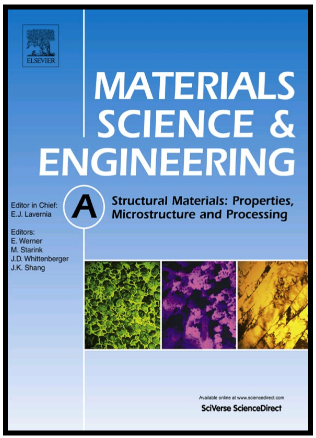

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Deformation Behavior of Additively Manufactures GP1 Stainless Steel

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Abstract.

In-situ neutron diffraction measurements were performed during heat-treating and uniaxial loading of additively manufactured (AM) GP1 material. Although the measured chemical composition of the GP1 powder falls within the composition specifications of 17-4 PH steel, a fully martensitic alloy in the wrought condition, the crystal structure of the as-built GP1 material is fully austenitic. Chemical analysis of the as-built material shows high oxygen and nitrogen content, which then significantly decreased after heat-treating in a vacuum furnace at 650 °C for one hour. Significant austenite-to-martensite phase transformation is observed during compressive and tensile loading of the as-built and heat-treated material with accompanied strengthening as martensite volume fraction increases. During loading, the initial average phase stress state in the martensite is hydrostatic compression independent of the loading direction. Preferred orientation transformation in austenite and applied load accommodation by variant selection in martensite are observed via measurements of the texture development.

Keywords: Neutron diffraction; Additive manufacturing; Stainless steel; In-situ Loading; Phase transformation

Introduction.

Additive manufacturing (AM) is a rapidly developing processing pathway that produces components by selectively melting and solidifying feedstock to build a desired geometry, rather than subtractive machining from cast or wrought stock material [1,2]. A major difference between the two routes is the microstructure of the material in the final component [3]. Casting and thermo-mechanical processing to produce wrought stock material has been optimized over centuries and a wide variety of thermal and deformation processing options are commonly used to obtain a desired component microstructure, which defines performance. In contrast, there are more limited opportunities to optimize microstructures of AM materials after manufacture, primarily because components are built to near-net shape to minimize the amount of material and post-build machining needed. As a result, most bulk thermo-mechanical treatments, (e.g., rolling, forging, etc.) cannot be readily applied. Options for modifying AM component microstructures after manufacture are generally limited to surface deformation treatments (e.g., shot or laser peening) and bulk or surface thermal/chemical treatments [4]. AM processing parameters have perhaps the strongest influence on component microstructure, and significant research is being performed to establish both empirical connections between the input parameters and the achieved microstructure and properties, and physics-based models to guide AM process optimization [5].