Electron microscopy of a high strength Mg-Zn-Y alloy containing a quasicrystalline phase

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Abstract

A new magnesium alloy containing quasicrystalline particles was developed in magnesium rich Mg-Zn-Y system. This new alloy exhibits high strength and large elongation at room and elevated temperature. The Mg95Zn4.3Y0.7 specimen was fabricated by conventional casting followed by thermomechanical processing, i.e. hot-rolling around 473 K and then annealing for 30 min at 673K.

The as-cast alloy consisted of primary áMg dendrites and eutectic pockets (Mg and icosahedral(i-) phase) in the interdendritic region. The hot-rolled alloy showed equiaxed áMg grains with size of 14 ìm and a distribution of small i-phase particles (0.5-2.0 ìm) near the grain boundaries of the áMg, which were destroyed dendrites during hot-rolling.

To understand the strengthening mechanism of this alloy, TEM investigations were carried out using Philips CM20 and JEOL 3000F transmission electron microscopes. Bright field images show the existence of i-phase particles distributed in áMg. The existence of i-phase in this deformed specimen clearly indicates that the i-phase thermally equilibrates with áMg. Furthermore, any debonding or nanoscale defects at the particle/matrix interface cannot be observed in the tested specimen.

Besides the i-phase, two more nano-sized phases were found throughout the áMg grains. One has a very fine acicular morphology (50 nm in width, 0.5-3.0 ìm in length) and the other has a bulky particle shape (a few hundred nanometer) as shown in Fig. 1. The acicular phases seem to be orthorhombic structure and show specific orientation relationships with the áMg matrix. The Mg [0001] direction is parallel with longitudinal direction of needle of acicular phases. HREM imaging shows a coherent interface between acicular nano-phases and Mg matrices (Fig. 2). The bulky nano-phases seem to have hexagonal

structure and also have specific orientation relationships with the Mg matrix. A high density of dislocations was also observed in this specimen. It is, therefore, thought that in addition to the strengthening effect of i-phase particles, strengthening of this alloy was also achieved by these fine particles, which can act as obstacles for moving dislocations.

In general, particle/matrix debonding has been considered as an initial stage of the failure mechanism during the high temperature deformation of alloys with intermetallic compound particles at grain boundaries, and the coalescence of many cavities at large strains can induce the failure of such an alloy. However, careful examinations of the i-phase/matrix interfaces in this alloy do not reveal any defects. Therefore, the improved mechanical properties might be due to stable i-phase/matrix interfaces. HREM imaging shows that the i-phase/matrix interfaces sometimes have the orientation relationships of I2//Mg[0001], even though i-phase particles are highly phason-strained.

Acknowledgements

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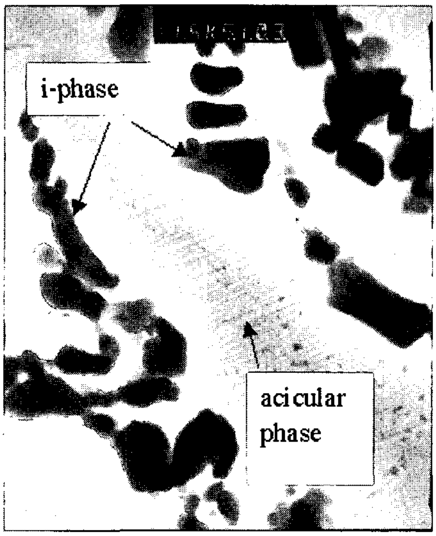

Fig. 1. Bright field image of a Mg95Zn4.3Y0.7 alloy showing the fine precipitates between icosahedral quasicrystalline particles

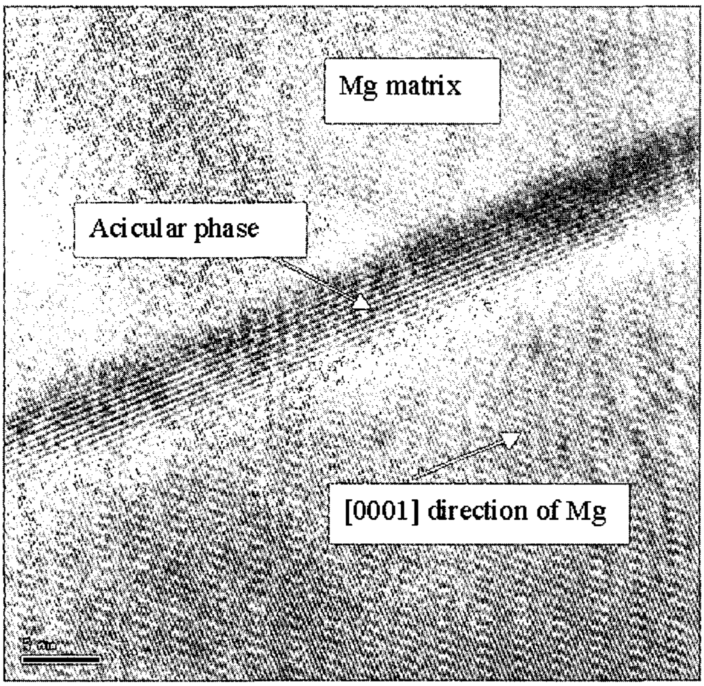

Fig. 2. High resolution electron microscope image showing an acicular phase in Mg95Zn4.3Y0.7 alloy