Contribution ID: **142** Type: **Invited talk (30 min + 5 min discussion)**

Utilizing in-situ characterization techniques to probe the heat treatment response and micromechanical performance of LPBF processed and heat-treated Ti-6Al-4V

Thursday 5 December 2024 13:05 (35 minutes)

Ti-6Al-4V is the workhorse among all titanium alloys that are processed by solidification-based AM technologies. Its popularity resides from its interesting combination of quasi-static and dynamic mechanical properties, and its relatively low density, making it a candidate material for lightweight applications.
The structural performance of L-PBF processed Ti-6Al-4V parts, however, is heavily affected by the formation of a martensitic phase during rapid cooling, its partial decomposition during sequential heating and cooling cycles and a macroscopic internal stress distribution within L-PBF processed Ti-6Al-4V parts.
Martensite decomposition and stress relaxation behaviour in L-PBF processed Ti-6Al-4V is investigated using in-situ dilatomettry, allowing to inductively heat a sample while being irradiated by synchrotron X-rays, enabling to simultaneously measure the thermal expansion, phase fraction and internal stress evolution of an LPBF processed Ti-6Al-4V during heating and cooling.
The micromechanical behaviour of as-built and heat-treated two-phase Ti-6Al-4V samples is compared, both in the elastic and plastic regime, based on X-ray synchrotron diffraction spectra recorded during uniaxial tensile loading. The elastic stiffness and plasticity variations in the different hexagonal α and α'phase directions is discussed and compared with numerically predicted critical resolved shear stress values.
The plastic deformation behaviour, strain localization and fracture onset of bilamellar Ti-6Al-4V, is discussed based on strain fields, obtained by 2D digital image correlation, recorded during uniaxial tensile loading inside a scanning electron microscope.
Generally, recommendations are given on how to heat treat LPBF processed Ti-6Al-4V alloys in order to enhance its quasi-static mechanical performance.

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Session Classification: Material Science

Track Classification: Material Science