

Synchrotron-radiation based microtomography reveals 3D microstructure of Mg-Al-Zn alloy

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The beta phase $\text{Mg}_{17}\text{Al}_{12}$ influences high temperature strength as well as corrosion properties of Mg-Al-Zn alloys. $\text{Mg}_{17}\text{Al}_{12}$ develops during casting and its morphology depends on heat treatments and processing. Normally the beta-phase, its morphology and distribution are determined by standard metallographic methods leading only to a two dimensional picture. Synchrotron-radiation based microtomography is able to give a 3D image of the microstructure and was used to characterize the distribution of $\text{Mg}_{17}\text{Al}_{12}$ and Al_8Mn_5 in as-cast Mg-Al-Zn alloys [1].

Synchrotron-radiation based microtomography (SR μ CT) allows the 3D reconstruction of a specimen from a set of 2D projections using the backprojection of filtered projection algorithm [2]. The SR μ CT was performed at Hamburger Synchrotronstrahlungslabor HASYLAB at Deutsches Elektronen Synchrotron DESY (Hamburg, Germany). The specimens were imaged by microtomography in absorption mode utilizing synchrotron radiation at beamline BW2 using 16 keV photon energy. Exposed to the parallel synchrotron X-ray beam, the sample was precisely rotated 0.25° stepwise to 180°, and after every fourth step the reference image (projection) was recorded to eliminate intensity inhomogeneities and variations of the X-ray beam. The projections of the parallel beam were detected using a fluorescent screen made of a CdWO_4 single crystal of 200 μm thickness. The optical images were recorded by the use of a video-camera lens with a focal length of 25 mm in front of the CCD chip, 1536 x 1024 pixel each 9 x 9 μm^2 (Kodak KAF 1600) with 14 bit digitization at a frequency of 1.25 MHz (KX2, Apogee Instruments). The 3D structure was finally reconstructed from 720 two-dimensional projections using the BKFIL-procedure of the DONNER-library [3]. The specimens were investigated in two different positions of the z-axis to scan the total volume at optimal spatial resolution. These two separately reconstructed datasets were finally stacked to an entire dataset. The voxel size of an unbinned dataset was 1.35 μm , the magnification was 6.673 and the spatial resolution was 2.59 μm . Histograms of reconstructed data were used to determine thresholds for the different compositions of the tomogram (Fig.1) [4].

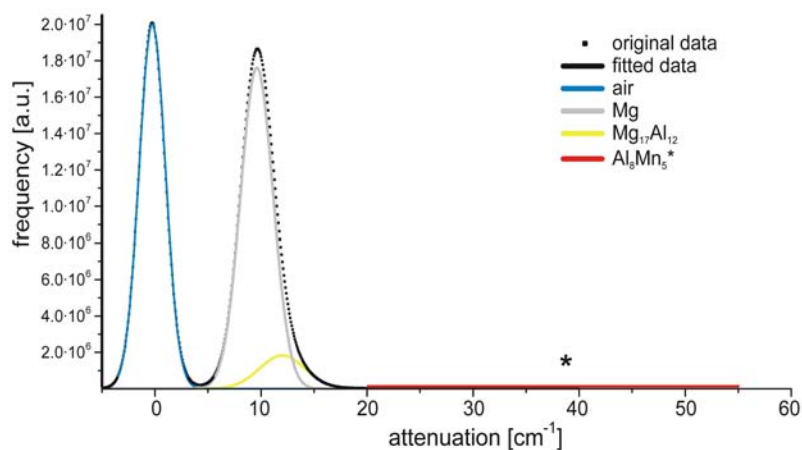


Figure 1: The histogram shows the total amount of voxels in the reconstructed data set displayed as the frequency of voxels depending on their specific attenuation value. Gaussian fits of measured attenuation values of the material compositions was used to demonstrate the most predominant components of the recorded data set. (*) Al-Mn-phases showed a broad shoulder of just 10.000 voxels, probably due to partial volume effects of the minute amount of tiny Al-Mn-phases.

The microtomography using synchrotron-radiation revealed the 3D distribution of the beta-phases, micro pores and high density areas of Al-Mn particles (Fig. 2, a + b). The typical microstructure of $\text{Mg}_{17}\text{Al}_{12}$ precipitates in the form of secondary, lamellar structures could be observed in 3D reconstructions (Fig. 2).

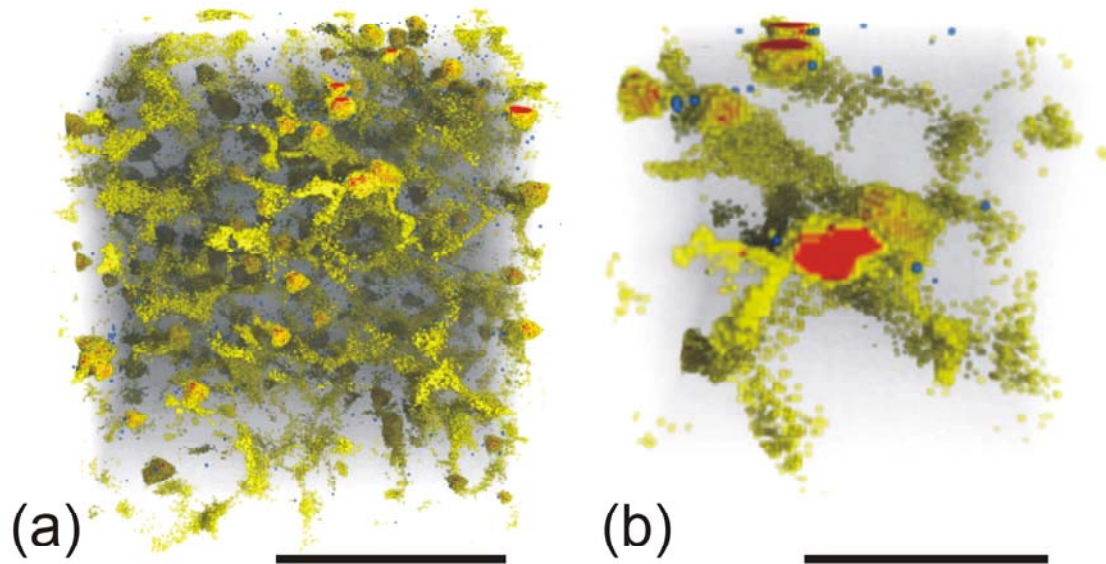


Figure 2: The diagram (a) shows 3D-segmented beta-phases (yellow), micropores (blue) and Al-Mn-phases (red) in an as cast AZ91D. The diagram (b) shows an magnification of (a), demonstrating the lamellar character of the beta-phases enclosing the Al-Mn-phases in a kind of network.
Scale bar: (a) = 150 μm , (b) = 50 μm .

References

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