MM 65: Additive Manufacturing: Microstructure Development

Time: Thursday 16:45–18:00 Location: C 230

MM 65.1 Thu 16:45 C 230

Atomistic Simulations of Laser-based Powder Bed Fusion — Fabio Oelschläger[1], Azad Gorgis[1], Jonas Schmid[1], Kevin Vietz[1], Dominic Klein[1], Sarah Müller[2], and •Johannes Roth[1] — [1]FMQ, Universität Stuttgart, Germany — [2]GSaME, Universität Stuttgart, Germany

Applications of additive technologies continue to demand an improvement in quality and reproducibility. Using atomistic molecular dynamics simulations we are able to better understand the root causes for defects and may also be able to derivate actions for defect avoidance. The biggest challenge to the simulations are the scales: although we use multi-million atom systems and run "long" simulations we have to scale parameters like particle size, laser power, power density, scanning speed, laser focus diameter and gravity.

Using parameter studies for scanning speed and laser power while also including the influence of protective argon gas, different inclusion defects in pure aluminum particles are shown. The simulation of powder beds formed by spheres of different sizes show holes which vanish if filled with vacuum but persist if the simulation box is filled with protective gas allowing insight into the defect formation. Recrystallization in a box filled with a bimodal distribution of aluminum particles has been observed. Additionally, different configurations of binary materials made of aluminum and titanium have been simulated: the study compares spheres formed by a core of aluminum and an outer shell of titanium or vice versa, and homogenous spheres of a TiAl alloy.

MM 65.2 Thu 17:00 C 230

On the Road to Hierachically Porous Silicon by Dealloying Additively Manufactured Aluminium-Silicon Alloys — •Manfred May[1,2,3], Philipp Timm[1], Maria Mailwald[4], Dirk Herzog[5,6], Ingomar Kelbassa[5,6], and Patrick Huber[1,2,3] — [1]Hamburg University of Technology, Institute for Materials and X-Ray Physics, Hamburg, Germany — [2]DESY Centre for X-Ray and Nano Science, Hamburg, Germany — [3]Hamburg University, Center for Hybrid Nanostructures, Hamburg, Germany — [4]Hamburg University of Technology, Institute of Laser and System Technologies, Hamburg, Germany — [5]Hamburg University of Technology, Institute for Industralization of Smart Materials, Hamburg, Germany — [6]Fraunhofer, Institute of Additive Production Technologies, Hamburg, Germany

This study focuses on the synthesis of a novel hierarchically porous silicon material through a multi-step approach. Beginning with the selective laser melting fabrication of Al-Si alloys, the subsequent stages involve porosification through dealloying in HCl or KOH, creating a distinctive "coral" structure. Subsequently, another hierarchical layer is introduced via metal-assisted chemical etching or electrochemical anodic etching techniques. Different alloy compositions are investigated, and the impact of the microstructure of the 3D printed alloy for a successful dealloying process is shown. The dealloying process is checked via energy dispersive X-ray spectroscopy and X-ray diffraction experiments. Depending on the alloy composition, specificsurface areas (SSA) between 5.2 m^2/g to 48 m^2/g are achieved, with an additional increase in SSA up to 22% via anodic etching.

MM 65.3 Thu 17:15 C 230

Developing of Zr-Based Bulk Metallic Glass through Laser Powder Bed Fusion Employing Conventional and Non-Standard Beam Distributions — •Sepide Hadibeik[1], Hossein Ghasemi-Tabasi[2], Andreas Burn[3], Florian Spieckermann[4], and Jürgen Eckert[5] — [1]Chair of Materials Physics, Montanuniversität Leoben, Jahnstraße 12, 8700 Leoben, Austria — [2]Switzerland Innovation Park Biel/Bienne, Aarbergstrrasse 46, 2503 Biel/Bienne, Switzerland — [3]Switzerland Innovation Park Biel/Bienne, Aarbergstrrasse 46, 2503 Biel/Bienne, Switzerland — [4]Chair of Materials Physics, Montanuniversität Leoben, Jahnstraße 12, 8700 Leoben, Austria — [5]Erich Schmid Institute, Austrian Academy of Sciences, Jahnstraße 12, 8700 Leoben, Austria

Limitations in metallic glass additive manufacturing arise from the relaxation of solidified layers, diminishing free volume and adversely affecting part quality. Modifying the laser beam shape offers control over the molten pool's configuration and temperature distribution, bolstering productivity. Employing an advanced beam shaping technique in laser powder bed fusion, featuring a non-Gaussian, uniform beam distribution, resulted in a shallow and broad molten pool. Analysis using pair distribution function and differential scanning calorimetry demonstrated improved amorphous structure with reduced relaxation. This non-standard beam shape induced increased free volume and enhanced atomic rearrangements, contributing to improved structural heterogeneity observed in hardness measurements.

MM 65.4 Thu 17:30 C 230

Characterization of gas-flow assisted additive manufacturing of metallic glass powders on ground and in microgravity — Mélanie Clozel[1], Christian Neumann[1], Johannes Thore[1], •Fan Yang[1], Janka Wilbig[2], Olof Gutowski[3], Ann-Christin Dippel[3], Jens Günster[2], and Andreas Meyer[1] — [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 51170 Cologne, Germany — [2]Bundesanstalt für Materialforschung und Prüfung (BAM), 12205 Berlin, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), 22607 Hamburg, Germany

We studied bulk metallic glass samples produced from gas-flow assisted laser powder bed fusion process, which is capable of additively manufacture metallic parts under microgravity. The process was performed in a compact sounding rocket payload called MARS-M, in which two metallic glass alloy compositions, $Zr_{59.3}Cu_{28.8}Al_{10.4}Nb_{1.5}$ and $Zr_{52.5}Cu_{17.9}Ni_{14.6}Al_{10}Ti_5$ have been processed on ground and under microgravity. Using scanning electron microscopy and synchrotron X-ray diffraction tomography, we show that for both compositions the obtained samples contain given crystalline fractions, which preferably form at the interlayer boundaries. Very similar microstructures and crystalline fractions are also observed in the sample manufactured under microgravity conditions. Part of the nanocrystalline phases can be identified as the Cu_2Zr_4O phase, which might be related to the oxygen content in the initial material and the processing atmosphere. With these results, these process conditions can be improved for further space applications.

MM 65.5 Thu 17:45 C 230

Research progress for developing Fe-based soft magnetic metallic glasses for additive manufacturing — •Amirhossein Ghavimi[1], Maryam Rahimi Chegeni[1], Bastian Adam[1], Lucas Ruschel[1], Gabriele Barrera[2], Enzo Ferrara[2], Paola Tiberto[2], Isabella Gallino[3], and Ralf Busch[1] — [1]Saarland University, Chair of Metallic Materials, Campus C6.3, 66123 Saarbrücken, Germany — [2]INRIM, Strade delle Cacce 91, Torino, Italy — [3]Department of Materials Science and Engineering, Metallic Materials, TU-Berlin, Ernst-Reuter-Platz 1, 10587 Berlin, Germany

This research aims to create suitable Fe-based soft magnetic amorphous alloys for the 3D printing of motor parts, based on the iron-silicon-boron (Fe-Si-B) ternary system. The goal is to enhance the glass forming ability (GFA) to achieve a fully amorphous structure in 3D-printed parts, which is expected to improve motor efficiency by increasing magnetic softness and reducing energy losses. This is achieved through adjusting the compositions while maintaining competitive soft magnetic properties.

For increasing GFA, the critical thickness of samples was examined. The structure and thermal behavior of the samples were characterized using XRD, DSC, and DTA. Magnetic properties were determined by VSM. The hysteresis loops were measured in the low and medium frequencies.

The eutectic zone of the Fe-Si-B system was experimentally determined. Evaluating quaternary and quinary component alloys involved studying the effects of elements on GFA and magnetic properties.