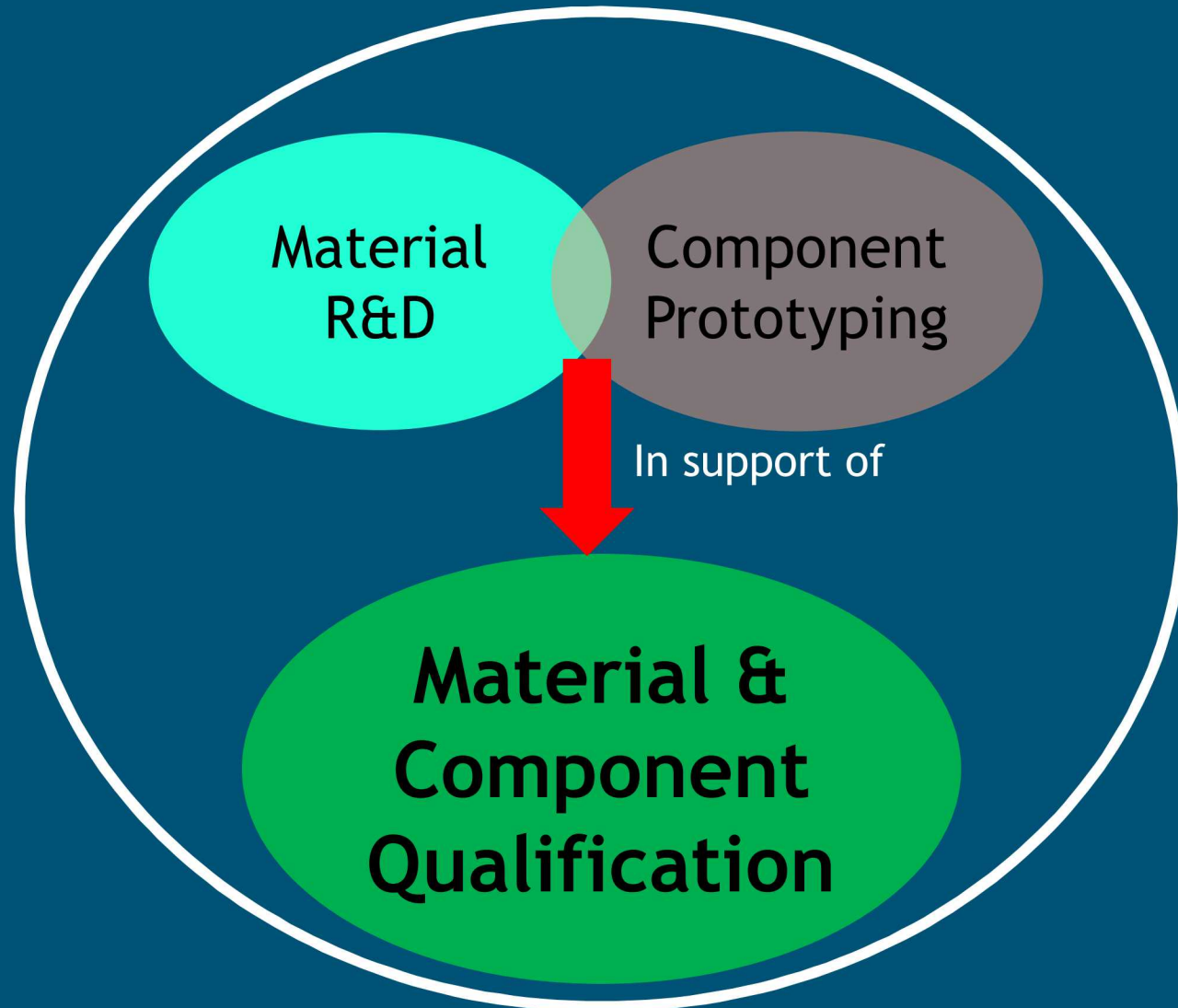
safety margin

Functionality II

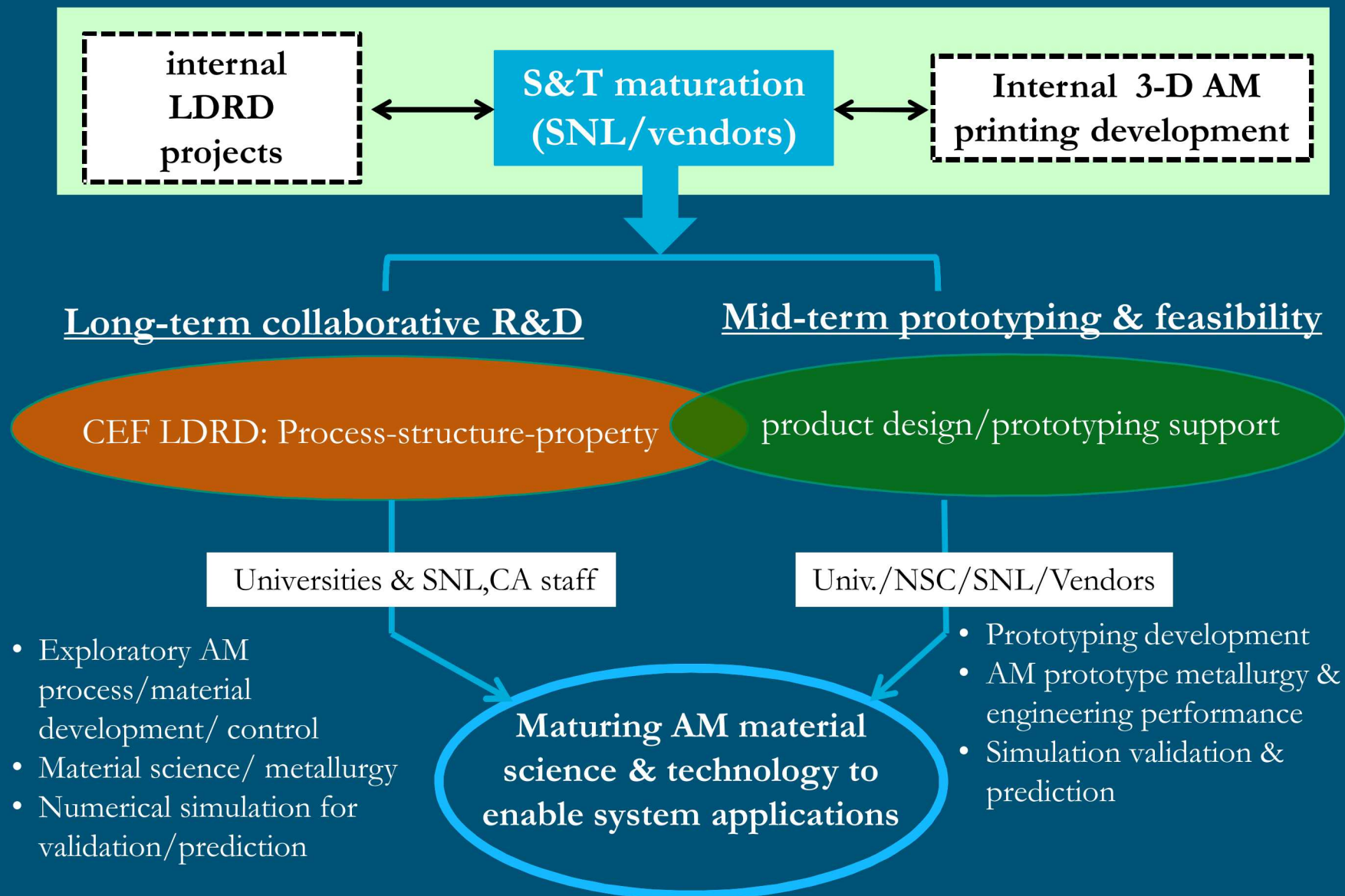
Functionality IV



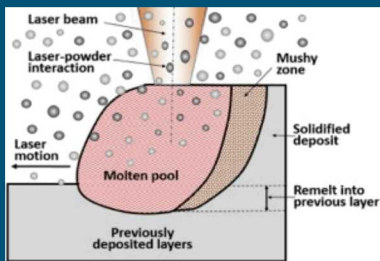
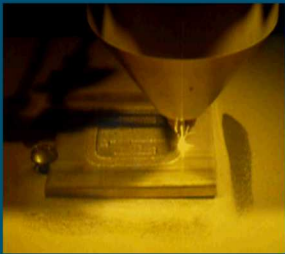
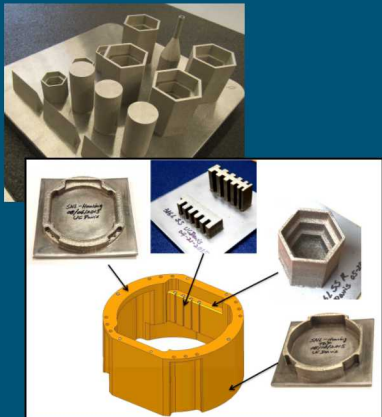
Candidate component processing & prototyping



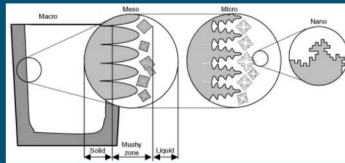
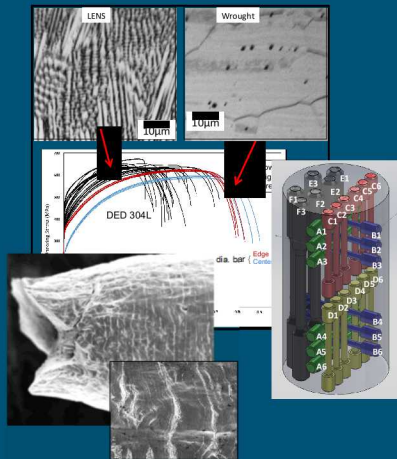
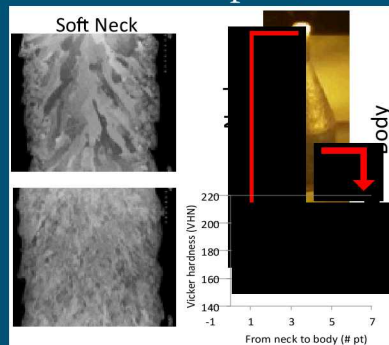
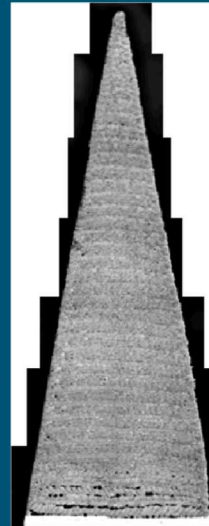
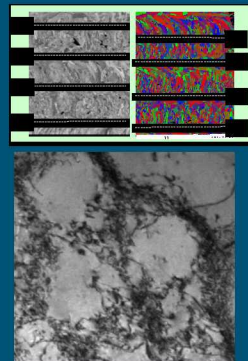
Existing SNL,CA programs and potential UC collaboration



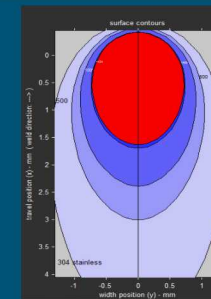
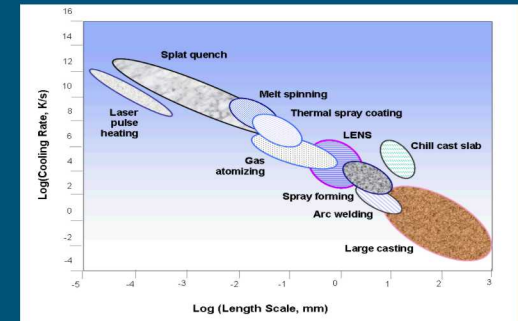
Process- & prototyping

Laser-material interactionProcess optimizationPrototyping feasibility

Material science

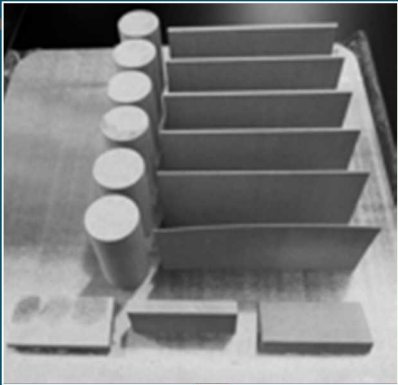
Solidification basisMechanical behaviorThermal transportGeometry & structural defectMicrostructure & Anisotropy

Numerical modeling

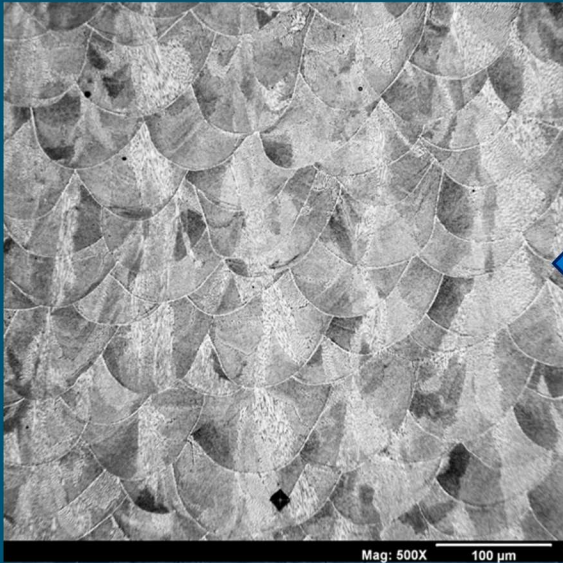
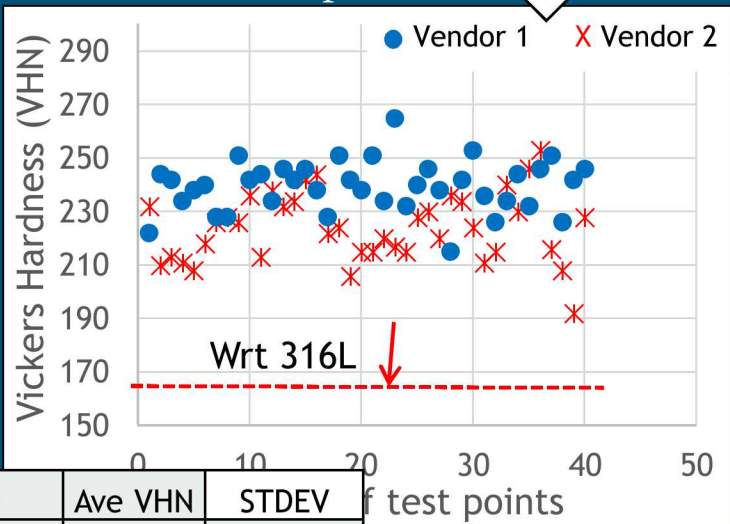
External collaborations

- UC Davis/Irvine: LENS Prototyping
- UC Berkeley: Microstructure-solidification
- Stanford: Thermal transport & process control & modeling(TBD)
- NSC: AM prototyping
- PolarOnyx: Femtosecond AM printing,

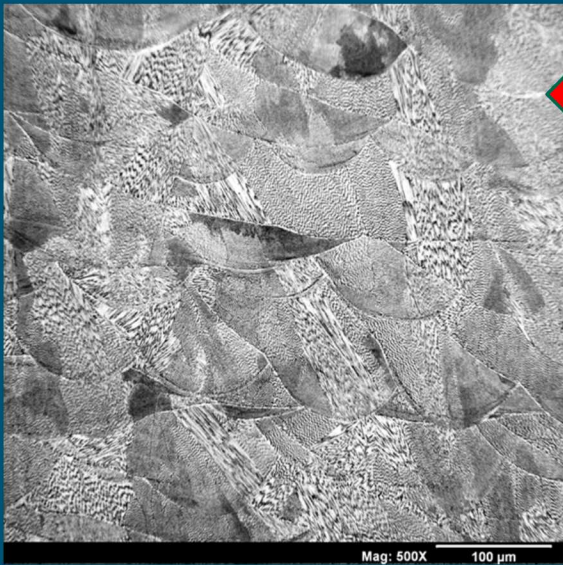
3-D LPBF 316L product possess high & uniform strength but is printer hardware dependent



Vickers hardness profile



Vendor 1

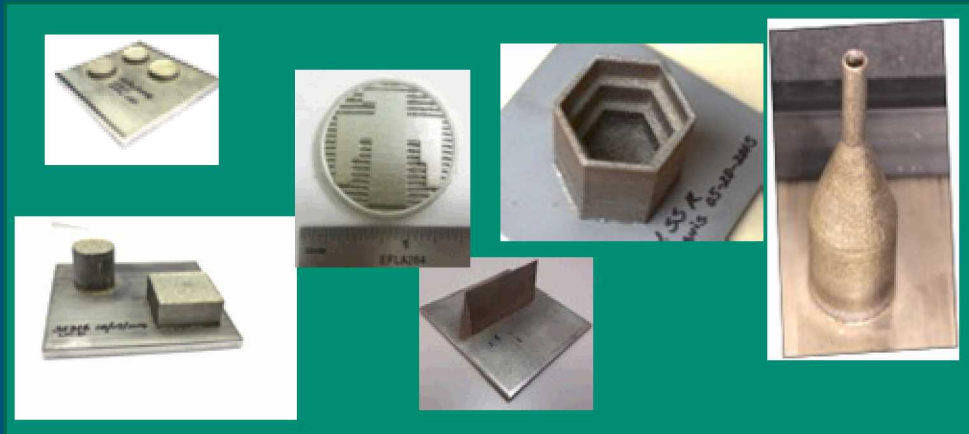


Vendor 2

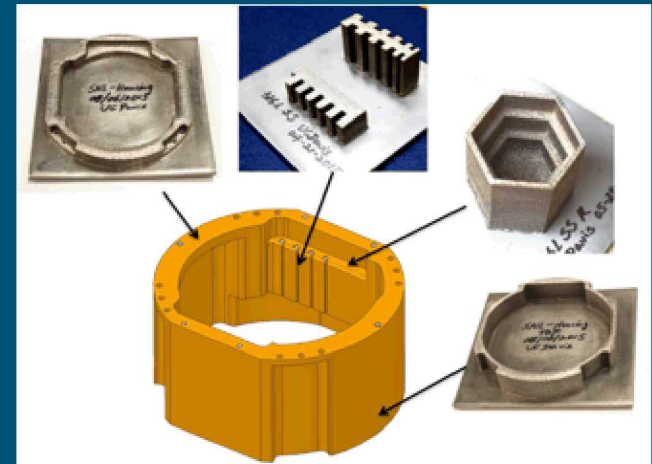
Coarse solidified grains & columnar cells yield softer material

316L LENS- / LPBF- S&T maturation and prototyping

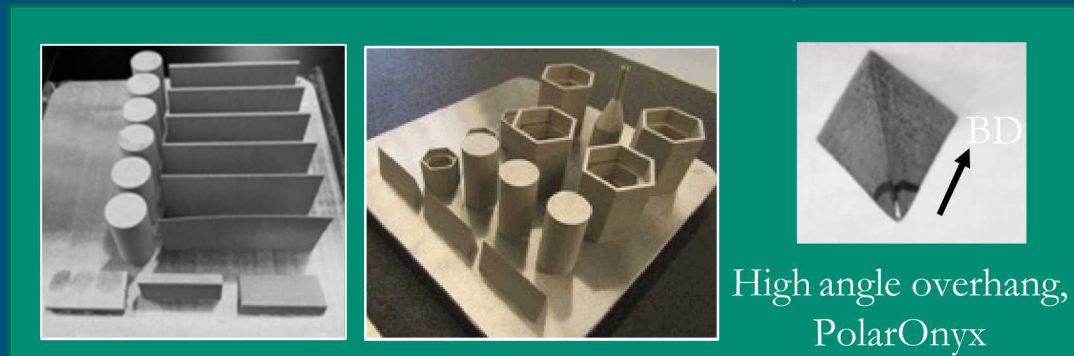
3-D LENS prototypes



A&E housing prototype



3-D LPBF prototypes



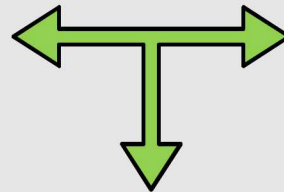
Novel LPBF pyramid (Femtosecond)

High angle overhang,
PolarOnyx

Material Assurance



AM processing
(Development/control/
optimization)



**Materials testing and
characterization**
(Structure & properties)

Modeling and simulation
(Predictive capabilities)



- Process-structure-property- relationships
- Geometry/precision & limitation/manufacturing constraints
- Materials properties control and defect mitigation



Science-based AM system engineering

Future Research Opportunities

- Anisotropic topology optimizing software that accounts for print strategy or mass/volume optimization
- Develop software package to convert STL files to parametric CAD files
- Development of high z material AM components
- Material properties characterization (fatigue, environmental corrosion, tensile hardness, etc.)
- Develop inspection methods for unique topology optimized parts
- Develop an understanding of how voids and imperfections affect topology optimized parts.

An aerial photograph of a university campus, showing various buildings, green spaces, and a central road. The image is overlaid with a semi-transparent blue filter. A vertical orange bar is on the left side. A horizontal bar with a multi-colored pixelated pattern is located near the bottom of the slide.

Questions?