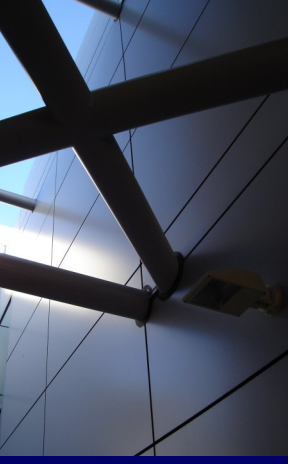

MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Anthony Fong

Monday, June 6, 2016, 3PM
Winston Chung Hall 205/206

Synthesis, Structural Characterization, and Transport Properties of Metastable Phases in the Mg-Sn System

Doctor of Philosophy, Graduate Program in Mechanical Engineering
University of California, Riverside, June 2016
Dr. Javier Garay Chairperson

Mg-Sn alloys have many uses due to their relative elemental abundance, low toxicity and low densities. Some applications include thermoelectric energy conversion, hydrogen storage, and enhancement of structural alloys. The thermoelectric application is of particular interest because Mg-Sn-Si based materials have shown promise in recent years.

It is well accepted that materials structure-property relationships are at the root of the improvement of a device's performance. Due to the interdependence of the transport properties, research for efficient thermoelectric conversion has focused on synthesizing materials with novel microstructures and compositions. Metastable structures present a unique opportunity in this regard. The Mg-Sn material system has a relatively unknown metastable phase which remains largely unstudied.

My work represents one of the first studies of the metastable Mg-Sn phase in a polycrystalline bulk form. I present a new synthesis route using a combination of high energy ball milling (powder synthesis) and current activated pressure assisted densification (CAPAD) (powder densification). This method allowed for the synthesis of the metastable trigonal phase at 600 °C and 112 MPa, significantly lower pressures and temperatures than have been demonstrated previously. This method produces samples large enough for the first neutron diffraction study allowing for Rietveld structural refinements to a high degree of accuracy.

Through careful control of the synthesis process, I have also studied and characterized the densification and transformation kinetics for the trigonal phase. Analysis of the real time deformation data during CAPAD processing reveals that the transformation mechanisms can be isolated from the densification mechanisms. The transformation process is analyzed using the KJMA model modified for constant heating and shows an activation energy of 74 kJ/mol. Transformation under isothermal conditions follows a second order rate law with a higher activation energy (448 kJ/mol) caused by differing degrees of transformation completion.

The amount of metastable phase can be controlled by varying the CAPAD processing parameters. Incorporating the metastable phase into the microstructure changes the thermal, electrical and Seebeck coefficient behavior. The first measurements of this trigonal phase show bipolar diffusion behavior at much lower temperatures than the previously reported Mg-Sn based materials without the metastable trigonal phase.