Texture Evolution in Electron Beam Powder Bed Produced Ti-6Al-4V with Varying Build Strategies

A.I. Saville[1], J. Klemm-Toole[1], S. Vogel[2], S. Kumar[3], A.J. Clarke[1]

[1]Colorado School of Mines, Golden, CO, 80401 USA

[2]Los Alamos National Laboratory, Los Alamos, NM, 87545, USA

[3]University of Tennessee, Knoxville, TN, 37996

Abstract

Understanding the formation of anisotropic behavior present in additively manufactured metallic alloys is of major interest to a number of industries. Here, Ti-6Al-4V was produced via three varying scan strategies using an electron beam melting process to understand the evolution of texture. Linear raster, random spot, and periodic spot deposition processes were used to vary the local thermal conditions during the build of each specimen, with the objective to evaluate potential α-Ti crystallographic texture differences between the specimens. Neutron diffraction was used to measure bulk texture at the center of each specimen. The results show significant variations in α-Ti orientations with reference to build direction. Spot scan strategies produced Ti-6Al-4V with increased bulk texture, whereas the linear deposition process produced the lowest bulk texture, suggesting further studies on correlating microstructural features to observed bulk textures is warranted.

Introduction

Ti-6Al-4V is a workhorse titanium alloy due to its combination of desirable strength, corrosion resistance, and low density. Because of these attributes, roughly half of the titanium feedstock used to produce components and parts worldwide is Ti-6Al-4V. [1,2] At room temperature Ti-6Al-4V is a two-phase alloy, consisting of a hexagonal close packed (HCP) α phase and a body centered cubic (BCC) β phase. At higher temperatures the alloy becomes single phase β and transforms into a two phase $\alpha + \beta$ system below 950°C via a $\beta \rightarrow \alpha$ phase transformation.

Upon transformation from $\beta \rightarrow \alpha$, one of 12 crystallographic α orientations may form from the parent β phase. The possible so-called α “variants” follow the crystallographic orientation relationship (OR) given below [3–8]:

$$\{0001\}_{\alpha} || \{011\}_{\beta}$$

$$< 11\bar{2}0 >_{\alpha} || < 111 >_{\beta}$$

Ti-6Al-4V is also amongst the most commonly produced titanium alloys in powder and wire based additive manufacturing (AM). In the medical and aerospace industries, the alloy is associated with long production lead-times and high machining costs, and thus has been studied extensively for more rapid and cost-effective production via AM. [9]

Several challenges still face the use of AM to produce Ti-6Al-4V. One of the most prominent challenges is non-uniform loading response. The sharp thermal gradients experienced during most forms of metallic AM result in anisotropic mechanical performance. This is the consequence of