Characterization of an ultrafine eutectic Ti-Fe-based alloy processed by additive manufacturing via Near-Field Ptychographic Tomography

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Additive manufacturing (AM) represents a change of paradigm across multiple industries such as the aerospace, biomedical and automotive sectors. One of its key strengths is the fabrication of components with complex geometries providing inner channels for cooling fluids or bionic load-optimized structures of minimal weight not achievable by conventional production methods. Nevertheless, current alloys for AM are based on conventional compositions, which results in complex and costly process chains[1]. It is therefore essential to create new metals tailored to exploit the unique metallurgical conditions of AM. We are currently developing two novel high-strength alloys with ultrafine eutectic microstructure: a titanium-rich Ti-32.5wt%Fe-(Sn, Nb) and an iron-rich Fe-15wt%Ti-(Nb, Zr) alloys[2]. This is the first attempt to produce ultrafine Ti- and Fe-based eutectics by AM. To characterize such ultrafine microstructures, one needs a very high-resolution imaging technique that does not require slicing the sample and enables imaging relatively bulky samples. The emerging variant of ptychographic-tomography in synchrotrons, the **Near-Field X-ray X-ray Computed Ptychography (NF-PXCT)**[3], is capable to image the samples in 3D with a relatively large field-of-view and high resolution. We present here the results of the characterization of the ultra-fine structure of Ti-32.5wt%Fe produced by selective laser melting using high-energy NF-PXCT, which was performed at ID16A beamline[4,5] of the ESRF. NF-PXCT takes full advantage of the X-ray transverse coherence and nanofocusing at the beamline to provide a 3D image of unprecedented resolution and contrast sensitivity of the structure of the alloys. The fine details were imaged down to a resolution of ~30 nm with a voxel size of 15 nm. This paves the way for the new characterization methods of the eutectic metallic mixtures with a nanometric resolution by X-rays. The results help us to understand the dynamics of melting and the velocity of the solidification front during AM. These alloys will constitute a new generation of high-strength metallic/intermetallic structural materials and will enable novel technological developments in automotive, aero-engine, and tooling areas.

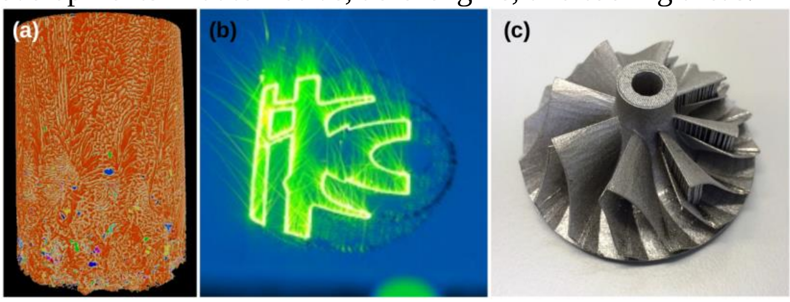

Figure 1: (a) 3D rendering of the Ti-32.5wt%Fe obtained by NF-PCXT [2]. (b) Rocket engine components being produced by selective laser melting. (c) 3D printed compressor wheel. Figures from: www.dlr.de/wf/en

References

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