

Critical assessment of the hydrogen uptake during the powder-bed laser

3D-printing of Al-Si grade

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Recent years saw an increasing interest for 3D printing technologies; not only as a fast prototyping tool, but also as an alternative manufacturing way allowing potential drastic reduction of cost owing to the net-shape production with no waste. Amongst the different technologies, the powder-bed selective laser melting, with its versatility and easiness, is very much studied. The somewhat shift of paradigm in the way 3D printing is considered, from prototyping to manufacturing, is accompanied by increasing requirements for the structural integrity and mechanical properties of the produced parts and pieces; requirements which are not necessarily compatible with the alloys currently used and the present practice. Indeed, laser melting and fast solidification of successive layers of powder brings specific defects that need to be characterised in order to be minimised. Furthermore, the use of powder exhibiting huge levels of specific area, magnifies the interactions and reactivity with the atmosphere, potentially bringing oxidation and hydrogen uptake.

In this context, this work considered the hydrogen uptake and release in the case of powder-bed selective laser printing of Al-Si alloys. After processing, the samples were either stored at liquid nitrogen or at room temperature. The total amount of hydrogen present after 3D printing was measured and related to the process parameters. Thermal desorption analysis (TDA) was also conducted in order to quantify the levels of diffusible and trapped hydrogen. The microstructure was characterised owing to scanning electron microscopy and x-ray tomography. Specific attention was put on the characterisation of the porosities. Finally, beside quasi-static mechanical behaviour, relaxation tests were also performed to highlight the risk of delayed fracture. The influence of the microstructure on both plasticity and fracture behaviour was also clearly established. As a conclusion, a first insight on the mechanisms of hydrogen uptake and release is clearly established.

Keywords : Hydrogen uptake – 3D printing – Al-Si alloy – thermal desorption analysis