Computational Process Modeling for Additive Manufacturing

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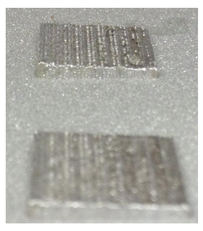
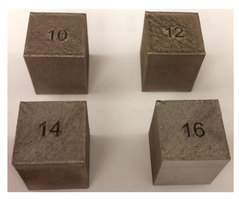
Motivation and Goals

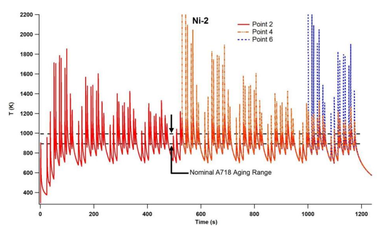
- Computational Process and Material Modeling of Powder Bed additive manufacturing of IN 718
- Optimize material build parameters with reduced time and cost through modeling
- Increase understanding of build properties
- Increase reliability of builds
- Decrease time to adoption of process for critical hardware
- Potential to decrease post-build heat treatments

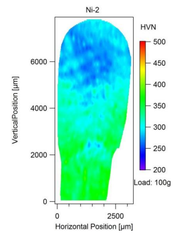
Approach

- Conduct single-track and coupon builds at various build parameters
- Record build parameter information and QM Meltpool data
- Refine Applied Optimization powder bed AM process model using data
- Report thermal modeling results
- Conduct metallography of build samples
- Calibrate STK models using metallography findings
- Run STK models using AO thermal profiles and report STK modeling results
- Validate modeling with additional build









MSFC track and coupon builds; AO and microstructure results -

Image Credit: Kurt Makiewicz Master Thesis 2013

Results

Part / Layer	Contour	Diode Intensity	From Photodiode, average intensity value of contour trace
		Meltpool Intensity	From Camera, average integrated IR intensity of contour trace
		Meltpool Area	From Camera, average number of pixels above threshold color level during contour trace
	Plane	Diode Intensity	From Photodiode, average intensity value of bulk material / hatch scan
		Meltpool Intensity	From Camera, average integrated IR intensity of bulk material / hatch scan
		Meltpool Area	From Camera, average number of pixels above threshold color level during hatch scan

Fig 1: QM Meltpool Data Descriptions

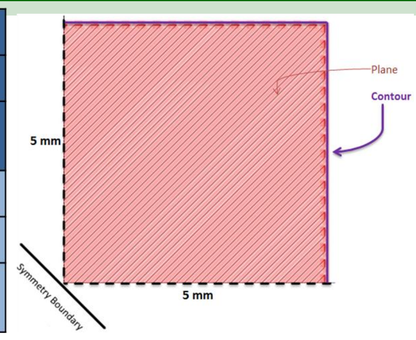


Fig 2:Qualitative image of contour and plane laser paths for one layer of cubic

Data collected from the in-situ quality management module.

Power 126 W Speed 600 mm/s

Power 321 W Speed 850 mm/s

Fig 3: Single Tracks on SS build plate

Fig 4: Single Tracks on SS Build Plate with 1, 2, 3 layers of In718 Powder

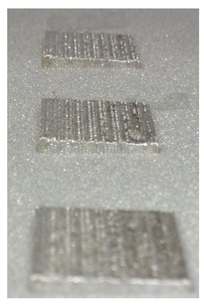


Fig 5: Single Tracks on In718 Bases

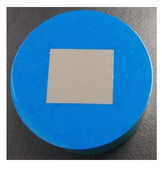


Fig 6: Coupon samples and coupon mounted for metallography

Samples built by Concept Laser M2 Powder-Bed Additive Manufacturing System

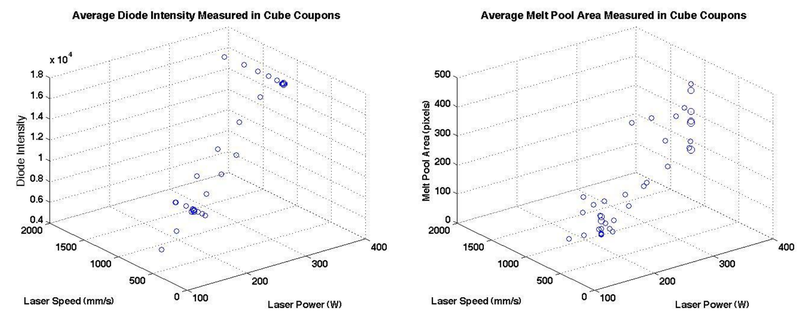


Fig 7: Diode and Melt Pool Area data from Cubic Coupon Sample builds

QM Meltpool Data compiled and delivered to CIMJSEA. Diode intensity and melt pool size increase with power.

Conclusions

- Photodiode Intensity measurements highly linear with power input
- Melt Pool Intensity highly correlated to Melt Pool Size
- Melt Pool size and intensity increase with power
- Applied Optimization will use data to develop powder bed additive manufacturing process model

Future Work

- Examine weld bead geometry and provide data to AO
  - Image and record shape and geometry of weld “scallops”
- Examine microstructure to understand evolution
  - Record grain shape, size, orientation, EBSD
  - Compare bottom and top layers
- Measure and record micro-hardness over the height of the samples (build direction)
- Evaluate samples for porosity, cracking (inter-dendritic, liquation), dendrite arm spacing, TEM, Microprobe, etc. as determined by team after initial results reported
- Begin calibration and modeling of STK at OSU