Mechanics of Acceleration and Impact of Polymer Particles for Cold Spray Application

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The goal of this work was to investigate the mechanics and material response of polymer particles during high velocity impacts to ultimately achieve polymer cold spray coatings. Experiments were conducted by using a unique experimental setup known as the laser-induced projectile impact tester (LIPIT) which can accelerate a single spherical microparticle towards a substrate, and can record the acceleration, free-flight, impact and rebound or bonding phases of the particle by using high speed photography. All four phases of the LIPIT process were simulated by using appropriate polymer mechanic models, and interaction physics by using the commercially available finite element code Abaqus. Experiments and simulations revealed the complex material response during the all four phases unique to the LIPIT setup and polymers. In the acceleration phase, experiments showed that polymer particles experience significant permanent deformation. Measured and simulated particle shapes during flight reveal interesting and unintuitive mechanics including the amount of residual stress develops during flight before the impact. In the impact phase experiments revealed that like metal particles, polymer particles also have lower and upper bounds of critical bonding speed. Particle bonding was modeled by using the cohesive zone model (CZM) in impact simulations. Bonding energy levels were thus quantified.