Solid-state additive manufacturing of high-strength aluminium alloys:

towards understanding of microstructural changes employing ultrafast differential scanning chip calorimetry

Additive Manufacturing (AM) of high strength aluminium alloys by fusion based approaches is often limited by the occurrence of solidification related defects. Solid based approaches form an attractive alternative where the temperature during deposition remains below the melting point. The in house developed Friction Screw Extrusion Additive Manufacturing (FSEAM) process is a very promising approach to fabricate aluminium and magnesium parts with much higher resolution and part complexity than state-of-art solid state approaches. First results have been very interesting (Fig. 1), but better understanding of the deposition process is required to optimize the process and exploit all potential benefits.

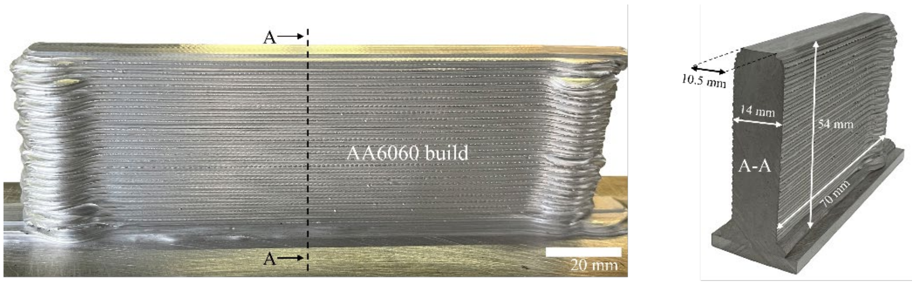

Fig. 1. Example of a FSEAM build fabricated from AA6060 (Al-Mg-Si alloy) at 500 mm/min.

After the fabrication process, the strength of the build is reduced as compared to the feedstock material. This because the process temperature is high enough to dissolve the precipitates that provide the strength of the material. The complicated thermal history due to the layer-by-layer deposition process determines the properties in the as-printed state. Typically, a non-uniform distribution of the strength over the fabricated part is observed.

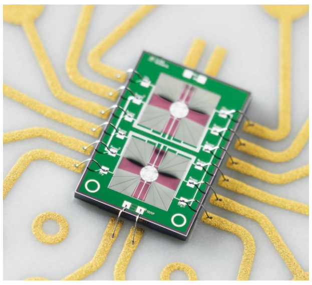

Fig. 2. Heart of the fast differential scanning chip calorimetry setup, where miniature samples can be heated and cooled at impressive rates well above 2 million C/min to accurately follow phase transformations such as the dissolution and formation of strengthening precipitates.

In this research project the influence of the process conditions on the strength evolution during FSEAM and additional post manufacturing heat treatments will be investigated. A new and unique device based on Fast differential Scanning Chip calorimetry (FSC) will be employed for the first time which enables the measurement of tiny heat differences in the aluminium alloy exposed to real heating and cooling cycles (Fig. 2). The FSC device can heat and cool with rates above 2 million C/min over the full temperature range of the FSEAM process providing detailed qualitative and quantitative understanding in material behavior.

The new insights available should enable a further optimization of the FSEAM process. Would you like more information on this fascinating assignment? Please contact:

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