In situ structural analysis of AlSi10Mg for additive manufacturing – from powder to thermally treated parts

R. Krisper[1,2*], M. Albu[1], J. Lammer[1,2], M. Dienstleder[1], E. Fisslthaler[1], G. Kothleitner[1,2], W. Grogger[1,2]

[1]*Graz Centre for Electron Microscopy (ZFE), Steyrergasse 17, 8010 Graz, Austria*
[2]*Institute of Electron Microscopy and Nanoanalysis (FELMI), Graz University of Technology, Steyrergasse 17, 8010 Graz, Austria*

In situ STEM heating experiments allow us to characterize the process of laser melting-based 3-D printing of metal alloys, their structure and elemental composition – from pristine printing powders to as-built structures and thermally treated materials.

Printing 3-D, robust metallic structures via laser beam melting of alloy powders is a rapidly growing industry branch. Manufacturers of such parts optimize their processes to improve material properties, as well as to enhance the interchangeability of building platforms and thus, their economic flexibility. The number of critical parameters for 3-D printing is large and most simulations or macroscopic tests do not sufficiently predict the outcome of a recipe. Parts from the same powder alloys with slightly different building parameters do not possess the same mechanical properties due to the grade of intrinsic thermal treatment that they experience in the respective laser-melting process. Differential scanning calorimetry (DSC) and X-ray diffraction (XRD) are prominent techniques used to provide information on transitions and crystallinity in the material before and after additional treatments, but the results are often inconclusive with respect to morphological changes [1,2]. AlSi10Mg is a high-hardness lightweight alloy with well-known casting properties which is of great interest for additive manufacturing. We studied its micro- and nanostructure through *in situ* thermal treatments in the TEM: Our correlated EDXS and EELS results for structural and elemental analysis of feedstock powders and 3-D printed parts explain data obtained from DSC and XRD; they aid in improving production processes and the tuning of materials, that would otherwise be based on trial-and-error approaches [3].

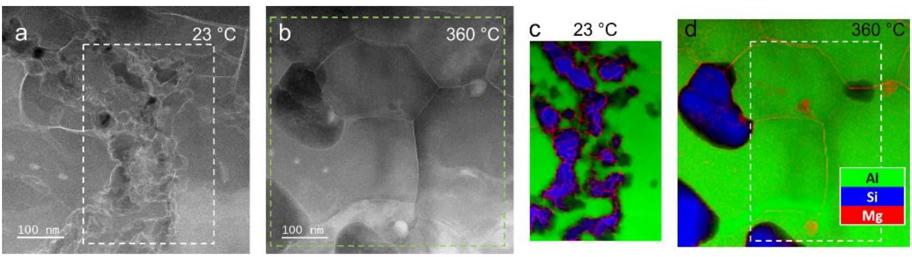

Figure 1. Elemental distribution of Si (blue) and Mg (red) in the Al (green) matrix acquired through STEM-EELS in an *in situ* heating experiment of an AlSi10Mg as-built specimen without prior thermal treatment. a, c) at 23 °C; b, d) at 360 °C. The spectrum image (c) is taken from the dashed white area in (a). The elemental map (d) is taken from the region in (b), bordered in dashed green and includes (c) (dashed white).

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*Corresponding author: robert.krisper@felmi-zfe.at