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Thermophysical property characterization of aerospace alloys for modeling In-Space Manufacturing processes (Appendix I: Modeling of Manufacturing Processes in Micro and Reduced Gravity Environments)

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This proposal is in response to the FY2021 NASA EPSCoR Rapid Response Research Opportunity Appendix I: MSFC EPSCoR Research Areas, and Tasks: Modeling of Manufacturing Processes in Micro and Reduced Gravity Environments (EM04/Prater).

Several methods of additive manufacturing (AM) are currently under investigation for application in micro- and reduced-gravity environments including bound metal deposition (BMD), wire+arc AM, and laser-based fusion methods. All of these methods include either the generation of a melt pool or surface wetting of the metal alloy feedstock to facilitate generation of the desired geometry. The evolution of the liquid phase, in-turn, is influenced heavily by the gravitational field, with samples undergoing distortion relative to the gravitational environment. Studies of gravitational effects on liquid phase sintering of tungsten heavy alloys in microgravity (STS83 and STS94 missions) found that samples that distort in ground-based sintering also undergo distortion in microgravity, however, the samples tended to form spherical shapes. Efforts to model these manufacturing processes therefore rely heavily on available thermophysical, surface energy and interfacial energy property data. Given the availability of these difficult to measure data, the influence of the local gravitational field can then be predicted relative to: buoyancy effects; the formation of solid-liquid and liquid-vapor interfaces; microstructural segregation; particle agglomeration; and parts deformation.

The proposed project will support ISM modeling through the measurement of thermophysical (melting range, density, viscosity) and surface and interfacial energies of several aerospace alloys of interest for ISM applications, namely Al7075, Ti-6Al-4V, and SS316L. Measurements will be conducted via electrostatic levitation (ESL) and high temperature (up to 1800 C) contact angle measurements. In addition, we will use high-temperature differential scanning calorimetry (DSC)/thermal gravimetric analysis (TGA)/thermal diffusivity (Hyperflash), and dilatometry to measure specific heat, enthalpy of fusion, melting range, melting enthalpy, thermal conductivity, and thermal expansion coefficient for generation of a comprehensive data set.