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Imaging of AFSD Al 6061 and a 6061-TiN MMC

Additive friction stir deposition (AFSD) is a rapidly developing additive manufacturing (AM) process which is derived from friction stir welding (FSW). Unlike fusion-based AM methods which involve melting, AFSD is a solid state process which relies on heat generated during plastic deformation, reaching 60-90% of the deposited material's melting temperature. Solid state processes avoid problems encountered during solidification, can utilize commercially available feedstock, and can build parts at a higher rate and larger scale than fusion-based AM. However, AFSD equipment has only become commercially available within the last 5-6 years, and the challenges for industrial utilization of AFSD are still being discovered. Feedstock composition, toolhead rotation speed, deposition track (direction and travel speed), and the resulting temperature distribution affect plasticity of the deposit, and consequently microstructure development and texture in the printed part. This can result in bulk heterogeneity and anisotropy of mechanical properties in the printed part. This work explores structural heterogeneity in AFSD alloys and metal matrix composites (MMCs) printed with this new AM technology, which varies over micrometer to centimeter length scales along the build directions of the deposition. We are investigating processing-structure-property-performance relationships, aiming to correlate microstructure and mechanical property variations throughout the layers of the build. The penetration depth of neutron imaging, paired contrasting lubricant and composite particles, will indicate how these secondary phases are distributed by friction stir process at a length scale commensurate with part size. These results demonstrate successful use of neutron imaging and computed tomography to quantitatively analyze composite particle mixing through a bulk part. Understanding interlayer mixing behavior with and without a composite particle in AFSD Al6061will lead to better understanding of material flow, plasticity, and recrystallization behavior during deposition.

Topical Area

Emerging research and multimodal techniques

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