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Building metallic glass structures on crystalline metal substrates by laser-foil-printing additive manufacturing

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ABSTRACT

In laser-foil-printing additive manufacturing, 3D metallic glass structures can be built by laser welding of amorphous foils, layer by layer, upon a crystalline metal substrate. In this paper, weldability studies for laser welding of $Zr_{52.5}Ti_5Al_{10}Ni_{14.6}Cu_{17.9}$ amorphous foils onto a Ti-6Al-4V (Ti 6-4) or Zr 702 substrate are conducted. After laser welding, the weldments are analyzed using X-ray diffractometer, optical microscope, scanning electron microscope equipped with energy dispersive spectroscopy and micro-hardness tester. The results show that Zr 702 is a suitable substrate for Zr-based metallic glass structure since crack-free weld joints can be obtained owing to the formation of ductile α-Zr, while Ti 6-4 is not an appropriate substrate since it has high cracking susceptibility due to the formation of a large amount of hard and brittle intermetallics near the foil-substrate interface. It was found that the mixing between melted substrate and foil is not uniform but exhibits a distinct "swirl" pattern. The swirl structure is more pronounced in Ti 6-4 than in Zr 702 substrate which may contribute to its high cracking susceptibility. The aforementioned mixing leads to partial crystallization of the first amorphous layer; however, fully amorphous is achieved in the additional welding layers.