Summary

Titanium alloys are a class of metallic materials widely used in several industrial fields, such as automotive, aerospace and biomedical. Their main advantages lie in excellent corrosion resistance, high specific strength and low density. Among these alloys, Ti-6Al-4V shines as the "workhorse" material, covering almost 50% of the total titanium products market.

The conventional industrial sectors in which this class of materials is employed are ideal for Additive Manufacturing (AM) implementation, as the components typically produced are already characterized by a high level of complexity and the production lots are limited in number. These are typical manufacturing scenarios where modern AM technologies are highly advantageous. Moreover, AM technologies grant a lower degree of material usage and higher levels of customizability, with respect to other techniques.

Among all the titanium alloys conventionally available, only a limited number were optimized for their processing by AM. The Ti-6Al-4V alloy was one of the first materials to be processed in general and it is now well-established for being manufactured via Laser Powder Bed Fusion (LPBF). Oppositely, the Ti-6Al-2Sn-4Zr-6Mo alloy, a substitute of Ti-6Al-4V with higher strength for some niche applications, was never processed before using this technology. Ti-6Al-4V is also well suited to be produced by Electron Beam Melting (EBM) and Directed Energy Deposition (DED).

The goal of this thesis was to analyse the microstructure, the mechanical properties and their relationship for the Ti-6Al-4V alloy produced by EBM and DED. Moreover, the LPBF produced Ti-6Al-4V samples were compared with Ti-6Al-2Sn-4Zr-6Mo specimens produced for the first time using the same system.

Initially, the optimal process parameters to manufacture the Ti-6Al-4V samples by DED were assessed using the single scan approach. This step was necessary as these were the first specimens produced using this system. The microstructure of the 3D samples was carefully analysed and correlated with the environmental factors and thermal history of the process. Consequently, the mechanical properties were determined. These analyses were also conducted on samples that underwent different post-processing heat treatments, in which the cooling means were varied.

In the case of the EBM produced samples, standard process parameters were used, and the analysis of the heat treatments focused on the significance and effect of a post-annealing ageing step.

The heat treatments performed on DED and EBM produced specimens were specifically tailored in order to be comparable. Moreover, the annealing temperature was set high enough to allow a complete recrystallization of the initial microstructure. By doing so, the comparative analysis did not

result biased by the significantly different microstructures typically produced using these two manufacturing technologies.

The innovative Ti-6Al-2Sn-4Zr-6Mo alloy was processed by means of LPBF. Since no prior works on the subject were found, the most suitable process window had to be determined. After that, a microstructural and mechanical characterization of the samples was conducted. Since the industrial relevance of this alloy is related to its superior mechanical properties with respect to Ti-6Al-4V, the same investigation was performed on LPBF produced Ti-6Al-4V samples with the aim to assess whether this feature was maintained when switching to LPBF as a manufacturing technology or not.