

In-situ Observation of Solidification in Al-Cu Binary Alloys Using BL20B2 Beam Line at SPring-8

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In-situ solidification observations with synchrotron radiography were carried out at the SPring-8 facilities on Al-Cu binary alloys of varying composition (Al-xCu-yTi, where x=2,5,10,15 and y=0, 0.1).

The unrefined sample (Al-2Cu-0Ti) shows fewer nucleated grains, while the refined grains show numerous nucleated grains. The massive patches on the Al-15Cu-0.1Ti images are areas where the sample got torn during the melting process. Results from these experiments are being further processed to extract more information such as nuclei density, growth rate of dendrite tips, and the grain size.

Keywords: In-situ X-ray imaging, Magnesium alloys, solidification

Background and aim:

In-situ solidification experiments were carried out for Al-Si alloys to validate the Interdependence model of grain refinement in 2012A1192 and 2012B1430 [1]. The results from these experiments showed wave like nucleation events in the grain refined alloys. This confirmed the predictions of the Interdependence model.

The growth rate of grains was also estimated as a function of the alloy composition and plotted as a function of grain size. The Si poisoning effect was seen and it came to light that the grain-size and growth-rate relationship is not well understood in the literature. It is desirable to investigate this phenomena further to develop a generalised model explaining this relationship. A system which would provide a good atomic number contrast was deemed suitable and Al-Cu system was chosen. Following this a range of Al-Cu samples were prepared and tested at the BL20B2 beam line. Note that the manuscript preparation for the Al-Si work is in its final stages for Acta Materialia [2].

Experimental:

Synchrotron radiography experiments were carried out at the SPring-8 facilities on Al-Cu binary alloys of varying composition (Al-xCu-yTi, where x=2,5,10,15 and y=0, 0.1). The experiments were carried out on the BL20B2 beam line. This beam line has a large field of view (5 mmx5 mm) and hence a slightly lower spatial resolution than that which can be achieved at maximum magnification.

The experiment consisted of firstly casting the alloys of the desired composition. The castings of each alloy composition were in the form of 20 mm diameter cylinders. 1cm disc was sectioned from these cylinders, which were further cut, ground and polished to 100 μ m thickness. The thin sample was sandwiched between quartz films and inserted into the furnace. The sample was placed within the furnace aligned with the furnace window. The furnace window was set up in line with the X-ray beam in the BL20B2 line. The samples were melted and then cooled at 0.3 K/s. The cooling resulted in solidification of the sample. The entire sequence of remelting and solidification was carried out with the X-ray beam exposure.

Results and discussion:

The experiments with the BL20B2 beam line were successful. Figure 1 (a-d) shows the images of snapshots of solidification for Al2CuTi (a-b) and Al15CuTi (c-d) respectively for two different time steps during the solidification sequence. It can be clearly seen that enough contrast is generated for visualization of grain formation in the 15Cu sample. However, the grain growth images in the 2Cu samples are not as sharp. Nevertheless, the following observations can be made. The unrefined sample (Al-2Cu) shows fewer nucleated grains, while the refined grains show numerous nucleated grains. The massive patches on the

Al-15Cu-Ti images are areas where the sample got torn during the melting process.

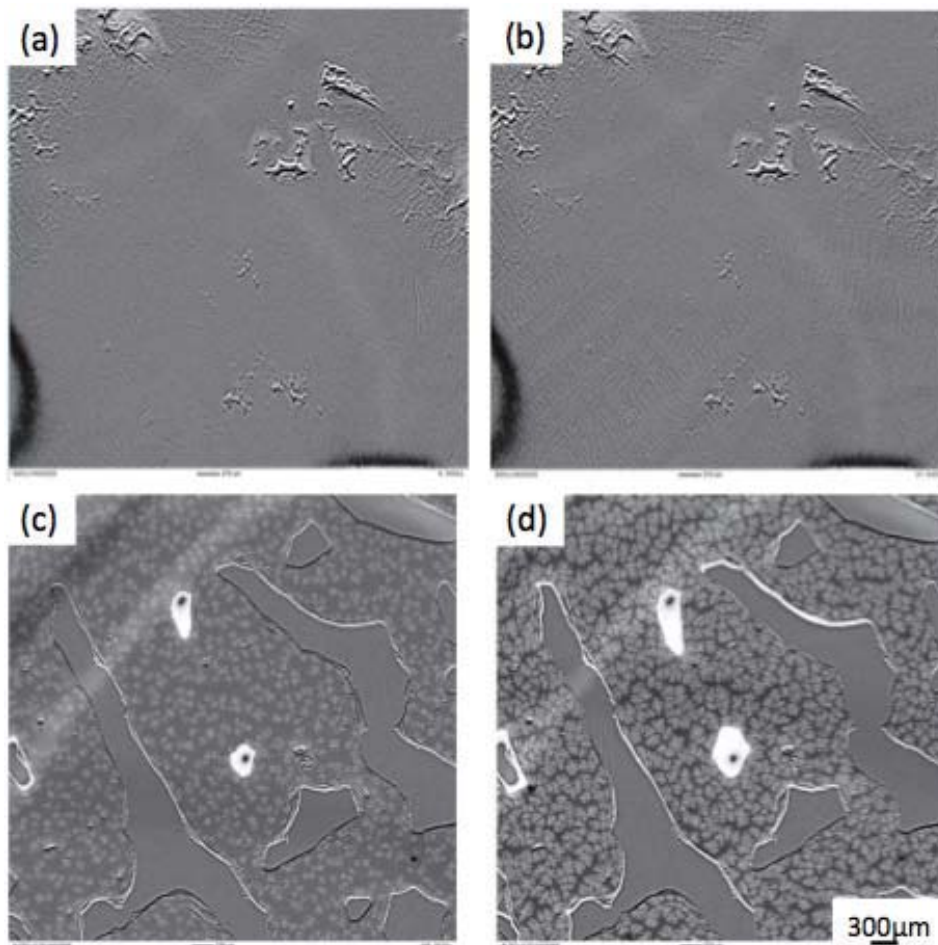


Figure 1. (a) and (b) First attempt on image processing for the Al-2Cu experiment. There is enough contrast to see the grains appearing in the (a) bottom left and right hand side of the image. (b) Grains from (a) have grown to larger size. The unrefined alloy has a few nucleated grains only. (c) and (d) Similar image processing for the Al-15Cu-Ti sample. The contrast is much better. Several grains have nucleated in the grain refined alloy which can be clearly seen.

Conclusions and future works:

Results from these experiments are being further processed to extract more information such as nuclei density, growth rate of dendrite tips, and the grain size.

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References:

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