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Peening-Induced Densification and Bonding Behavior at Subcritical Particle Impact Velocities in Cold Spray

Abstract
In cold spray deposition, particle rebound and in situ shot peening can induce pronounced plastic deformation, which contributes to coating densification and improved mechanical properties. To explore the role of accumulated strain, this study examines pure aluminum and copper coatings produced under a wide range of spray parameters. The study combines mechanical testing and microstructural analyses, evaluating deposition efficiency, coating strength, porosity, and hardness, while also assessing particle deformation and grain orientation through EBSD. The results demonstrate that even at low particle impact velocities, associated with reduced deposition efficiencies, coatings exhibited negligible porosity and high cohesive strength, in some cases surpassing those obtained at higher velocities. Consistent with the low deposition efficiencies, single particle impact tests confirm that particle bonding events were rare at subcritical velocities. This indicates that coating microstructures are mainly determined by cumulative peening effects, as rebounding particles induce interfacial strain, disrupt surface oxides, and enable localized metallic bonding around embedded particles. In addition, variations in traverse speed revealed a clear influence of process temperature: Slower traverse speeds, associated with higher thermal input, generally led to increased coating strength, particularly under high-velocity impact conditions. These findings not only provide strategies for improving coating quality but also deepen the understanding of bonding mechanisms in the low-velocity impact regime of cold spray.

Biography
Levke Wiehler has been a research associate and PhD student in materials engineering at the Helmut Schmidt University in Hamburg, Germany, since 2021. Her research focuses on cold spray of pure metals.