High deposition rate wire-based laser directed energy deposition of millimetre-scale features

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Wire-based laser directed energy deposition (DED) exhibits promising advantages on low feedstock costs [1], up to 100% material utilisation [2], cleaner process [3], better surface finish [4] and easier for fabricating multi-material structures [5] when compared with powder bed systems. This study reveals the possibility of fabricating defect free, smooth surface appearance, and millimetre-scale features using 3 kW of laser power with a relatively large beam diameter [6] of 3 mm. This can be done at a high deposition rate of 400 g/h. It was found that using a larger beam size can enhance the chance of deposition success due to enough specific point energy applied, a relatively lower but even distribution of the power density, and less energy discrepancy projected on wire and substrate, as a result, reducing the possibility of undercuts and lack-of-fusion defects appearing, thus, increasing the chance of feeding more material in the melt pool. At the same time, a reduction in the wire position sensitivity enables the possibility of reaching 750 g/h of the deposition rate and the feasibility of submillimetre-scale features fabrication. The plume was observed during the whole deposition process due to the ease of evaporation of the small size of the wire used and the high-level laser power applied, however, because of the smooth surface and continuous bead appearance, the good deposition performance was not affected by the plume. This implies that wire-based laser DED is capable of manufacturing millimetre-scale features with good performance at relatively large beam sizes and competitively high deposition rates to satisfy the rapid manufacturing requirements in additive manufacturing.

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