Abstract

Historically, tracer diffusion studies have been performed using radioactive isotopes as tracers. Handling these radioactive isotopes demands a significant increase in safety requirements over non-radioactive isotopes resulting in increased cost and effort. In this study we have used Secondary Ion Mass Spectrometry (SIMS) to measure tracer diffusion of stable Mg isotopes avoiding the need for radio tracers. SIMS analysis of magnesium is subject to a number of issues that lead to a significant loss of depth resolution which results in a significant error in the measured diffusion coefficient. Some of the issues dealt with include:

Induced Topography:
Sputtering of the sample surface causes increased topography of the analyzed surface. This increase in topography causes reduced depth resolution and leads to incorrect calculations of diffusion coefficients. Primary beam accelerating voltage, species and incident angle, along with the steady state oxygen concentration, will all have an effect on the measurement integrity. Characterization techniques, such as AFM, were used to evaluate SIMS craters and optimize the analysis conditions producing optimal results and significantly enhanced SIMS measurements.

Grain Size:
Grain size was also found to affect the surface morphology during analysis, causing increased roughness and inferior data. EBSD was used to characterize the changes in grain size and orientation, steps were then added to optimize grain size and correct for this source of error.

Long Diffusion Depths:
Top down depth profile methods are really only practical to depths of <20 microns. Sample preparation methods were developed and verified that solves this issue. This method for long diffusion depths makes analysis of diffusion depths of greater than several millimeters.

The methods used to minimize these errors will be presented along with the data comparing these optimized methods to the data collected under normal analysis conditions. The resulting optimized SIMS technique was used to calculate diffusivities for Mg and the data was verified against historical data using radio tracers.

Once an optimized SIMS technique was verified the work was expanded to its current stage, which includes Mg alloys. The current work focuses on understanding the effect alloy compositions have on isotopic ratio measurements, induced topography from sputtering along with the effect they have on the actual diffusivity of Mg in the alloy system.

In summary, a SIMS method has been validated as a reliable alternative to the radio-tracer technique for the measurement of Mg self-diffusion coefficients over both short and long diffusion lengths and now can be used as a routine method for determining diffusion coefficients.

Biography

Jay Tuggle graduated with a B.S. in chemistry from Radford University in 2003. He worked for Alliant Techsystems from 2003-2005 providing laboratory support for their TNT operation and R&D for their next generation energetic materials. He then worked for Polymer Solutions Incorporated from 2005-2011. While working at Polymer Solutions, Jay provided characterization expertise, legal support and managed the Microscopy and Physical Testing Groups. In 2011, Jay entered the MSE Department at Virginia Tech in order to further his education in 2011.