Cold Sprayable Metal-Matrix Composites for Mechanical and Electrical Applications

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Metal-matrix composites (MMCs) are integral in modern society due to their superior multifunctional properties. As an emerging field, MMCs development using cold spray remains challenging. Issues include poor inter-particle bonding, delamination from the substrate, and poor mechanical properties. If these challenges are carefully addressed, we can efficiently utilize the untapped potential of cold spray for fabricating scalable MMCs. We are fabricating cold sprayable titanium (Ti)-silicon (Si)-graphite (C) composites as model systems to address these issues. The addition of Si helps improve the wear resistance, while Ti and C help improve electrical conductivity.

We successfully deposited Ti-Si-C composites (>100 layers and 5 mm thickness) on mild steel substrates. A homogeneous feed powder mixture was prepared using pure Ti, Si, and C powders. We then optimized the feed powder temperatures and pressures and studied the mechanical properties. At 600ºC and 800 psi, we obtained uniaxial tensile strength (UTS) and uniaxial compressive strength (UCS) of 78.9 and 646.1 MPa, respectively. Next, we added aluminum (Al) as an additional reinforcing material and increased the feed powder temperature to 650ºC. Interestingly, Al helped form a compact coating and simultaneously improved mechanical properties. The UTS and UCS increased to 144 and 810 MPa, respectively, in the Ti-Si-C-Al system. These composites exhibit a slightly lower electrical conductivity (1.1×10^6 S/m) than pure Ti (1.6×10^6 S/m). Research is underway to improve mechanical and electrical properties by tuning the elemental composition. These materials are potential candidates for mechanical and battery applications.