

Synchrotron X-ray nano-tomography study of healing solutions for a Laser Powder Bed Fusion (LPBF) manufactured high-strength Al-Mg alloy

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Aluminium alloys are increasingly used and processed by Laser Powder Bed Fusion (LPBF) for aeronautical and aerospace fields. To avoid replacement of damaged parts and production of new ones, materials able to heal their damaged sites present great potential.

In this research, a new high-strength healable Al alloy processed with LPBF is developed. Zr is dispersed into an Al-Mg alloy to form hardening precipitates. 3D manufacturing allows to obtain a very thin microstructure consisting of an Al matrix enclosed by a Mg-rich low melting point eutectic network, comparable to a biological vascular system ensuring an efficient transport of the healing agent to damaged sites. Two kinds of healing treatment can be applied after damage: a healing heat treatment (HHT), in which the low melting point eutectic phase melts and flows inside defects to seal and weld them upon solidification and a Healing Heat and Pressure Treatment (HHPT), in which the pressure closes the cavities while the temperature welds them similarly to HHT.

The damaged regions were imaged in 3D before and after healing using synchrotron X-ray nano-tomography at beamline ID16B ESRF. Following a HHT at 540°C for 30 minutes, 42% of the voids were completely healed, and the volume of voids with an equivalent diameter of 2µm or less was reduced by at least 50%. To evaluate the impact of the HHT on the mechanical properties, tensile tests were conducted. The evolution of the microstructure was observed using Plasma FIB-SEM, a critical correlative electron microscopy technique.