Understanding intermetallic compound nucleation and growth using synchrotron x-ray radiography

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Controlling the morphology and size of intermetallic compounds (IMCs) is a challenge in the Al industry since IMCs can have a strong effect on the mechanical performance, especially the ductility and toughness, of final components.

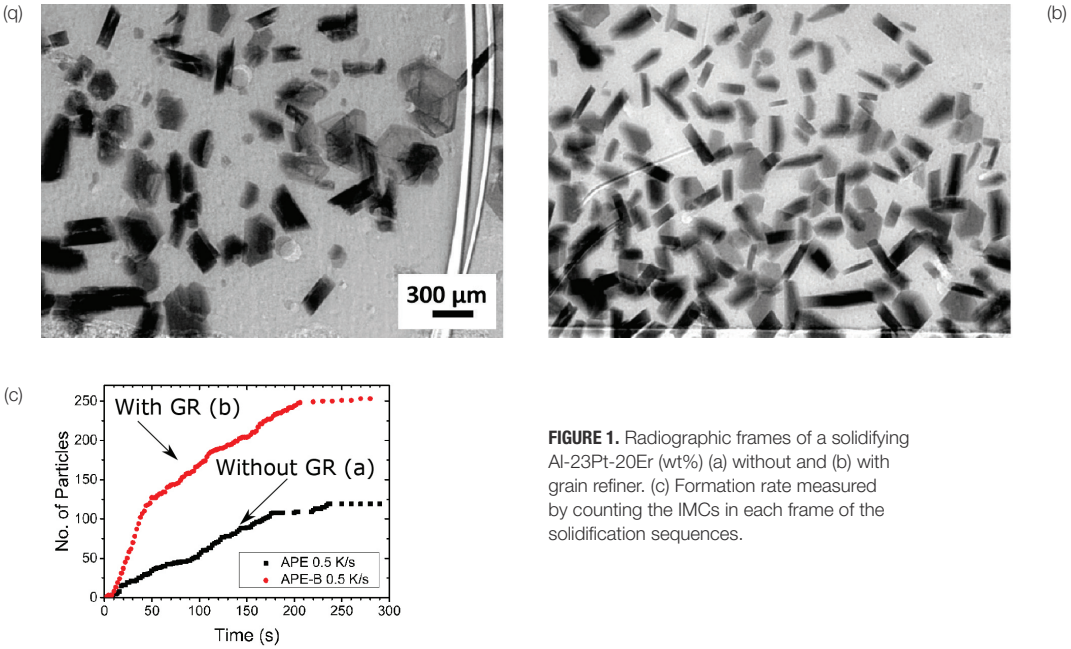

FIGURE 1. Radiographic frames of a solidifying Al-23Pt-20Er (wt%) (a) without and (b) with grain refiner. (c) Formation rate measured by counting the IMCs in each frame of the solidification sequences.

This research aims to deepen the fundamental understanding of how IMCs form (nucleation) and thus how to manipulate solidification and alloy conditions to contrive less harmful IMCs.

The effect of grain refiners and cooling rate on the nucleation of primary IMCs in a model Al-Pt-Er alloy (which is an analogue to the IMCs in commercial Al-Si-Fe and designed to enhance imaging contrast) was studied by X-ray radiography at the ESRF synchrotron. Figure 1a-b are two frames showing IMC density in two samples (a) without and (b) with grain refiner (TiB_2). The count of the number of IMCs in each frame for the two solidification sequences shows that grain refiners, usually added to promote equiaxed α-Al grains, also favour the nucleation of the IMCs.

Understanding the fundamental aspects of IMC formation could help to eliminate or reduce current costly post-solidification heat treatments that are used to manipulate IMC populations and morphology. The same understanding may also be helpful in improving Al alloy recyclability by suggesting approaches to increase the tolerance of alloys to tramp elements such as Fe and Si.

Preliminary synchrotron X-ray radiography results suggests that TiB_2 is an effective nucleation site for the same type of IMCs that are commonly found, and are potentially embrittling, in Al alloys.

Further synchrotron experiments aim to measure nucleation undercooling as well as nucleation rates in more industry standard Fe containing Al alloys.

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