Investigation of the fatigue life of aluminium alloys processed via additive manufacturing

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Additive manufacturing (AM) is an emerging field in materials processing that could allow the production of complex shape and high-end application components for a variety of industries such as aeronautical, defence and biomedical. AM leads to a convoluted 3D organisation of the metallic material microstructure due to the different physical and metallurgical phenomena at play during the fabrication process. The microstructure features generated during AM will obviously affect the material properties. It is therefore paramount to properly characterise this microstructure and to understand its effect on the properties of interest for a given application.

In this paper, we are focusing our investigation on understanding how the fatigue behaviour of an AlSi10Mg aluminium alloy produced via selective laser melting is affected by its microstructure. Fatigue experiments have shown that different processing parameters such as the building direction, speed and temperature, and further heat treatment can have a direct impact on the fatigue limit of the material. These processing parameters affect the microstructure at five different scales: (i) Defect population (10-200 μm) such as keyholes, lack of fusion; (ii) 3D grain organisation (10 x 10 x 100 μm); (iii) Melt pool structure (50 x 200 x 600 μm); (iv) Precipitate structure (1-10 μm); and (v) Dendrite arm spacing (1μm). All scales can have an effect on the fatigue limit. This paper aims at characterising, at all these scales using electron backscatter diffraction (see Fig. 1) and micro-computed tomography, the microstructures of this alloy produced using different processing parameters in order to obtain complete and reliable 3D representation of the microstructures and to understand the fundamental role of the microstructure organisation on the fatigue limit for this 3D printed materials.

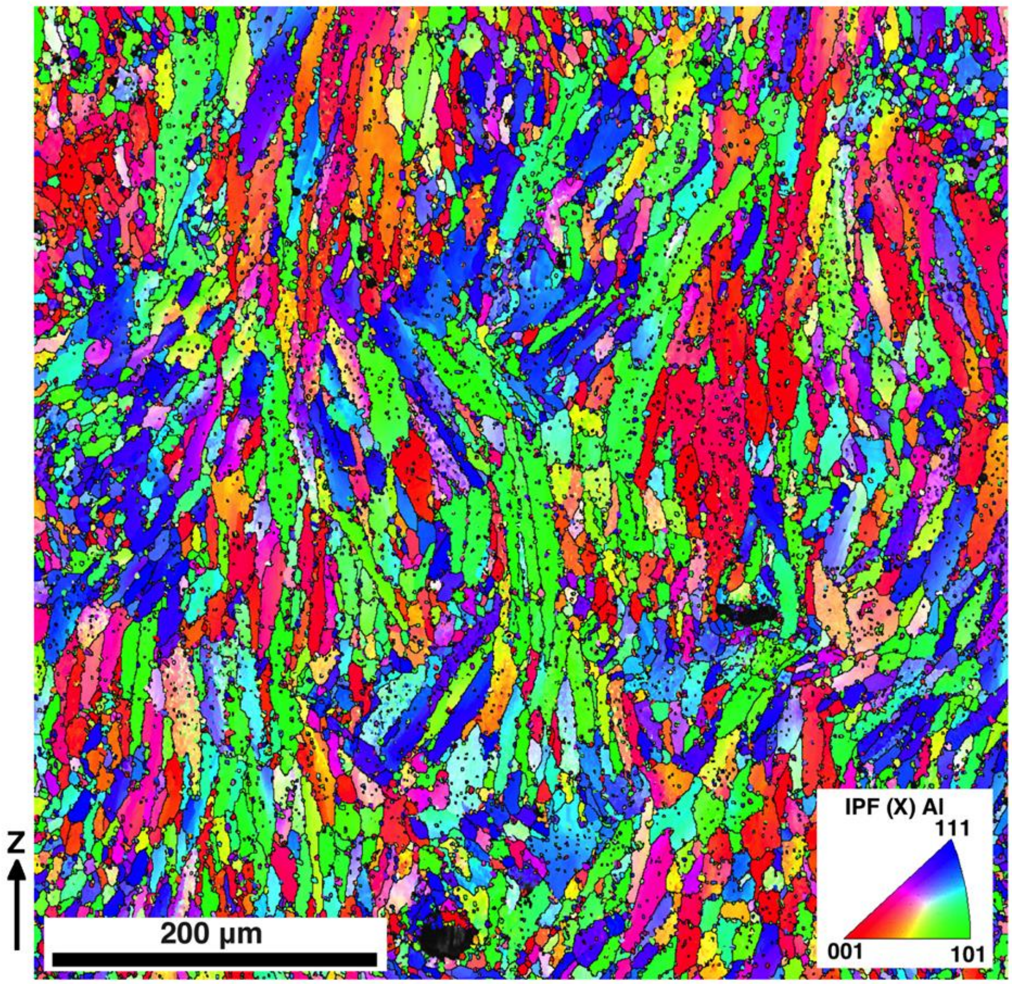

Figure 1: Inverse pole figure map of the AlSi10Mg aluminium alloy produced via selective laser melting after T6 heat treatment. The z-direction indicates the direction normal to the printing plane.