A study of melt pool dynamics and microstructure evolution of Inconel 718 single tracks manufactured through PBF-LB

Background

Powder Bed Fusion – Laser Beam (PBF-LB) is one of the additive manufacturing (AM) technologies commonly used to manufacture components for aerospace, medical and automotive applications. For a chosen material and PBF-LB machine, a window of processing parameters needs to be identified through experiments. However, such parameter optimizations are performed on a cube with a certain dimension (for ex: 10 mm). But the microstructure is highly dictated by the intensive local heating by a focused laser beam which creates a non-equilibrium microstructure through rapid solidification. And it can be interesting to study this isolated rapid solidification for melt pool dynamics, microstructure evolution and defect formation which is enabled by single track experiments. For instance, examination of the molten track morphology helps to understand how melt pool dynamics are changed by the laser processing parameters, and microstructural characterization of the cross sections of single tracks helps to understand how grains are oriented with respect to the laser scan direction and thermal gradient.

Description of the thesis work

Most of the thesis work will be dedicated to the characterization of single tracks printed with varied laser processing parameters, i.e., laser power, scan speed, hatch distance, and layer thickness, through optical microscopy and Scanning Electron Microscopy (SEM). The student will develop methodologies for evaluating the melt pool stability and link the observed trends in experiments to existing theories, i.e. Rayleigh instability, Marangoni flow, evaporation, etc. The printing process is also monitored by state-of-the-art online monitoring systems where thermal radiation from the single-track specimens during the L-PBF process can be extracted to help analyzing the results. At a later stage, the student will down-select a few samples out of the extensive sample matrix for in-depth microstructural characterizations using advanced techniques such as Electron-Backscattered Diffraction (EBSD) mapping.

Figure. Scanning Electron microscopy image of melt pools from single track (Courtesy: Dr Zhuoer Chen)
Organization

The thesis will be performed at the Department of Industrial and Material Science, which is hosting the competence center ‘Centre for Additive Manufacturing – Metal (CAM²)’ that involves a broad network of national and international companies.

Extent and time plan

30 hp master thesis project running from January 2023 to May 2023.

Qualifications

- Interest and curiosity in material science and additive manufacturing.
- Completed courses on additive manufacturing and phase transformations.
- Basic skills in image and data analysis.

Supervisor and Examiner

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