Contribution ID: **8** Type: **Invited Talk**

The effect of substrate temperature in laser-induced high velocity micro-particle impacts

Thursday, November 7, 2024 11:30 AM (25 minutes)

The impact of microscale particles with a surface is of fundamental importance in surface coating technologies such as laser-induced forward transfer or cold spray. Successful bonding between the particles and the substrate requires impact velocities higher than the so-called critical adhesion velocity. Previous experimental and theoretical results showed that the critical velocity is a function of numerous factors. Among them, the substrate temperature is important since substrate deformation and rupture of the oxide on the substrate through such deformation are critical to forming metallurgical bonds with the particle. Herein we conducted single-particle impacts on a variable-temperature substrate for three systems (Al–Al, Sn–Sn, and Ti–Ti) with particles individually selected within a narrow size distribution. The experimental investigations were carried out using an in-house-designed all- optical platform known as laser-induced particle impact test (LIPIT).

Our results show a downward shift of the critical velocity for each material combination, by a significant amount, which we attribute to the lower dynamic strength of the thermally softened substrate. Our experimental results are in good agreement with numerical simulations, where we predict the dependence of bonding window and the critical velocity in function of substrate temperature. The results support literature trends that a higher substrate temperature can compensate for a lower particle velocity, which may speak to improved procedures for particle deposition in cold spray or laser-induced forward transfer technology.

Type of presence

Presence online

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Session Classification: Advances in Nonlinear Optics and Laser-Matter Interactions