MSE SEMINAR

Materials Science and Engineering
Michigan Technological University

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Room 610, M&M Building

Synthesis, Measurement, and Characterization of Magnetoelastic Fe-based Alloys

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Abstract

Since the discovery of the extraordinary increase of magnetostriction strain in Fe-X alloys through the addition of non-magnetic gallium, investigations have sought to understand the origin of the enhanced magnetoelasticity and to tune the chemistry and optimize the magnetoelastic behavior of Fe-based solid solution alloys. Detail structural characterizations of Fe-Ga alloys suggest that a local clustering of gallium atoms may act as elastic dipoles, leading to enhanced magnetoelastic coupling. When combined with the dramatic softening of the shear modulus in this alloys, large increases in strain over pure Fe are found. First principle calculations also confirm that the local atomic structure is an important parameter in determining not only the value of strain but also the sign of the strain. In this presentation, I will review the development of the Fe-Ga (Galfenol) binary alloys for magnetostrictive application. These investigations utilize single crystalline measurements as single crystals provide the ideal vehicle to assess the effectiveness of the addition on the magnetostrictive properties by eliminating grain boundary effects, orientation variations, and grain-to-grain interactions that occur when polycrystals respond to applied magnetic fields. Results show that in the regions where monotonic increases in $(3/2)\lambda_{100}$ are exhibited, single phase A2 or $D0_3$ are found. For the alloys in the range of 18-21 at% Ga, quenching extends the single phase A2 to higher Ga concentrations thereby continuing to enhance magnetostriction. The sudden decrease in $(3/2)\lambda_{100}$ near Fe–19 at% Ga as well as Fe-29 at% Ga were associated with the formation of phase mixtures, either ($A2+D0_3$) or ($D0_3$ + unidentified secondary phases), respectively. For quenched alloys between 25 and 29 at% Ga, a phase mixture of ($A2+B2+D0_3$) was found although the presence of this phase mixture does not seem to have a large effect on magnetostriction. Similar magnetoelastic behavior is found for other alloy elements X including Al, Si and Ge. The general conclusion these results support is that phase stabilization of the disordered bcc structure is one of the key components to optimize magnetoelasticity of Fe-Ga alloys.

Bio: Dr. Lograsso received his Ph.D from MTU in 1986. Following graduate school he held a post doc position at Rensselaer Polytechnic working with Marty Glicksman on a space shuttle experiment called the Isothermal Dendritic Growth Experiment which eventually flew in the mid 1990's Prior to flight he left RPI and joined The Ames Laboratory in 1988 where he has held various positions. He currently serves as the Director of the Materials Science and Engineering Division at Ames Laboratory with a total research budget of $25M and approximately 175 research and administrative staff. His research group focuses on materials discovery and synthesis of novel alloy systems: solidification and single crystalline processing to the design structural intermetallic alloys, quasicrystalline compounds, active materials, giant rare earth based magnetocaloric compounds and rare earth free magnetostrictive rare earth alloys. Often the single crystals prepared are the first to be grown and characterized of a specific materials system. Current research activities include Fe-X based magnetostrictive alloys and FeAs-based superconductors.

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