Linking Process, Structure, and Property in Additive Manufacturing Applications through Advanced Materials Modelling

Wing Kam Liu*, Puikei Cheng*, Orion L. Kafka*, Wei Xiong, and Jacob Smith***

*Department of Mechanical Engineering
Northwestern University
2145 Sheridan Rd, Evanston, IL 60208-3111, USA
e-mail: w-liu@northwestern.edu

**Department of Materials Science and Engineering
Northwestern University
2220 Campus Dr, Evanston, IL 60208-3111, USA

ABSTRACT

Additive manufacturing (AM) processes have the ability to build complex geometries from a wide variety of materials. A popular approach for metal-based AM processes involves the deposition of material particles on a substrate followed by fusion of those particles together using a high intensity heat source, e.g. a laser or an electron beam [1], in order to fabricate a solid part. These methods are of high priority in engineering research, especially in applications for the energy, health, and defense sectors. The primary reasons behind the rapid growth in interest for AM include: (1) the ability to create complex geometries which are otherwise cost-prohibitive or difficult to manufacture, (2) increased freedom of material composition design through the adjustment of the ratios of the composing powders, (3) a reduction in wasted materials, and (4) the fast, low-volume, production of prototype and functional parts without the additional tooling and die requirements of conventional manufacturing methods. However, the highly localized and intense nature of these processes elicits many experimental and computational challenges. These challenges motivate a strong need for computational investigation, as does the need to more accurately characterize the response of parts built using AM. The present work will discuss these challenges and methods for creating multiscale material models that account for the complex phenomena observed in the AM production environment. The linkage between process, structure, and property [2] of AM components, e.g., anisotropic plastic behavior [3,4] combined anisotropic microstructural descriptors afforded through enhanced data compression techniques, will also be discussed.

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