In-Situ Tensile Test Revealing Strain Evolution and Deformation Mechanisms of Wire-Arc Direct Energy Deposited (WDED) Single α-Phase Ti

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Abstract

The complexity of thermal history during Wire-arc Direct Energy Deposition (WDED) of commercially pure titanium (cp-Ti) leads to microstructural inhomogeneity. The inherent hexagonal closed-packed (HCP) structure of titanium is anisotropic and exhibit multiple deformation mechanisms simultaneously or sequentially when subjected to stress. A combination of advance imaging techniques was implemented to capture them in real time. In this study, *in-situ* digital image correlation (DIC) coupled with local crystal orientation measurements by using the electron back scattered diffraction (EBSD) are performed to study the deformation characteristics of the α-Ti WDED. Quasi *in-situ* tensile tests were precisely performed scrutinizing the grain dependent variants of twin deformation guided by the crystal orientation. Strain maps obtained by DIC have elucidated the elasto-plastic deformation of individual layers along the buildup showing a heterogeneous distribution attributed to the distinct grain morphology. These findings elucidate the inherent deformation mechanisms along with strain distribution and offer theoretical directives for the advancement of large-scale additive manufacturing of high strength structural materials.