In-situ microscopy of laser melting processes in 316 stainless steel powders

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Abstract

Additive manufacturing (AM) of metals is a rapidly evolving field with emerging nuclear, aerospace, and electronics applications. Frequently, technological and application development outpace relevant materials science discoveries in spaces such as laser powder bed fusion (LPBF). *In situ* and *operando* microscopy of solidification and solid-state phase transformations during and following laser beam interactions offer promise for filling the scientific knowledge gaps in LPBF. We present here techniques aimed at rapidly understanding some of the fundamental physical, chemical, and morphological changes associated with LPBF by employing *in situ*, *operando*, and *ex situ* observations of laser material interactions via electron microscopy. The combination of *in situ* laser irradiation in a scanning electron microscope (SEM) and scanning transmission electron microscope (TEM) allows for direct observation of sintering, melt pool dynamics, phase transformations, and morphological anomalies over length scales ranging from millimeters down to angstrom level. We present data on our chosen model system of 316 stainless steel powders showing *in situ* observation of the effects of particle size, distribution, packing, laser fluence, and effective scan rates on melt pool formation dynamics. Melt pool modeling capabilities will be presented to aid in understanding the primary factors that influence melt pool geometry and how these may affect printed metal morphology.

Biography

Steven Randolph received a PhD in Materials Science and Engineering from the University of Tennessee, Knoxville in 2005. While there, he investigated mechanisms involved in focused electron beam induced deposition and etching. In 2007 he joined the Beam Chemistry group of the FEI Company in Oregon. There, he worked to develop new chemistries and applications for focused ion beam induced chemistry, developed a system to study *in situ* ultrashort pulse laser interactions in DualBeam FIB/SEM. In 2021, he assumed the role of group leader for the Nanofabrication Research Laboratory in the Center for Nanophase Materials Sciences at ORNL where he studies electron, ion, and photon induced surface chemistry and nanofabrication.