Hybrid Bond Layers for Cold Spray Nb Metallization of CFRP Surfaces

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To metallize non-metallic substrates by cold spray, a hybrid metal-polymer bond layer (BL) is introduced to reduce substrate erosion, and to mitigate the disparate properties of substrate and deposit. The objective of this project is to determine the effects of particle impact velocity on the adhesion of Nb onto carbon fiber reinforced polymer (CFRP) with a BL. Deposit structure and adhesion depend on the particle impact velocity, which affects the extent of mechanical interlocking, depth of penetration, and crack propagation. Lug shear tests revealed that the greatest bond strength was associated with the lowest spray pressure. To understand the underlying mechanism of this, stress, strain, and temperature fields during deposition are investigated by using finite element analysis (FEA). Coupled Eulerian-Lagrangian (CEL) method was used for the numerical model. The initial impact state of the particle was calculated with one-dimensional computational fluid dynamic (CFD) simulations and subsequently used in the FEA. A constitutive model that depends on temperature and strain rate was used to create a homogenized model of a polymer domain containing Al microparticles. This model used an advanced three-network model which was calibrated by Split Hopkinson Pressure Bar (SHPB) tests at different temperatures and strain rates. Both experimental and numerical results indicate that excessive impact velocity leads to damage accumulation in the polymer domain, resulting in a decrease in bond strength. Composite metallization by cold spray can impart resistance to erosion and impact, increased conductivity, and facilitate component restoration.