Project 36G-L: Control of Microstructure During Additive Manufacturing of Ni Alloys

Spring 2022 Semi-Annual Meeting
Student: Ruben Ochoa (Mines), Faculty: Amy Clarke (Mines), Jonah Klemm-Toole (Mines), Industrial Mentors: Jeremy Iten, Elementum 3D

CANFSA
Center for Advanced Non-Ferrous Structural Alloys
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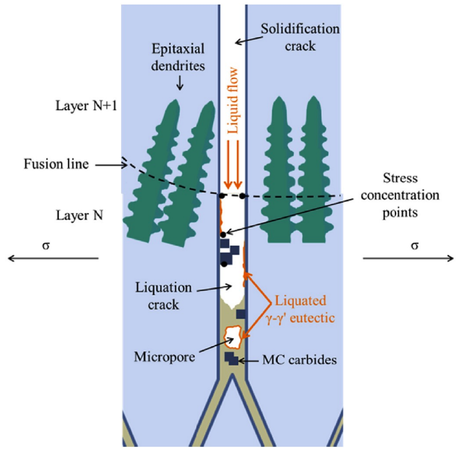
Background:

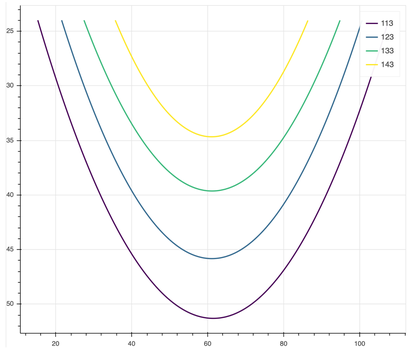
- Nickel based super-alloy weldability is dependent on γ', Ni_3(Al, Ti, Ta, Nb) content
- Eutectic has the lowest melting point, creating a liquidous film capable of rupturing under thermal residual stresses
- Larger solidification temperature range caused by $\gamma - \gamma'$ eutectic promotes hot cracking



Schematic diagram of hot cracking.
J. Xu et al., Journal of Alloys and Compounds, 2018, 749:859–870

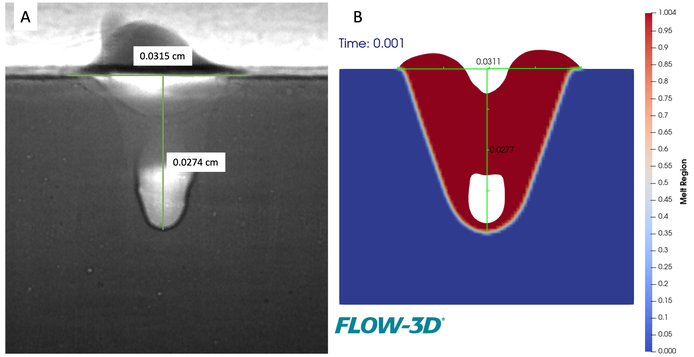
Procedures:

- Track solid/liquid interface of spot and raster melts by in-situ synchrotron x-ray radiographs
- Convert solid/liquid interface positions into velocities
- Simulate melt pools by computational fluid dynamics software, Flow3D, to model thermal gradients
- Compare grain morphologies as a function of base plate morphologies, powder conditions, and laser powder by EBSD

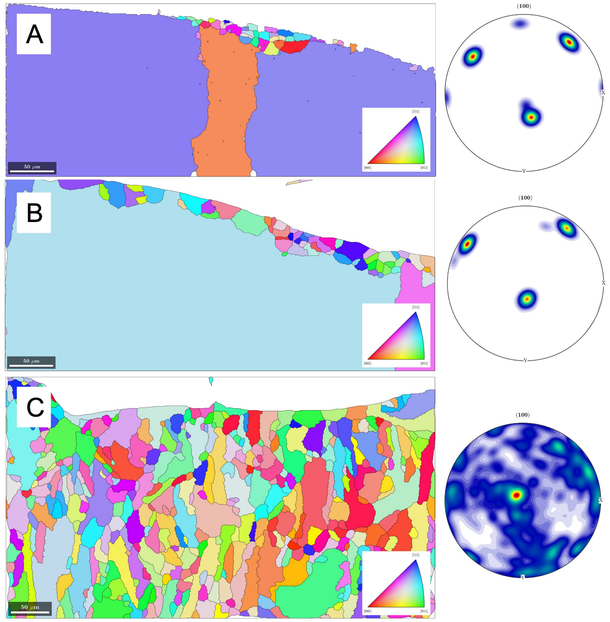


Relative pixel location of solid/liquid interface at various frames for Inconel 738 at 108 Watts.

Results:

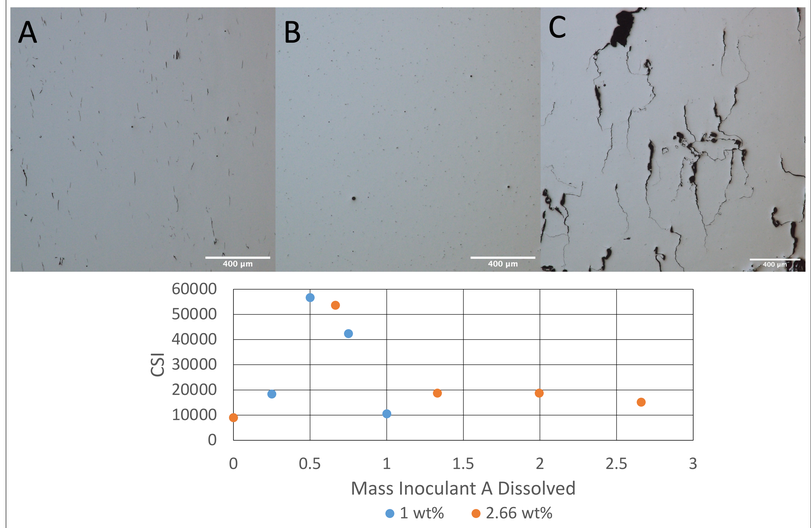


Dimensional comparison of synchrotron x-ray radiograph and simulated spot melt.



Inverse Pole Figure (IPF) map and Orientation Distribution Function (ODF) near the end of a raster of Inconel 718 under various conditions.

Results Continued:



Effects of Inoculant A dissolved into Haynes 230.

Future Work:

- Perform additional Flow3D simulations
- Simulate melt pools with powder layers
- Develop solidification processing maps and compare microstructural outcomes
- Create Columnar to Equiaxed Transition (CET) models for different alloys and perform validation with EBSD results

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