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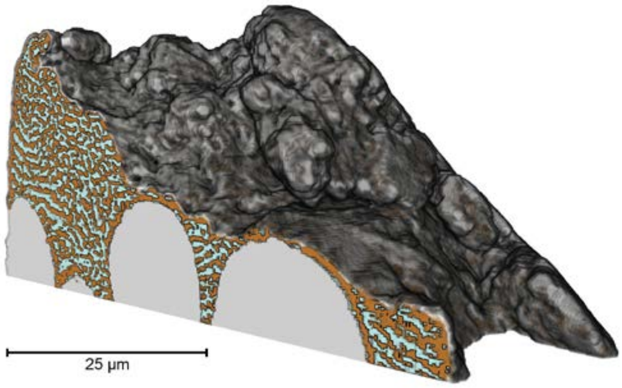
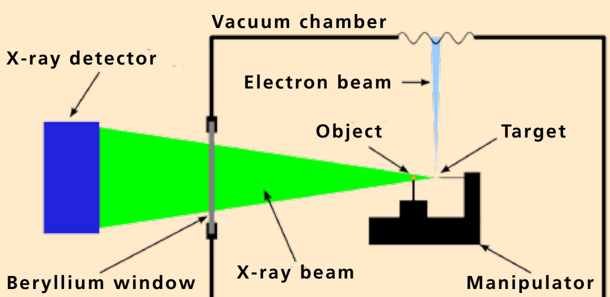


NANO CT OF AN AL ALLOY

A nano-CT system has been developed by Würzburg University's Chair of X-ray Microscopy (LRM) and Fraunhofer EZRT's Nano-CT Systems project group. The system will be used to image three-dimensional structures at a resolution of a few hundred nanometers that are significant for the material characterization of metal structures. We present an early CT image from this instrument. The sample is the binary alloy AlCu21 (mass%).

The System

The instrument is based on a scanning electron microscope (JEOL JSM- 7100F) equipped with a nanomanipulator (Klocke Nanotechnik). The target (a tungsten film) and the object are mounted on the manipulator. The radiation passes through a beryllium window and images are recorded on the CdTe detector (Pixirad, Fig. 1) installed outside of the vacuum chamber. Software developed at the LRM is employed for iterative volume image reconstruction, followed by phase correction (Paganin method).



1 Layout of the CT Scanner

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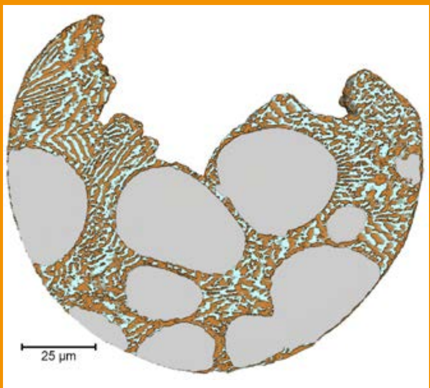
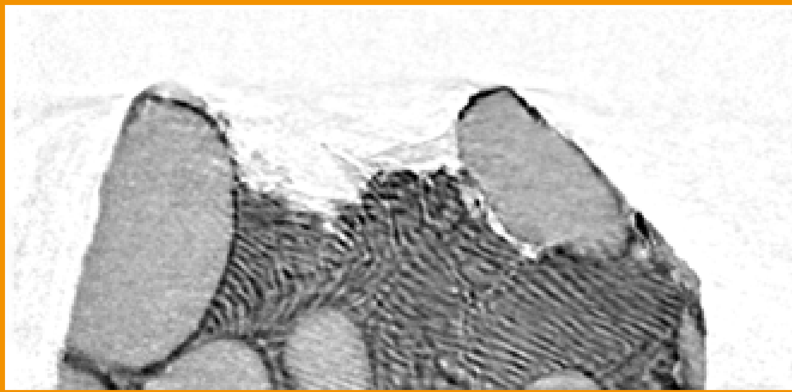


2 *Section parallel to the YZ plane of the segmented data (Avizo Fire); the α-aluminum phase is shown in gray, the aluminum in the eutectic is light blue, and the Al_2Cu intermetallic phase is shown in dark orange.*



3 *Sagittal section along the XZ plane of the reconstructed gray-scale data*

Application: Alloy

The microstructure of binary AlCu21 alloy consists of two phases: alpha-Al and Al_2Cu, present as primary Al and eutectic structure. The tip-shaped sample was milled from the ingot. Part of the tip broke off during cutting. The alloy's phases and structures were extracted from the data by segmentation (Fig. 2).

In the sample, the primary aluminum can be identified as roundish particles with a diameter of 20 to 30 µm, embedded in an eutectic of secondary aluminum and Al_2Cu phase. Due to rapid cooling of the ingot, the eutectic structure forms very fine lamellae structure approximately 0.6 µm wide with a lamellar spacing of approximately 1.2 µm. The alloy's structure is clearly visible even without segmentation (see Fig. 3).

Summary and outlook

The results shown here are very promising. They demonstrate that the nano-CT system's performance is significantly better than that of standard micro-CT scanners. These instruments typically have a spatial resolution of 1 to 1.5 µm (FWHM of the point spread function), and are unable to resolve the eutectic lamellae. Resolution can be further improved by using a very sharp needle as target in the XRM. In contrast to microsectioning, the nano-CT system provides 3D data that allow precise measurement of the phases' volumes. The orientation of the lamellae can also be determined, which is extremely useful in understanding the cooling process.

Electron source: SEM (JEOL)

Target	Tungsten film
Acceleration voltage	30 kV
Sample current	ca. 300 nA

Detector: CdTe (Pixirad)

Pixels	1024 x 476
Pixel size	60 µm (hexagonal)
Active surface area	61,8 x 25 mm
Bit depth	15

Measurement

Measurement area	150 x 70 µm
Magnification	ca. 350 x
Voxel sampling	ca. 150 nm
Spatial resolution (FWHM)	ca. 450 nm
Measurement time per projection	15 min
Projections (360°)	600