Selective Laser Melting of magnesium alloys

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INTRODUCTION: Additive Manufacturing (AM) technologies enable the realisation of most complex parts. The AM technology Selective Laser Melting (SLM) uses laser radiation to subsequently melt and fuse thin layers of powder according to a sliced CAD-model. SLM allows for manufacturing e.g. individualised implants with designed, interconnected porosity.

METHODS: During this study, a laboratory SLM setup is used. The optical setup consists of a single mode ytterbium fiber laser (IPG YLR-200) with 230W maximum output power, a galvanometric scanner (SCANLAB hurrySCAN 20) and a f-theta focussing lens (SILL S4LFT 3254/126). The process chamber enables processing in an argon inert gas atmosphere with oxygen content below 10ppm. The materials used are gas atomized powders out of WE43 and AZ91 with almost spherical particle shape (MSE Clausthal). The powders are sieved to particle sizes 25-63µm before SLM processing. To build various SLM test specimen, the main SLM process parameters such as laser power, scan speed, hatch distance and exposure strategy are varied. SLM test specimen are analysed by means of SEM, EDS and light microscopy.

RESULTS: According to EDS analysis of cross-sections of SLM-specimens out of AZ91 the magnesium content of the SLM-specimens compared to the aluminium content is linearly dependent on the energy input per unit volume. The higher the energy input the more magnesium is evaporated (Fig. 1 left). On the other hand, the part density is usually higher for higher energy input (Fig. 1 right).

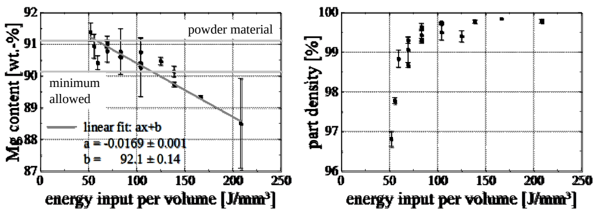

Fig. 1: Effect of energy input per unit volume on magnesium content (left) and part density (right)

Besides processing AZ91, first experiments for manufacturing scaffold-like structures with interconnected porosities out of WE43 were conducted.

The resulting parts show strong sintering of particles (Fig. 2 left). However, these adhering particles can be removed by e.g. sandblasting (Fig. 2 right). Sandblasted parts exhibit almost dense struts with thicknesses down to 300µm.

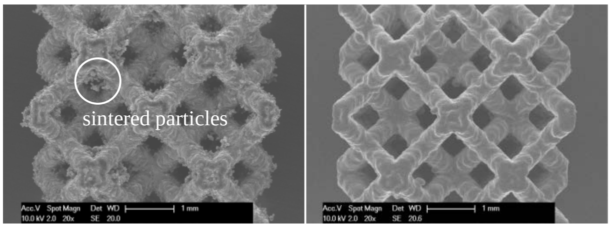

Fig. 2: SEM image of WE43 structure as-processed (left) and after sandblasting (right)

DISCUSSION & CONCLUSIONS: When processing AZ91 by means of SLM, the energy input influences the part quality in two competing ways. For higher energy input the amount of magnesium content in test specimens is reduced but the part density is increased. Nevertheless, a process window which allows for producing almost dense (>99.5%) specimens complying with the alloy specifications exists.

In addition, it is possible to fabricate scaffold-like structures with designed interconnected porosity out of WE43 by means of SLM (Fig. 3). This is a first step towards manufacturing individualised implants with designed, interconnected porosity.

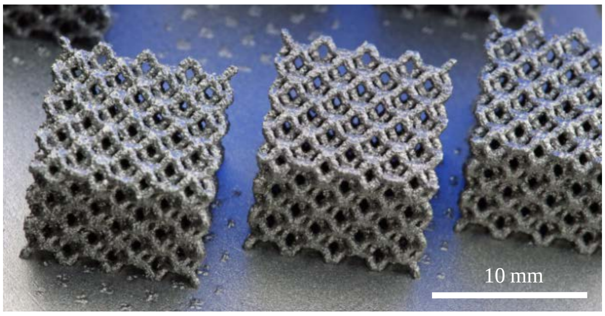

Fig. 3: scaffold-like structures with designed interconnected porosity out of WE43 made by SLM

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