Tailoring Microstructure and Compressive Strength of Aluminum High Entropy Alloy Powder for Cold Spray Deposition

Denny John[a], Bryer C. Sousa[b], Tanaji Paul[a], Sohail M.A.K Mohammed[a], Danielle L. Cote[b], Arvind Agarwal[a]

[a] Cold Spray and Rapid Deposition Laboratory (ColRAD), Department of Mechanical and Materials Engineering, Florida International University, 10555 West Flagler Street, Miami, FL 33174, United States

[b] Materials and Manufacturing Engineering Program, Department of Mechanical and Materials Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609-2280, United States

The absence of understanding of thermal evolution and its effect on microstructure and compressive strength of amorphous/nanocrystalline Aluminum High Entropy Alloy (Al HEA) powder limits the development of high-strength cold spray deposits. In this study, gas atomized (GA) Al HEA powder ($Al_{90.05}$-$Y_{4.4}$-$Ni_{4.3}$-$Co_{0.9}$-$Sc_{0.35}$ at. %) is devitrified at 298, 362 and 450^{o}C. Devitrification induced atomic rearrangement in the amorphous/nanocrystalline matrix to develop equiaxed Al grain and precipitates such as Al_3Ni and Al_3Sc. Equiaxed grain size increased from 0.2 µm at 298^{o}C to 0.3 µm at 450^{o}C. The evolution of grains and hard precipitates increased the hardness by 19% to 515 HV at 298^{o}C and decreased by 55% to 190 HV at 450^{o}C. The tailored hardness increased the compressive strength of GA powder by 5% to 1559 MPa at 298oC and decreased by 49% to 760 MPa at 450^{o}C. To enhance the limited sprayability of this Al HEA powder, compressive strength is used to model optimized cold spray process maps. This microstructural and strength tailoring advances the cold spray state-of-the-art for manufacturing bulk high-strength Al deposits.

Keywords: Heat treatment; Amorphous Alloys; Nanoindentation; Single Particle Compression