ABSTRACT

The present study deals with the influence of grain boundary structure and orientation on the microstructure and texture evolution in Ti-6Al-4V (Ti64) alloys. Strong bulk texture evolves in as-cast Ti64 alloy due to large β grains along with continuous grain boundary (GB) α having fewer α variants. Higher propensity of lamellar α phase formation via interfacial instability leads to a fewer and large lamellar α phase which further intensify bulk texture in as-cast Ti64 alloy. Addition of 0.1wt% of Boron induce smaller β grains and discontinuous GB α phase due to the formation TiB particles along the β grain boundary regions. Far higher number of GB α variants along with smaller lamellar α phase within a single β grain weaken texture in as-cast Ti-6Al-4V-0.1B alloy.

Forging of Ti64 alloy above β transus strengthen texture due to a complex interplay between the large elongated β grains having either $\mathrm{CD}\|(1\ 1\ 1)_{\beta}$ or $\mathrm{CD}\|(1\ 0\ 0)_{\beta}$ orientations leading to long micro-textured regions along β grain boundaries and strong α variant selection for basket weave structure within single β grains. In β extrusion on the other hand, larger fraction of equiaxed β grains having random orientation surround elongated β grains of $\mathrm{ED}\ \|\ (1\ 1\ 0)_{\beta}$ orientation in addition a large fraction of non-Burgers related GB α and smaller lamellar α variants which reduces the intensity of bulk texture evolution.

Additive manufacturing of Ti64 alloy by laser-based direct energy deposition leads to four types of α' martensite/α phase (primary, secondary, tertiary and quaternary) during deposition and spheroidization of lamellar α'/α phase by β phase penetration during reheating of previously deposited layers. The DED-processed Ti64 alloy exhibits moderately strong texture due to competitive effect of orientation similarity between columnar β grains, long lamellar α-phase and micro-textured regions across β grain boundary regions as oppose to the weakening contributions from all twelve possible α variant formation within the basket-weave α'/α structure inside the β grains as well as higher and lower frequency of $60^{\circ}/< 1\ 1\ \bar{2}\ 0 >_{\alpha}$ and $10.53^{\circ}/< 0\ 0\ 0\ 1 >_{\alpha}$ misorientation pairs, respectively between α variants.

Spatial distribution of elemental concentration at the near atomic scale represents inverse interrelations between Ti, Al and O concentrations as well as simultaneous segregation of interstitial impurities (O and C) along a line within the α phase of Ti64 alloy irrespective of Boron addition or β deformation. Overall, the present study highlights the importance of engineering the grain boundary micro-texture, either through thermo-mechanical processing

and/or selection of a suitable alloy composition, to modify the microstructure and bulk texture of Ti-6Al-4V alloy.

Keywords: Ti-6Al-4V alloy; as-cast and β-deformation; Additive manufacturing; microstructure; micro-texture; variant selection; angle/axis misorientation; substitutional and impurity elements