2020「中技社科技獎學金」

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Multiscale and Multiphysics Numerical Simulation in Powder-based Additive Manufacturing Technologies

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Abstract

Metallic Additive Manufacturing (AM) has begun to revolutionize many industries such as aerospace, automotive, and bio-medical engineering... However, extremely complex physical phenomenon behind the process are the biggest challenge in AM. Numerical simulation and system monitoring are the crucial keys to understand those phenomenon and to open the possibilities for AM to transform not only the manufacturing section but also how human fabricate things.

Research Focus

Laser Powder Bed Fusion (L-PBF)

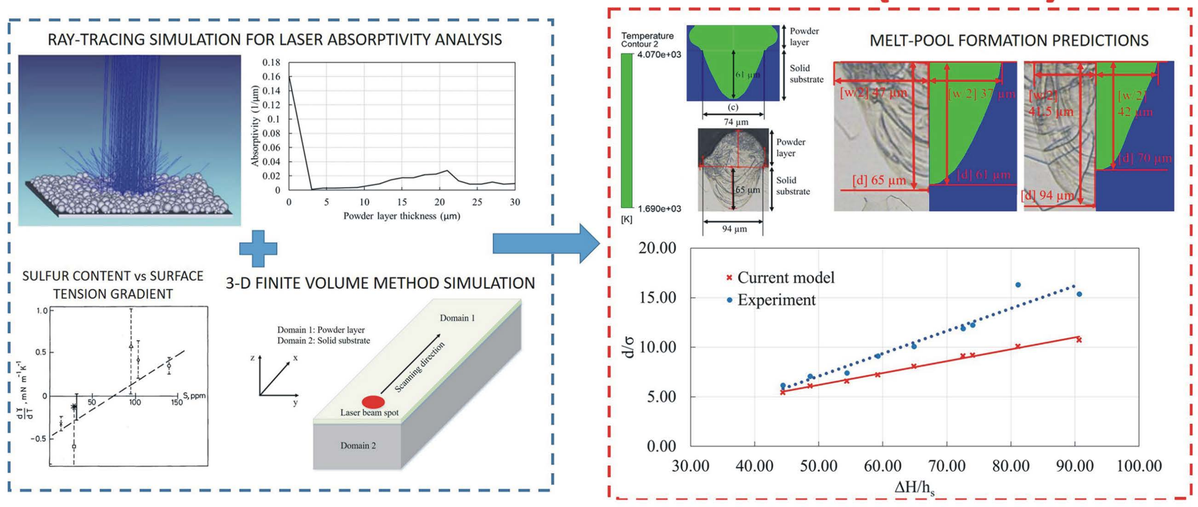

Fig. 1. Heat-and-mass transfer model for the melting and solidification in L-PBF process.

A highly comprehensive Computational Fluid Dynamics (CFD) model is constructed and run to predict the temperature field and the velocity field of the molten material during the process of L-PBF in order to predict the printability, calculate the cooling rates, and simulate the microstructure of printed parts.

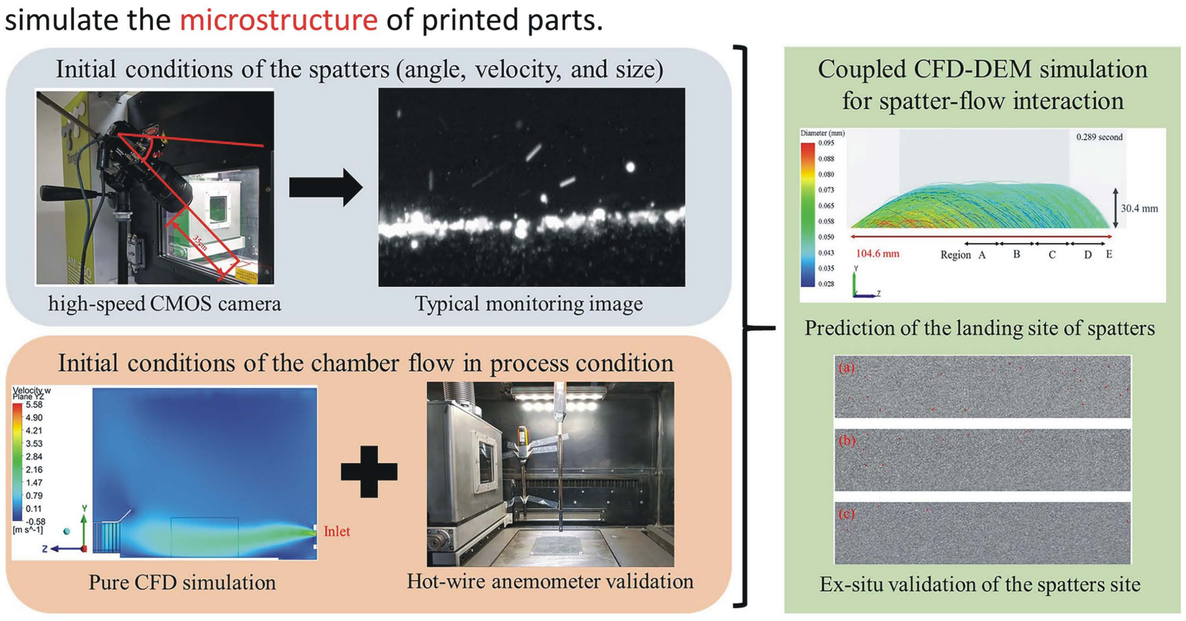

Fig. 2. Coupled CFD-DEM simulation to predict the trajectory of the generated spatters.

A multiphysics coupled Computational Fluid Dynamics (CFD) - Discrete Element Method (DEM) simulation is designed and run to study the interaction between the flow in the chamber and the spatter particles generated during the build process. The model is used to minimize the effect of spatters on the surface roughness and quality of the built parts.

Le, T. N., & Lo, Y. L. (2019). Effects of sulfur concentration and Marangoni convection on melt-pool formation in transition mode of selective laser melting process. **Materials & Design**, 179, 107866.

Le, T. N., Lo, Y. L., & Lin, Z. H. (2020). Numerical simulation and experimental validation of melting and solidification process in selective laser melting of IN718 alloy. **Additive Manufacturing**, 36, 101519.

Le, T. N., Lee, M. H., Lin, Z. H., & Lo, Y. L. (2020). Vision-based in-situ monitoring system for melt-pool detection in laser powder bed fusion process. **Under Review**.

Chien, C. Y., **Le, T. N.,** Lin, Z. H., & Lo, Y. L. (2020). Numerical and Experimental Investigation into Gas Flow Field and Spattering Phenomena in Laser Powder Bed Fusion Processing of Inconel 718. **Under Review**.

Electron Beam Melting (EBM)

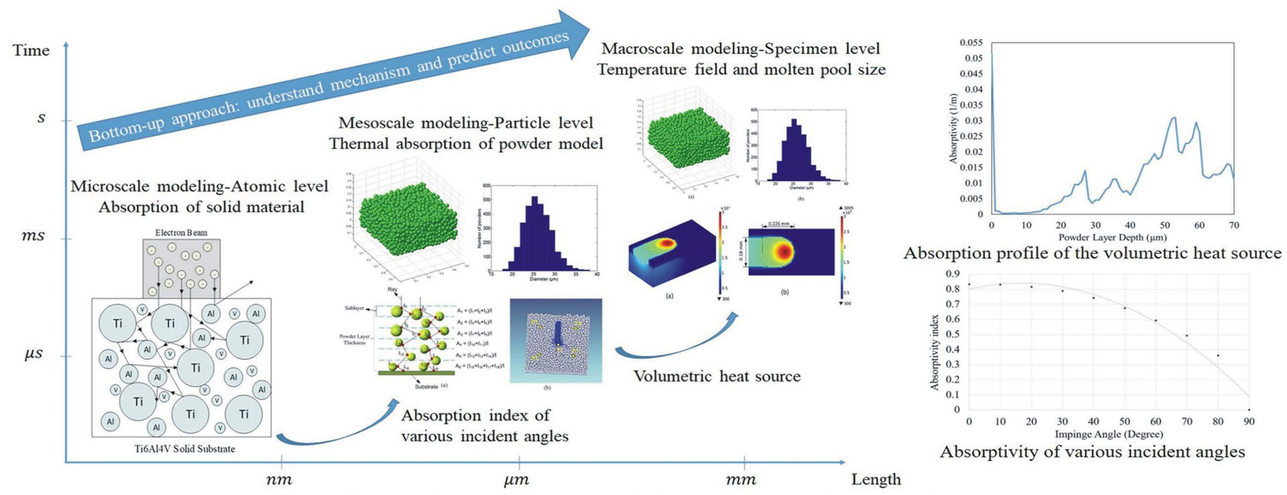

Fig. 3. Multi-scale simulation framework for single-track scan of EBM process.

A multiscale and multiphysics simulation framework is established to define a novel mathematical expression of the heat source from the electron beam in the EBM process utilizing ray-tracing simulations in both microscale and mesoscale. The framework is used to predict the printability, calculate the cooling rates, and simulate the microstructure of printed parts.

Le, T. N., Lo, Y. L., & Tran, H. C. (2019). Multi-scale modeling of selective electron beam melting of Ti6Al4V titanium alloy. **The International Journal of Advanced Manufacturing Technology**, 105(1-4), 545-563.

Direct Energy Deposition (DED)

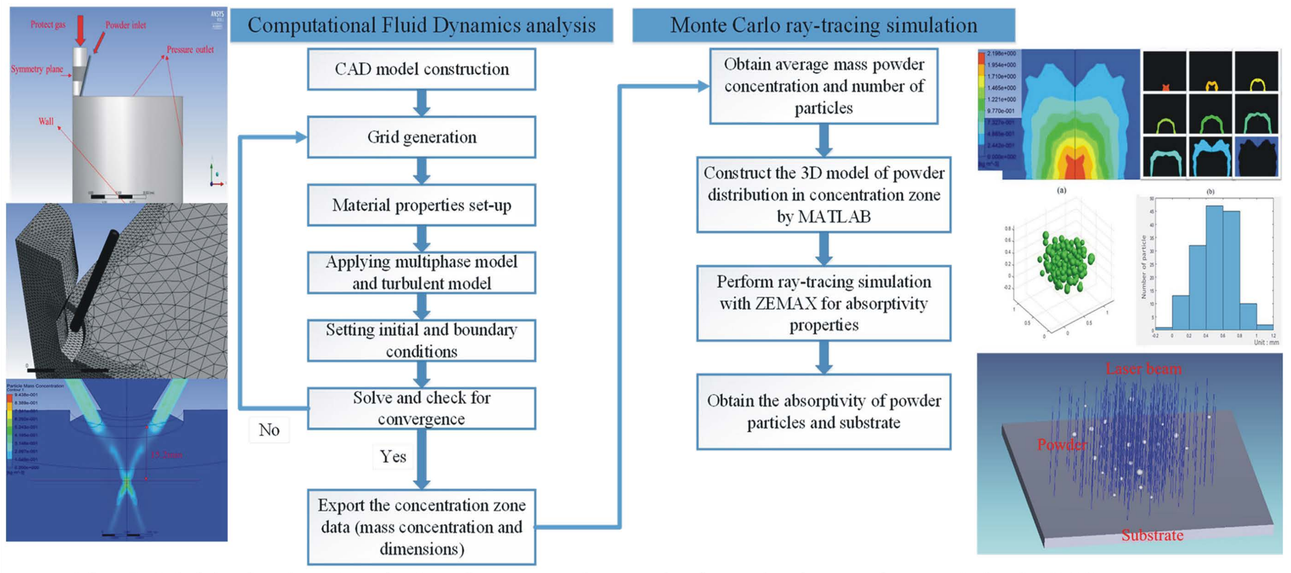

Fig. 4. Multi-physics simulation framework to calculate the laser absorptivity in DED process.

A multiphysics simulation framework utilizing CFD, DEM, and ray-tracing to define the laser heat source for the DED process. The framework is used to calculate the laser absorptivity of the flying powder particles and the calculated absorption is then used for a heat-and-mass transfer simulation for melting and solidification modelling.

Jhang, S. S., Lo, Y. L., & **Le, T. N.** (2019). Systematic modeling approach for analyzing the powder flow and powder energy absorptivity in direct energy deposition system. **The International Journal of Advanced Manufacturing Technology**, 105(1-4), 1765-1776.

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