Main Physical Phenomena in Metal Powder Bed Fusion

Q. 3 & 8

DC Workshop
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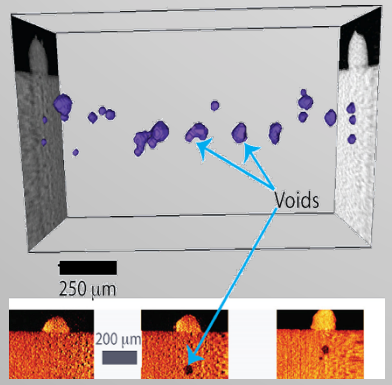
Main challenge: how to select correct process parameters for a final product that meets engineering standards?

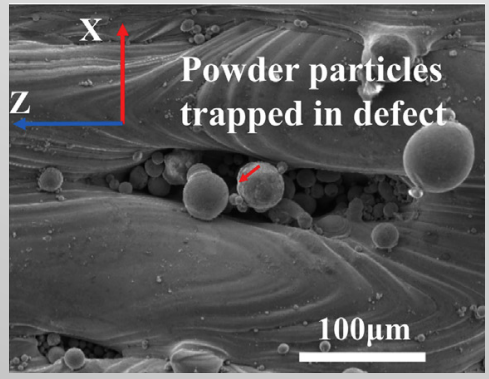
Defects are born at the single powder layer and may seed more defects in subsequent layers

Pores in Keyhole-mode

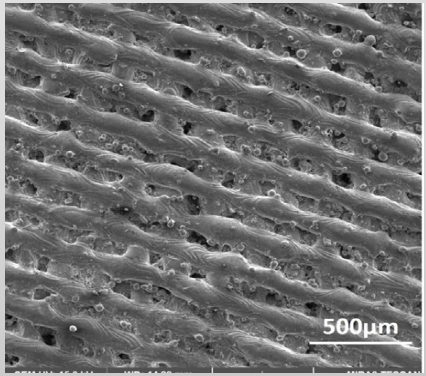


W. King, J. Mat. Proc. Tech. 2014

Incomplete melting

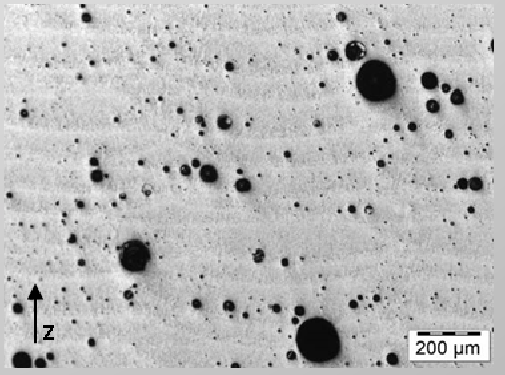


Rough surface, bad wetting



X. Zhou, Act. Mat. 2015

Low density part, bad quality

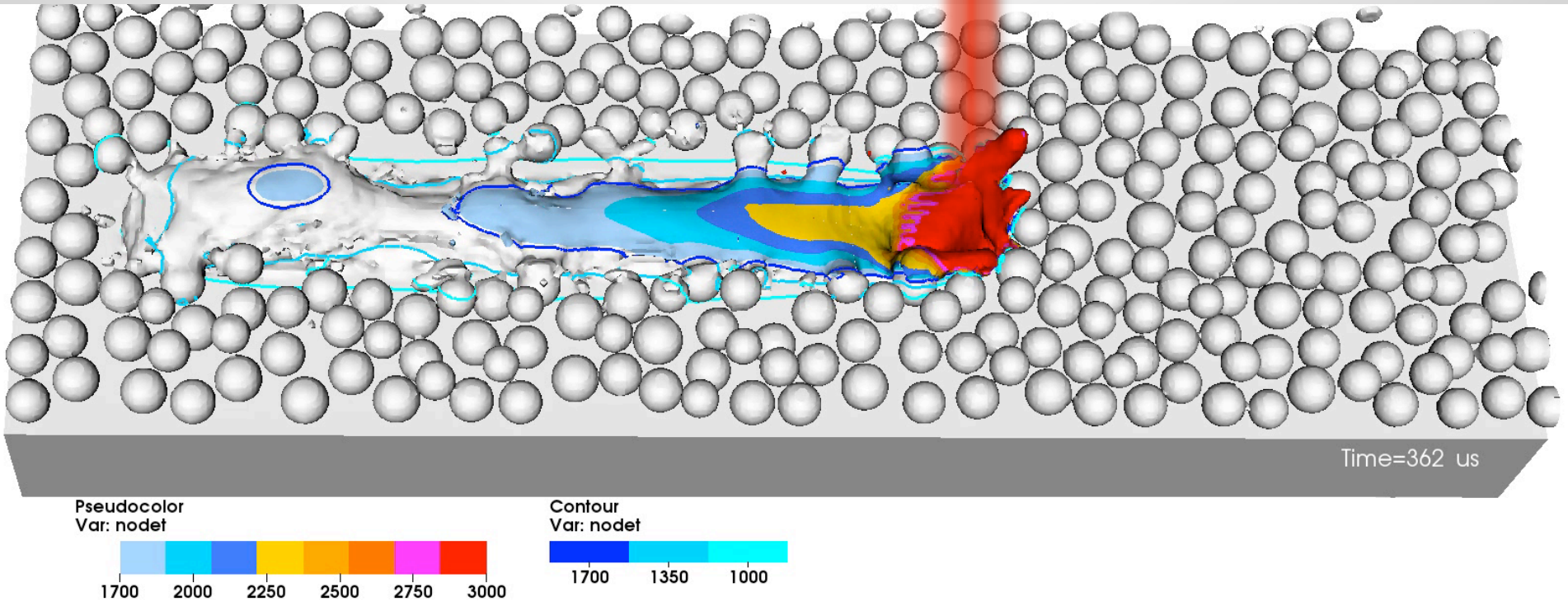


C. Weingarten J. Mat. Proc. Tech. 2015

Selective laser melting process is complex: It is easy to introduce defects. Our understanding of the interplay between process parameters (laser power/speed, powder distribution/thickness…) is still lacking.

Approach: Mesoscopic 3D simulation of metal powder bed fusion using ALE3D

Laser power	**200W**
Laser scan speed	**1500mm/s**
Substrate dimensions	**1000x300x50μm^3**

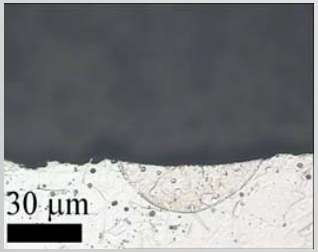


Physics
Pore Generation
Recommendations

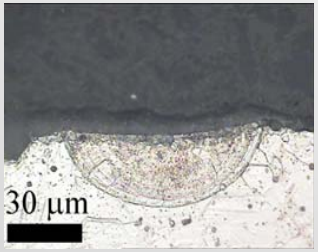
What is the driving physics?
How do pores form and evolve?
Guidance for better parameter choice?

Model-2104 (no recoil or MARANGONI) bare plate validation

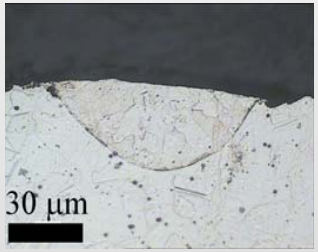
A.V. Gusarov, I. Y. (2009). "Model of Radiation and Heat Transfer in Laser-Powder Interaction Zone at Selective Laser Melting". *Journal of Heat Transfer , 131*, 072101.



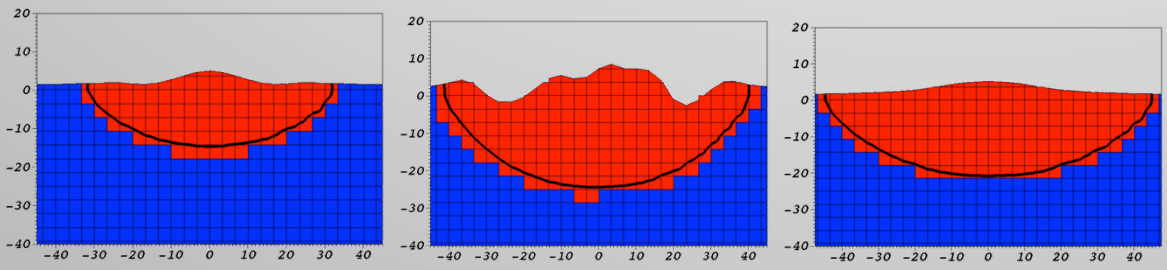
50% power 15 cm/s



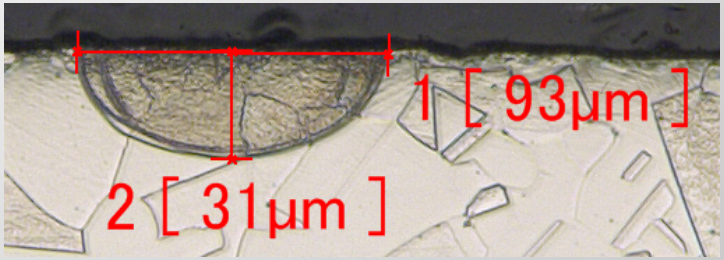
50% power 3 cm/s



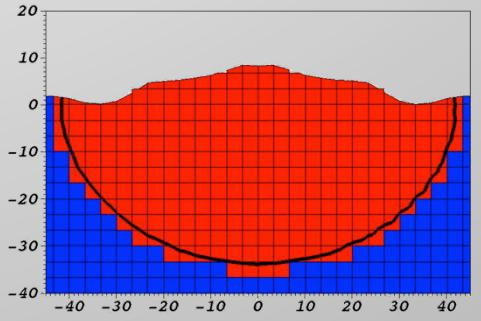
100% power 30 cm/s



LLNL **experiment** (uncertainty +/-5µm)



91 w 380 mm/s



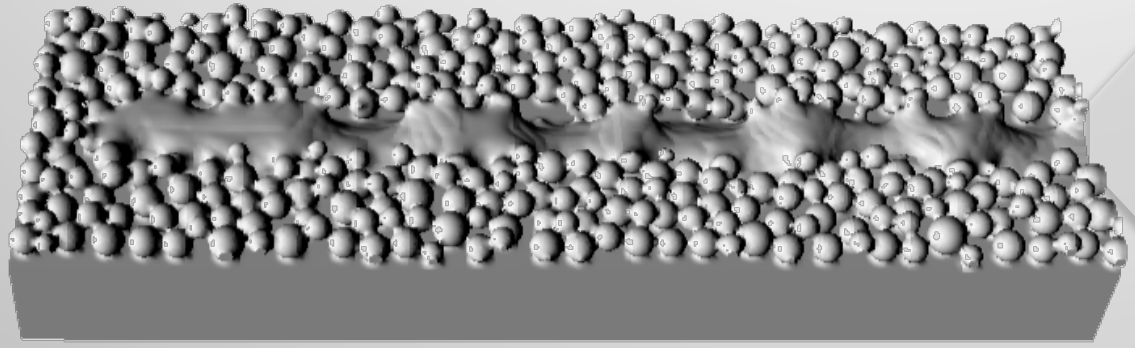
We match the bare plate melt pool dimensions well, although we consider an average value for the material absorptivity.

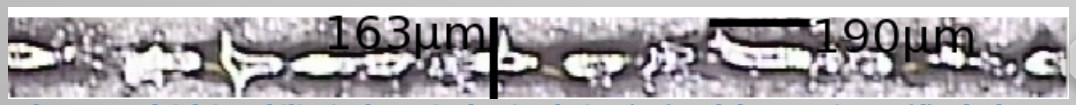
Khairallah, S.A., Anderson, A., 2014. "Mesoscopic Simulation Model of Selective Laser Melting of Stainless Steel Powder", Journal of Materials Processing Technology.

Model-2014 validation (no recoil or MARANGONI)

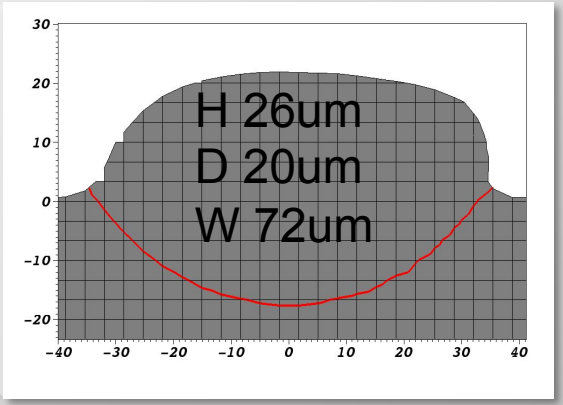
Khairallah, S.A., Anderson, A., 2014. "Mesoscopic Simulation Model of Selective Laser Melting of Stainless Steel Powder", Journal of Materials Processing Technology.

Simulation and experiment showing Plateau-Rayleigh instability

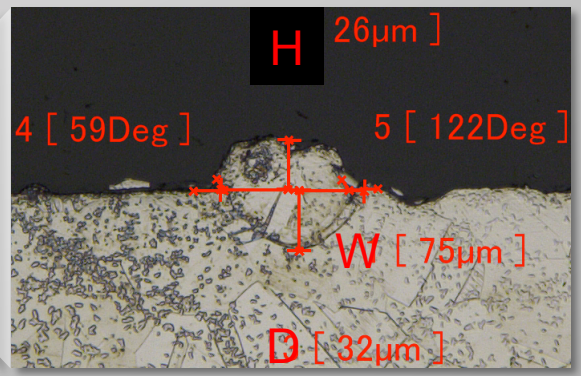




Melt pool profile



Experiment (uncertainty +/-5µm)



The simulation can predict well the main characteristics of the laser powder track

Model-2015 validation

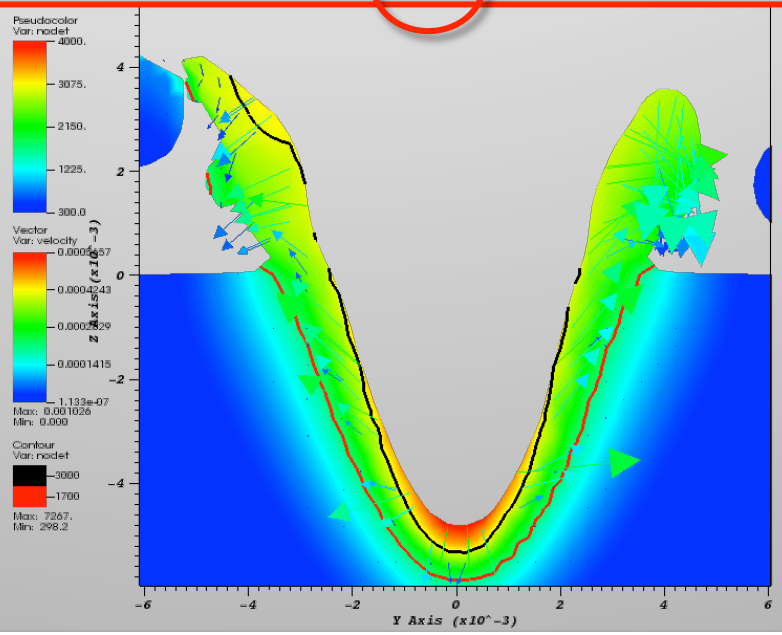
Table 3 The melt-pool width, height, and depth for the 14 tracks, along with the laser power and scan speed settings

Track number	Power (W)	Speed (mm/s)	Width (μm)	Height (μm)	Depth (μm)
1	400	1800	112	32	105
2	400	1500	103	79	119
3	400	1200	83	28	182
4	300	1800	94	57	65
5	300	1500	83	35	94
6	300	1200	111	76	114
7	300	800	118	54	175
8	200	1500	84	26	57

Melt pool profile

If Absorptivity is 0.4, then
Depth is 60um
Width is 80um

If Absorptivity is 0.3, then
Depth is 50um
Width is 74um



Depth and width calculations improved due to added physics

I would like to apologize for taking out some slides. The reason is these were submitted for publication in a journal.