In-situ Neutron Diffraction Solidification of Al-Cu Alloys

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In this study, in-situ neutron diffraction was used to characterize the solidification of an Al-5wt%Cu alloy. Neutron diffraction patterns were collected in a stepwise mode during solidification between 650 °C and 440 °C. The nucleation of the Al phase and Al_2Cu phase was successfully detected.

The peak evolution of Al 111 is depicted in Figure 1 over the solidification interval between 640 °C and 440 °C. Initially, at temperatures where solid crystals were beginning to evolve, a very high 'background' was observed, as shown in Figure 1 for 640 °C. As the temperature of the alloy decreased, however, the 'background' was lowered and peaks began to develop. Generally, as the alloy temperature decreased further, the area beneath the peaks was found to increase. Also, the angular position of the peaks shifted, corresponding to thermal contraction of the solid metal (i.e., a reduction in lattice spacing reflected by the shift in Bragg's peak position) [1]. Integration of the peak's normalized intensity over the angular range covering the peak's width was carried out. This enabled the retrieval of relative fraction solid (FS) for the selected temperatures within the solidification interval of the alloy.

The FS evolution of Al 111 and Al_2Cu 200 for the temperature range of solidification is presented in Figure 2. The graph presents separate profiles of solid aluminum and intermetallic Al_2Cu evolution. The first detection of solid Al (~6%) is at 640 °C. As the temperature decreases, the solid Al was found to evolve rapidly, as at 630 °C, the FS_{Al} was ~0.8. Beyond 630 °C, the growth in Al dendrites was more gradual and finally reached 100% solid at ~ 530 °C. The solid Al_2Cu (< 1%) is first detected at 540 °C. Initially, the evolution of this phase was gradual as the alloy cooled from 540 °C to 500 °C. Beyond 500 °C, however, the intermetallic growth then increased rapidly to 1 FS at 450 °C.

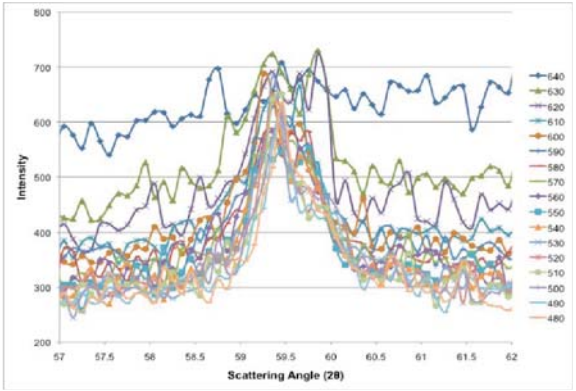

Fig.1. Phase evolution of Al 111 phase.

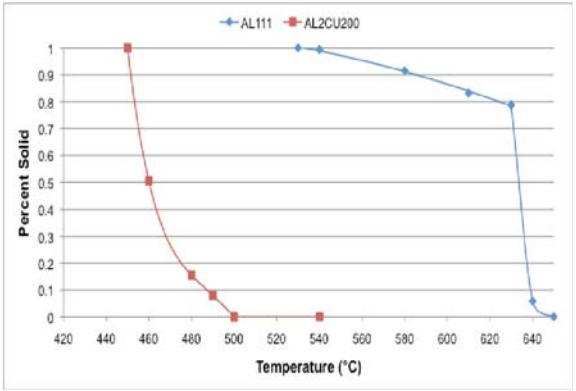

Fig. 2. Fraction solid development of solid Al and Al_2Cu.

Reference

[1] W. Kasprzak et al., "Solidification Analysis of an Al-19 Pct Si Alloy Using In-Situ Neutron Diffraction", *Metallurgical and Materials Transactions A*, 42A (2011), 1854-1862.