LSI SUPPORT FOR PhD-STUDENTS IN APPLIED AREAS

Understanding texture of a 3D-printed Mg alloy using photon and neutron-based techniques at large scale facilities

THE PURPOSE OF THE PHD PROJECT

Mg-alloys are biocompatible, biodegradable, and have mechanical properties close to bone. This is perfect for biodegradable orthopedic implants, and e.g. orthopedic fixtures of wrought Mg alloys are already on the market today. If adding the possibilities provided by 3D-printing, new individualized implants can be developed with complex designs for increased bio-compatibility. It would also be possible to exchange the inert 3D printed Ti64 mesh found in the industrial partner OssDsign’s commercial implants, rendering them completely degradable. The main challenge with Mg-based implants is the degradation rate which currently is too fast. This is due to phase texture and residual stresses (RS). RS are also common in components from 3D printing, regardless metal, thus need to be understood for the successful implementation of new Mg-implants.

USING A LARGE SCALE INFRASTRUCTURE

Lab-scale X-ray diffraction and electron backscatter diffraction (EBSD) offers great capabilities to investigate phase composition and texture. However, the sample volume is restricted. Local RS are more difficult to quantify in the lab, and only destructive methods are available. Neutron- and synchrotron-based sources both allows for bulk characterization of texture, as well as unique capabilities investigating RS. RS were evaluated with neutron imaging and diffraction at POLDI beamline of the SINQ facility (PSI, Switzerland), and with synchrotron XRD at the P61a beamline of Petra III, Germany. 12 samples produced by varying the hatch and scanning strategies (67° and 45° scan rotation between layers) were evaluated at both facilities. Taller samples were also produced with 50 µm hatch. The results were compared with stress relived. Additionally, yet not accepted proposals for texture measurements using neutron diffraction were written for a submission to SRESS-SPEC (FRMII).

RESULTS AND IMPACT

Due to travel restrictions, the measurements at SINQ/PSI were performed remotely, while at Petra III/DESY they were performed on site. The results show that there are large RS in the material. At PSI, neutron imaging was used to map the strain in the sample and neutron diffraction was performed to validate the results. As these measurements have not been done on 3D printed Mg before, reference values are missing, and the influence of the texture on the measured values is difficult to establish. Therefore, the analysis is still ongoing, and complementary measurements might be necessary.

Some results from the XRD analysis are presented below. The RS formed during printing was found to be stronger closer to the edges of the as-built samples (P2 vs. P4). In the build direction the larger samples presented a higher degree of residual stresses. The residual stresses also varied more in the edges of the samples, than in the middle and in the bottom.

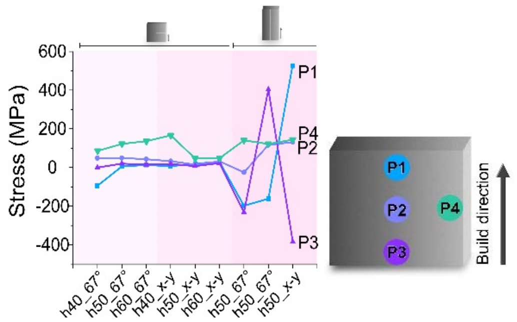

Figure: Results from the measurements of the residual stresses made ta DESY.

The measurements performed within the scope of this project has provided insight into the practicalities when working with LSI user facilities both for the industrial partners and the PhD student involved. Also, Mg-alloys were added to materials that expert and beamline managers are familiar with.

Future work will include using in-situ neutron diffraction to investigate how the texture and residual stresses changes under mechanical load, as well as looking into possible in-situ corrosion experiments, investigating the effect of residual stresses and texture on degradation mechanisms.

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