In situ synchrotron techniques for Laser Based Additive Manufacturing

Poster/Oral Presentation
Date of presentation
Time of presentation

M. G. Makowska[1]*, F. Verga[2], S. Van Petegem[1], S. Pfeiffer[3], F. Marone[1], K. Florio[1], K. Wegener[1], T. Graule[2], H. Van Swygenhoven[1]

[1] *Photon Science Division, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland*
[2] *Institute of Machine Tools and Manufacturing, ETH Zurich , Switzerland*
[3]*Laboratory for High Performance Ceramics, Empa,, Switzerland*

*e-mail: presenting_ malgorzata.makowska@psi.ch

Laser-based Powder Bed Fusion (LPBF) of ceramics enables the fabrication of objects with complex three-dimensional shapes otherwise challenging or even not possible to produce with conventional manufacturing routes. However, the mechanical properties of LPBF-manufactured ceramics components are poor due to the large amount of structural defects. Selected results of ex situ and in situ synchrotron studies providing deeper understanding of the mechanisms of structure and defect development will be presented, among others, operando diffraction and the first operando tomographic microscopy during LPBF, both using in-house built LPBF setups designed for usage at MS, microXAS and Tomcat beamlines of SLS. Operando diffraction measurements performed with up to 20 kHz of acquisition rate allowed for observation of the phase transformations occurring prior and after laser melting, as well as the evaluation of temperature profiles and cooling rates. Tomographic microscopy during LPBF processing was performed with a high speed tomography setup employing the gigabit fast readout system (GigaFRoST camera) and the LBPF setup allowing for the laser scanning during high-speed rotation of the sample stage. Operando 3D imaging with acquisition rate of 100 tomograms per second provided direct insight into the phenomena not accessible with other techniques, in particular, the surface roughness formation, powder denudation, meltpool dynamics and porosity formation mechanisms (Fig. 1) were investigated. The acquired information, not only provides understanding of underlying processes, but also is crucial for the development and the verification of models used for the LPBF process simulations.

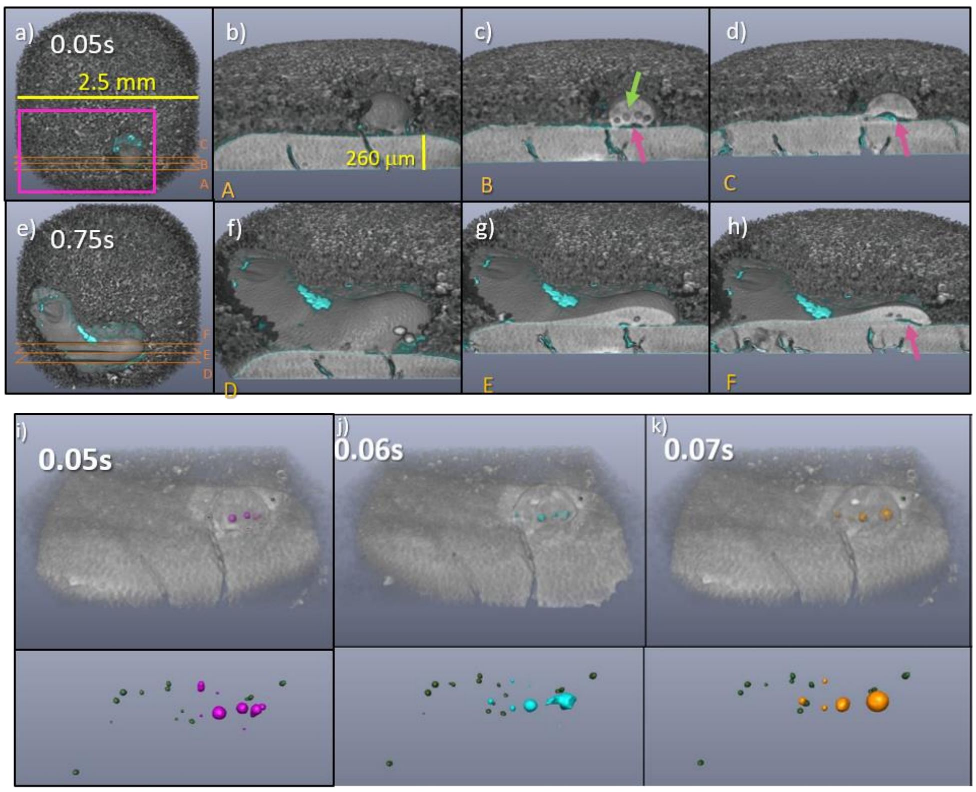

Figure 1 a)-h) Porosity due to evaporation within the liquid volume (green arrow) and due to lack of fusion with the previous layer (pink arrows) for two time frames t=0.05s and 0.075s for sample processed with 15.5W. i)-k) coalescence of gas bubbles within the molten material.

Acknowledgements: This project was financed by the Swiss National Science Foundation, grant number CRSK-2_196085.