Understanding the Magnetostructural Phase Transition Response: Effects of Nanostructuring

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ABSTRACT:

Materials systems that undergo magnetostructural phase transitions (simultaneous magnetic and structural phase changes) have the capability of providing exceptional functional effects in response to small physical inputs such as magnetic field, temperature and pressure. Owing to enhancement of the surface: volume ratio, such effects are expected to be amplified when the dimensions of the materials system are reduced to nanoscale. In this Ph.D. dissertation proposal, investigation of the correlations between the structural and magnetic properties of a selection of nanostructured compounds is anticipated to provide guiding principles for understanding and engineering phase transitions in magnetostructural materials for a wide array of technological applications including actuators and sensors. Chosen magnetostructural materials systems for this study include the near-equiatomic phases of FeRh, MnBi and, time-permitting, MnAs.

In this proposed work the physical dimensions of the selected materials systems will be nanostructured by two routes: (i) Rapid solidification processing; and (ii) Synthesis and post-deposition processing of thin films. The influence of the structural properties (Examples: interatomic distance, lattice distortion) on the magnetic characteristics (Examples: thermal hysteresis behavior, magnetic moment) of the magnetostructural phase transition response in the nanostructured systems will then be probed by a variety of techniques including x-ray diffraction, transmission electron microscopy and magnetometry. Additionally, the effects of annealing temperature,

magnetic field and pressure on the magnetostructural response will be examined. Comparison of the structure-property relations of nanostructured and corresponding bulk systems is anticipated to provide insight into the mechanism of magnetostructural phase transitions at the fundamental atomic level.

Preliminary studies have focused on understanding the effects of nanostructuring on the magnetostructural response of FeRh and MnAs. The properties of the nanostructured MnAs systems were consistent with previous reports in literature. FeRh was nanostructured via rapid solidification of an alloy of composition $(FeRh)_5Cu_{95}$, with the goal of precipitating nanoscaled FeRh in a Cu matrix upon annealing. Structural characterization of annealed $(FeRh)_5Cu_{95}$ ribbons confirms attainment of precipitates hypothesized to consist of FeRh, but with a CuAu-type structure, instead of the anticipated CsCl-type structure found in bulk FeRh. A highly-suppressed magnetostructural phase transition temperature was observed in the hypothesized nanoscaled FeRh phase ($T_{t,bulk}$ - $T_{t,nanoprecipitates}$=220 K). These results emphasize the sensitivity of the magnetostructural response to reduction in microstructural scale.