Location Dependent Texture Development in Ti-6Al-4V Thin Walls during Wire-feed Directed Energy Deposition

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Abstract

The application of additively made Ti-6Al-4V material in various structural aerospace components frequently requires it to be shaped into thin-wall structures. However, these Ti64 thin walls are mechanically anisotropic due to the inherent texture development through variant selection during $\beta \rightarrow \alpha$ transformation in the layer-by-layer additive manufacturing process. So, in this study, EBSD (Electron Back Scattered Diffraction) technique was employed to investigate variant selections, location dependent microtexture, and macrotexture in the wall specimens. The reconstructed map of β-Ti parent phase according to the Burger's crystallographic orientation relationship revealed columnar grains with clear (001)β fiber textures oriented to the build direction. The presence of a strong (001)β fiber orientation (typical of cubic solidification) was found to correlate with (01-12)α fiber texture in the as-built condition. The (-12-10)α and (-12-13)α fibers were also found to be oriented to the build direction. The volume fraction (01-12)α and (-12-10)α fibers decreased, while the (-12-13)α fiber volume increased with wall height. Moreover, the intensity and orientations of the alpha texture exhibited a weak correlation with the cooling rates in the walls. The variant analysis in the single as well as multiwalls showed that a strong variant selection exists with a preferred selection of Type 2, < 11-20> / 60 variant. However, the variant selections differed in the specific locations of the wall, notably in the white bands and transient regions. The major underlying mechanism of variant selection was determined to be the self-accommodation to compensate strain for the $\beta \rightarrow \alpha$ solid state phase transformation. The microtextured regions (MTR) were identified along the prior beta grain boundaries and the criteria for the formation of MTR was attributed to the crystallographric orientations of the grain boundary α. Furthermore, the estimated Schmid factor of α variants for prismatic slip systems were correlated to explain the anisotropy of the wall.

Keywords: Ti6Al4V, Thin Walls, Directed Energy Deposition (DED), Electron Back Scattered Diffraction (EBSD), Texture, Variant Selection, Microtextured Region (MTR), Schmid Factor (SF), Anisotropy

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