Time & Location: March 25, 2013 at 8:30 AM in OTC 304
Title: Interdiffusion and Impurity Diffusion in Magnesium Solid Solutions

Magnesium, being lightweight, offers potential to be developed into extensive structural applications. The transportation segment has particular interest in Mg and Mg alloy for applications where reduced vehicle weight is proportional to increased fuel efficiency. Al and Zn are two of the most common alloying elements in commercial Mg alloys. They improve the physical properties of Mg through solid solution strengthening and precipitation hardening. Diffusion plays a key role in the kinetics of and microstructural development during solidification and heat treatment. However, there is limited diffusion data available for Mg and Mg alloys. In particular, because Al is mono-isotopic, tracer diffusion data is not available. Interdiffusion of Mg solid solution with Zn also does not exist in literature.

The diffusional interaction of Al and Zn in Mg solid solution at temperatures ranging from 350 - 450°C was examined using solid-to-solid diffusion couple method. The objective of this thesis is two-fold: first, is the examination of interdiffusion in the Mg solid solution phase of the binary Mg-Al and Mg-Zn systems; second, is to explore non-conventional analytical methods to determine impurity diffusion coefficients. The quality of diffusion bonding was examined by optical microscopy and scanning electron microscopy with X-ray energy dispersive spectroscopy, and concentration profiles were determined using electron probe microanalysis with pure standards and ZAF matrix correction. Analytical methods of concentration profiles based on Boltzmann-Matano analysis for binary alloys are presented along with compositional dependent interdiffusion coefficients. As the concentration of Al or Zn approaches the dilute ends, an analytical approach based on the Hall method was employed to estimate the impurity diffusion coefficients.

Zn was observed to diffuse faster than Al, and in fact, the impurity diffusion coefficient of Al was smaller than the self-diffusion coefficient of Mg. In the Mg solid solution with Al, interdiffusion coefficients increased by an order of magnitude with an increase in Al concentration. Activation energy and pre-exponential factor for the average effective interdiffusion coefficient in Mg solid solution with Al was determined to be 186.8 KJ/mole and 7.69 x 10-1 m2/sec. On the other hand, in the Mg solid solution with Zn, interdiffusion coefficients did not vary significantly as a function of Zn concentration. Activation energy and pre-exponential factor for the average effective interdiffusion coefficient in Mg solid solution with Zn was determined to be 129.5 KJ/mole and 2.67 x 10-4 m2/sec. Impurity diffusion coefficients of Al in Mg was determined to have activation energy and pre-exponential factor of 144.1 KJ/mole and 1.61 x 10-4 m2/sec. Impurity diffusion coefficients of Zn in Mg was determined to have activation energy and pre-exponential factor of 109.8 KJ/mole and 1.03 x 10-5 m2/sec. Temperature and composition-dependence of interdiffusion coefficients and impurity diffusion coefficients are examined with respect to reported values in literature, thermodynamic factor, Φ, diffusion mechanisms in hexagonal close packed structure, and experimental uncertainty.

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Approved for distribution by Dr. Yongho Sohn, Committee Chair, on March 10, 2013.

The public is welcome to attend.