*Nanoinnovation 2018*

**Advanced material characterization for additive manufacturing**

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Additive manufacturing (AM) technologies based on a layer-by-layer production process assisted by a computer aided design (CAD) software are receiving growing attention, particularly for production of parts and devices based on metal alloys. Among several technologies available for production of metals parts by AM, the most interesting for industrial applications is Powder Bed Fusion (PBF), which consists in a powder layer selectively melted by a power source (laser or electron beam). PBF offers a number of advantages with respect to conventional manufacturing techniques, such as net shape production, lower time to market, efficient use of materials, direct production based on a CAD model, high level of flexibility, cost savings. Moreover, due to the additive process, PBF is capable of producing complex geometrical features and low volume devices in a single production process. These latter capabilities are particularly useful for biomedical applications where a high degree of individualization is required. However, the PBF process undergoes several intrinsic problems such as high temperature gradients and high cooling rates that give rise to thermal stresses, segregation phenomena and development of non-equilibrium phases. Therefore, microstructural anisotropies, leading to build orientation effects that influence the mechanical properties, can be developed during production. In order to reduce the building anisotropies thermo-mechanical treatments, which can further affect the mechanical behaviour of the alloy, are commonly adopted. Therefore, the macroscopic properties of any metallic device produced by PBF are closely related to the inner microstructure developed during production and post-production treatments. In this work, two metal alloys, Co-Cr-Mo and Ti6Al4V, commonly used in biomedical applications, have been investigated to correlate the mechanical response of the alloy to the microstructure developed both during the production process and after thermal treatments. Tensile and flexural tests were performed to study the mechanical response of the alloys while X-ray diffraction (XRD), electron microscopy (SEM, TEM, STEM) techniques, microanalysis (EDX) and neutron diffraction (ND) were used to investigate sample microstructure. Results evidenced the necessity to access different and complementary advanced characterization techniques to investigate the materials microstructure due to the development of unconventional microstructural features developed during the AM production process.