ESRF	**Experiment title:** Microtomography of directionally solidified ternary eutectic Al-Ag-Cu alloy	**Experiment number**: HC 1708
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Report:

Ternary eutectics show a variety of microstructures more complex than in binary eutectics [1, 2]. Thus it is also more complicate to conclude from 2D sections to the 3D microstructure. We investigated directionally solidified ternary eutectic Al-Ag-Cu alloy which show already clearly different grey values using the backscattering mode of the SEM [2, 3]. First 3D investigations with the x-ray tomography device nanotom (GE Germany) at our institute failed because the absorption contrast of the Ag-rich Al phase is similar to the Al_2Cu phase, and thus a clear differentiation to the Al_2Cu phase was not possible. Because synchrotrons provide X-radiation with defined energy (monochromatic in contrast to polychromatic radiation in laboratory utility) in combination with high intensity we applied for beamtime at ID 19 to investigate the microstructures of ternary eutectic Al-Ag-Cu in 3D.

We chose an energy value below the Ag_K edge (25.514 keV) to obtain a good contrast due to different absorption coefficients of all three phases even with varying Ag content in the Al phase. With the density (4.78 g/cm³) of the ternary eutectic alloy (69.1 at% Al, 18.1 at% Ag, 12.8 at% Cu) we estimated the sample thickness to be 0.5 mm to obtain 20% of transmission. From SEM investigations we already know how to solidify different types of microstructures with different length scales of the phases. 14 samples solidified with 0.08 to 1 µm/s were used to investigate so-called ladder structure, cobblestone structure, misaligned structure, paw like structure, crossed structure as well as irregular structure. Thus we engaged a company using ultrasonic drilling to rip out selected samples of 0.5 mm diameter from our 8 mm diameter SEM samples. The height of these rod like samples was between 3.5 and 9 mm, and they were glued after discussions with the beamline scientists to glass capillaries for the tomography experiment.

A first experiment was done with the insertion device which led to an energy of 19 keV. 3000 images with 0.1 s each were collected in a 180° rotation (fig. 1 left top). However, the transmission was reduced to about 4%, thereby reducing the contrast between the three phases in the reconstructed volume data (right top part of figure 1). The change to higher energy, but below the Ag_K edge, required the use of the multilayer monochromator. In addition to the energy change the distance between the sample and the detector was increased from 3 to 13 mm in order to improve the edge contrast in the sample, while still using the PCO edge camera. Fig. 1 left bottom shows an image collected after the change to 25 keV (6000 images/180°, 0.1 s/image). Thus both the transmission (to 19%) and the contrast between the three phases were increased. However, the big disadvantage of bright and dark stripes caused by the use of the monochromator leads to ring artefacts in the reconstructed volume data as visible in fig.1 bottom right as well as in the 3D visualization in fig.2.

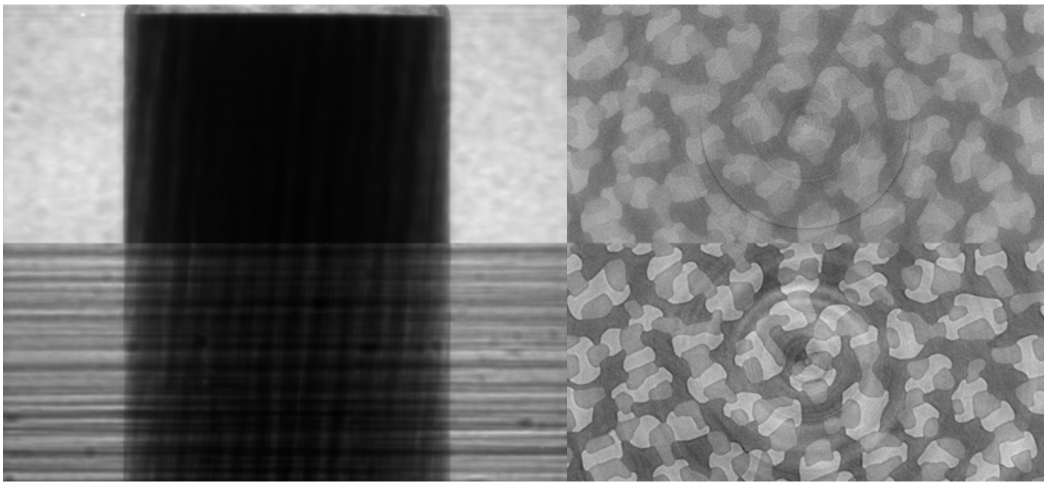

Figure 1: Left part shows data as collected. The image is divided in two parts: The top part was collected at 19 keV with the use of the insertion device, in contrast to the bottom part which was collected at 25 keV with the use of the monochromator. Right part of the image shows twice the same part of a reconstructed slice, in top the part was reconstructed using the 19 keV images whereas in bottom the reconstruction was performed with the 25 keV images.

Because of the ring artefacts in the reconstructed volume data it is (until now) not possible to assign automatically a grey scale reliably to the three phases in the complete volume. Nevertheless smaller volumes showing no (or less) bright and dark ring structures and can be used after a simple smoothing for a three-dimensional analysis as well as for comparisons to 3D simulations of directional solidification of ternary eutectic alloys. In this context, again we point to fig. 2 in which the difficulty of bright and dark regions is shown as well as small microstructure volumes that don’t have problematic intensity fluctuations.

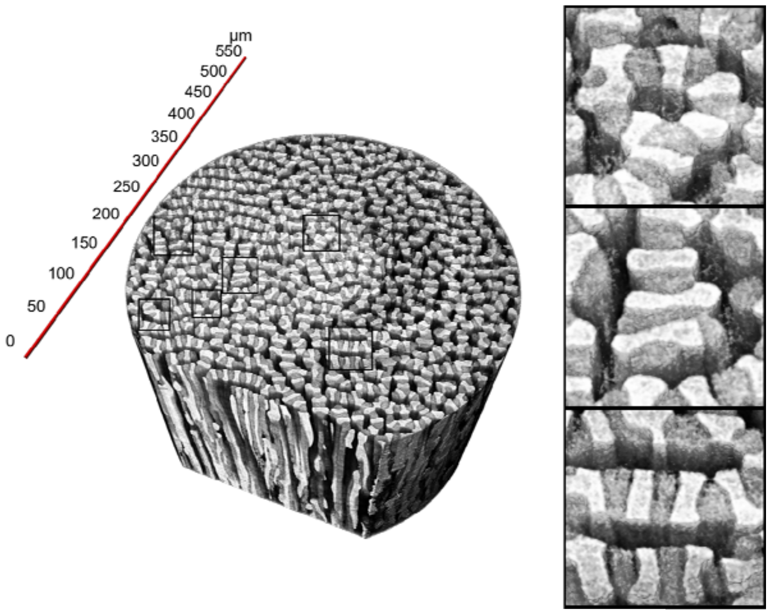

Figure 2: 3D visualization of a cobblestone structure solidified with medium velocity. In the right column structural details from some marked regions are shown.

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