# ABSTRACT

## Metals for Additive Manufacturing

Additive Manufacturing (AM) is assuming an increasingly important role in production thanks to techniques and materials that are taking it out of its traditional role as a tool for rapid prototyping. Although AM hit the headlines around 2000, the introduction of the first stereolithography printers' dates to the 1980s. In any case, the last 10 years have seen such a profound evolution as to allow the application of additive technologies in the manufacturing sector. This evolution has been accompanied by important changes in the management of AM and the birth of new business models: the improvements of the last decade in speed and precision have in fact allowed applications in contexts previously considered uninteresting or unfeasible. The increasingly complex requests from designers have prompted technologists to increasingly approach the AM revolution. The latter differs from traditional processing technologies because it does not remove material from the raw material but obtains very complex three-dimensional details through the progressive deposit of layers of material. The Powder Bed Fusion (PBF) process is a laser-based Solid Freeform Fabrication process that uses laser energy to melt a thin layer of metal powder. This process is repeated to produce a three-dimensional metal part and is capable of producing highly complex geometries that are impossible to produce with traditional methods. Compared with traditional manufacturing processes, PBF can also produce parts with higher density. Before a material is machined using this AM process, the suitable machining parameters are first identified. Over the years, various materials have been processed using the PBF process. However, very little has been done on the production of parts in precious metal and in general high-reflective materials such as copper and gold. This research project is based on two industrial case studies. The first concerns the manufacturing of a combustion chamber for satellite launchers, in the space sector, made by copper alloy. The second case study regards the manufacturing of gold rings, for the jewelry sector. The first steps were the analysis and the assessment of PBF process parameters for copper and gold alloy powders in order to print the components required by the selected case studies. To perform greater absorption for this type of highly reflective materials, has been used a green wavelength laser 5 source instead of an infrared one. Indeed, it has been proved the better absorption of green laser for the selected materials instead the infrared laser source. Furthermore, for the second case study,

welding tests of gold wires on gold plates were carried out, by using a blue laser source. Particle size distribution (PSD), bulk density was analyzed for both copper and gold powders before identifying suitable processing parameters for PBF. Due to the high cost and amount of gold material available for this job, a very small build platform was used to optimize material usage and reduce waste. Furthermore, the job was optimized by using the knowledge acquired from the first case study of copper, which appears to have characteristics close to the gold one, but the cost of copper alloys is cheaper than that of gold alloys. The copper and subsequently the gold cubes were printed by using the appropriate process parameters that were identified first by single-scan melting and after by single-layer experiments. Then the internal porosity of the printed cubes was analyzed. The reached porosity of the cubes was identified to be in the region where process parameters performed a good powder melting. The result was clearly a better material density of the printed components, as well as better mechanical properties and a better surface quality. For copper cubes, the reached average density is 98.7 %. To calculate the roughness, several tests were performed on samples printed with different inclinations. Considering the average roughness calculated, the best case was reached when the inclination angle is 51º. The maximum roughness obtained for gold cubes is 160 µm and the best density is 98.9 %. Regarding the welding of the gold wires, several tests were carried out by varying the process speed. The best result was found for speeds equal to 3mm/sec.