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Metal Matrix Composites Fabricated by Solid State Additive Manufacturing

R. Joey Griffiths, Thomas Glenn, Chase Cox, Jenny Sietins, Hang Yu

MSE Virginia Tech, Army Research Lab, MELD Manufacturing

Abstract

Metal matrix composites (MMCs) consist of a metal matrix with a reinforcement phase, often in the form of a particle or fiber. MMCs boast higher strengths and wear resistances than their plain metal counterparts, but at the cost of difficult processing and generally lower ductility. A unique Aluminum-Molybdenum MMC was fabricated using a new additive manufacturing technique called Additive Friction Stir Deposition (AFSD), commercially known as MELD. While AFSD typically uses solid metal feed rods, but can be adapted to print composites in a number of ways. Metals and composites printed with AFSD exhibit hot worked microstructures, similar to those in friction stir welding or processing. The high temperatures, stresses, and strain rates can lead to mechanically induced mixing and change in phases and precipitates in different metal systems. Upon investigation, the aluminum-molybdenum composite was found to contain a large volume percent of submicron intermetallic particles, upwards of 50% by volume, and no observable porosity. Mechanical testing revealed an average hardness of 357 HV and an ultimate flexural stress of 550MPa in the composite, while also retaining relatively good ductility. Through this composite system, AFSD is demonstrated to be a valuable process, capable of making fully dense composites on a large scale. Findings from this study could prompt research and applications in solid state alloying, composite manufacturing, surface coatings, and processing of non-equilibrium materials.

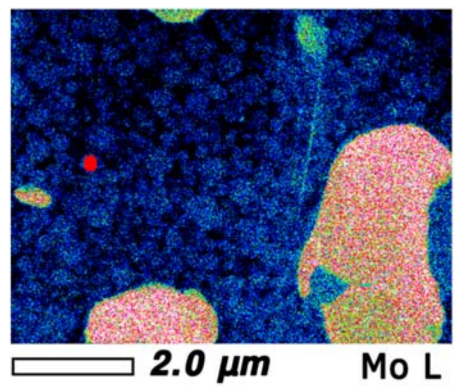
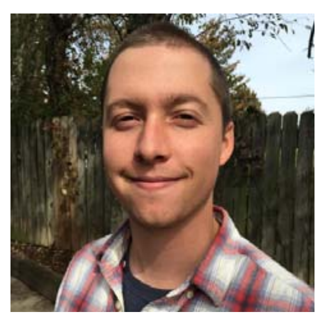


Figure 1: EDS Map of molybdenum in Aluminum-Molybdenum MMC

Biography



Joey Griffiths is a graduate student pursuing a PhD. in Materials Science and Engineering. He completed his undergraduate studies at Virginia Tech, earning a B.S. in Materials Science and Engineering. Joey began an accelerated Master's degree program working with Dr. Hang Yu during his senior year of undergraduate study in 2017, and continued the work, transitioning to a direct PhD track in 2018. He expects to complete his PhD. by 2021 Joey's work focuses on metal and composite additive manufacturing, specifically using the Additive Friction Stir Deposition process. His author and co-authorships include papers on metal and composite additive manufacturing. Joey's current work revolves around microstructure and property control and utilization in additively manufactured metal parts, focusing on material systems including aluminum alloys, copper, nickel aluminum-bronzes, and high entropy alloys.