Characterization of the healing ability and the mechanical properties of a new high strength healable aluminium alloy produced by additive manufacturing

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Topic: Healing as technology and sustainability enabler - 3D printing

The objective is to develop a novel, high-strength, healable aluminium alloy for processing with Laser Powder Bed Fusion (LPBF). An alloying element is dispersed into an Al-Mg alloy to form a high-strength alloy by the formation of hardening precipitates. The very thin microstructure obtained through the 3D manufacturing consists of an aluminium matrix surrounded by a Mg-rich low melting point eutectic network, akin to a biological vascular system ensuring efficient transport of healing agents to the damage sites. After damage, a healing heat treatment (HHT) is applied to induce the melting of the eutectic phase. This molten phase then fills the voids and seals them upon solidification. Furthermore, combining pressure and HHT (Hot Isostatic Pressing) can help to improve the healing ability by closing the voids.

In this work, the healing ability of the new alloy has been characterized in 3D by a synchrotron X-ray nano-tomography (nano-CT). The damaged regions before and after healing were imaged by nano-CT technique at beamline ID16B ESRF. It was shown that after a HHT at 540°C for 30 minutes, 42% of voids were totally healed and that the volume of voids with an equivalent diameter of 2µm or less is at least reduced by 50%. The impact of the HHT on the mechanical properties has been assessed through tensile tests while the evolution of the microstructure was observed by Plasma FIB-SEM, site specific electron microscopy techniques. Finally, the effect of HHT on precipitation was studied by Transmission Electron Microscopy.