A nanoindentation based investigation of the local deformation mechanism of additively manufactured Ti6242 alloy

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Abstract

The rate sensitive deformation mode of titanium alloys is of significant importance for the evaluation of its dwell fatigue performance. Dwell sensitivity arises due to the stress relaxation phenomenon during the stress hold. In the case of titanium and its alloys, it is common at room temperature as well. Dwell sensitivity of titanium alloy depends on the stress state, composition, microstructure and texture. The strain rate sensitivity and its correlation with the dwell sensitive behaviour of non-additively manufactured Ti and its alloys has been widely studied in the recent past. The role of Mo content on the slip activity of "soft-hard" oriented grain pair basically controls the dwell sensitivity. On the other hand, additively manufactured titanium alloys exhibit very complex microstructure consisting of multiple phases with various morphologies and texture at the nanometric scale of resolution. Therefore, it is essential to understand the nano-mechanical behaviour of such alloys in order to rationalise its macro-mechanical properties. In the present investigation, continuous stiffness measurement (CSM) using nano-indentation technique has been employed to measure the hardness and strain rate sensitivity parameter of additively manufactured Ti-6Al-2Mo-4Zr-2Sn (Ti6242) alloy. The measured nano-mechanical response and the calculated strain rate sensitivity (SRS) parameters have been interpreted based on local microstructure, composition and micro-texture using scanning transmission electron microscope (STEM), electron probe micro-analyser (EPMA) and electron backscatter diffraction (EBSD) respectively. Very interestingly, the chemical homogeneity of the microstructure lead to mechanical heterogeneity. Rather, the presence of the martensite phase and formation of the stress-induced nano-twins in the additively manufactured Ti6242 has been found to influence its nano-mechanical behaviour in a completely different way compared to the non-additively manufactured Ti6242.

Keywords: Nanoindentation, additive manufacturing, strain rate sensitivity, STEM

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