DATA INFORMATICS AND MACHINE LEARNING TECHNIQUES TO OPTIMIZE ADDITIVE MANUFACTURING

Additive manufacturing (AM) of metallic materials is a rapidly maturing technology that has captured the attention of academia and industry alike. Building layer-by-layer, AM can produce structural parts with arbitrarily complex shapes and spatially varying composition (functionally graded materials), providing an unparalleled freedom in design. However, because AM combines materials synthesis and part production into a single step, exercising the microstructural control that is required to produce components with consistent mechanical properties has proven elusive. Relying on consistency in composition and processing conditions, the classical process-structure-properties (PSP) triangle of materials science has historically drawn connections between process conditions and microstructure, between microstructure and properties, and vicariously between process and properties. Directly relating process and properties has relied on intuition and experience developed over years of heuristic observations. But because each set of build parameters, e.g. feedstock, part geometry and build order – in short, each AM process – is unique, no two designs will experience the same processing conditions, such as thermal history, obfuscating these already opaque relationships. These highly non-equilibrium conditions vary from design-to-design, from part-to-part, and even vary within the part itself to produce highly disparate, spatially varying microstructures. A full understanding of the interplay across hierarchical microstructures is, and will continue to be, an ongoing effort, but enabling manufacturability of AM parts will require a way of connecting process to properties more directly. This presentation will discuss the ongoing efforts to build the infrastructure, characterization techniques, data informatics and machine learning tools developed in the ADAPT Advanced Characterization Center to directly identify the process-structure-property relationships for additively manufactured metals.

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THURSDAY

Jan. 26

4:00PM

HH 202

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Metallurgical & Materials Engineering
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