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Correlative tomography-based characterization of a newly developed liquid assisted healable Al alloy

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1. Introduction

Designing self-healing metals is challenging because it requires a driving force such as high temperature conditions to trigger the diffusion and/or local melting process of a healing agent. Proper understanding of healing mechanism, followed by the healing treatment optimization depends on accurate microstructural analysis, performed at the exact location of damage [1]. Therefore, a correlative imaging is required to evidence the microstructure healing efficiency [2].

2. Materials and Methods

In this contribution, a multimodal correlative tomography approach has been applied to investigate healing mechanism within AlMg alloy. In-situ heat treatment of laser powder bed fusion (LPBF) manufactured sample has been performed at ID16B beamline at the European Synchrotron Radiation Facility (ESRF), combined with the 4D X-ray nano-tomography imaging before and after the healing process [3]. Full sample volume tomograms (voxel size of 200nm), served for localization of the high-resolution ROI scan data (voxel size 35nm), acquired at the critical damage location. Healed sample, mounted on a universal holder containing specific fiducial markers, was finally scanned with lab system Nanotom M (GE, Germany) (voxel size 2µm), for coordinates alignment between µCT and SEM imaging systems. Finally, the healing microstructure was further investigated with the correlative imaging approach. Precisely allocated, based on the nano-tomography ESRF data, sample sub-volume containing the healed damage, has been further investigated using PFIB-SEM combined with the EDX elemental material composition analysis. Automated serial sectioning tomography (SST) and acquisition of SEM back-scattered electron images with 60 nm voxel size, has been launched directly from the CoSMic tool within Avizo software using the Xe Plasma FIB-SEM microscope (Themo Fisher Helios Hydra DualBeam).

3. Results and Conclusion

A heat treatment above 500°C was applied in order to restore the metallic continuity by melting the low-melting point eutectic phase and its migration to the defects introduced by tensile loading. 4D nano-tomography highlighted the filling of the damage sites at different temperatures, allowing to optimize the healing temperature. A statistical tracking analysis used to determine the fraction and size of the healed damage sites, confirmed effectiveness of applied healing process, by revealing significant reduction of micro-pores and cracks. Applications of PFIB-SEM system in the workflow, guided by multiscale data from synchrotron and lab tomography, allowed reaching the exact location - with precision of 10 µm - and characterization of the 100 μm^3 ROI sample sub-volume, containing the critical defects. These preliminary results confirmed the potential of this AlMg healable aluminum alloy and indicated that the correlative microscopy approach allows for precise location and characterization of the critical defects, leading to better understanding and of the healing mechanism.

4. References

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