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Processing-Microstructure-Mechanical Property Relationships in Additively Manufactured Titanium

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A brief overview will be given for the mechanical properties of 3D printed Ti-6Al-4V. Regardless of whether the process is (laser) powder bed fusion (LPBF) or (laser hot) wire deposition (LHW), the unifying approach is to identify a process window i.e., interdependent parameter ranges in power, speed, hatch spacing etc. that result in >99 % density. Microstructures vary between martensitic and basketweave for higher versus lower cooling rates. Without plastic deformation, the microstructural evolution can be simulated with a multi-phase JMAK model using the (calculated) thermal history. Laser hot wire deposition with centimeter-scale tracks produces banded microstructures that arise from locally long dwell at the transus and consequent variations in properties, all of which can be modeled. Textures are columnar and therefore anisotropic. Strength is modeled on the basis of regression fits to experimental data from a variety of sources with features that include lath spacing, dislocation content and solute content of the hcp and bcc phases. Results will be shown for hardness and strength variations as a function of processing type, thermal history, part geometry etc., including the effects of texture.

Keywords: Ti-6Al-4V, Crystal Plasticity, VPSC, Additive Manufacturing, Directed Energy Deposition.

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