Characterization and Kinetics of the Magnetostructural Phase Transition in FeRh Thin Films

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Materials with coupled magnetic and structural phase changes — magnetostructural materials — may exhibit a large functional response to physical inputs such as small deviations in temperature, pressure, or magnetic field, and are thus of both basic scientific interest as well as technological interest for advanced sensors. In this proposed work, the near-equiatomic phase of FeRh serves as a test bed to understand the role of magnetic field, temperature, pressure (strain), and chemical modification on the character, kinetics and mechanism of the magnetostructural transition. These parameters are anticipated to provide a fundamental basis for future research to understand, predict and engineer phase transitions in magnetostructural materials for technological applications.

This proposal aims to characterize the magnetostructural transition and determine the impact of thickness and compositional variation on the degree of undercooling of the ferromagnetic (FM) phase, the energy barrier associated with the antiferromagnetic (AF) - FM and FM – AF transformations, and the nucleation and growth mechanism of FeRh thin films. These objectives will be accomplished through structural, thermal and magnetic characterization of high quality FeRh films of varied-thicknesses, ranging from 10 – 50 nm, grown by sputter deposition on (001)-oriented MgO substrates and capped with Al. Additionally, the effect on the magnetostructural transition of Au diffusion into the FeRh lattice will be characterized. These FeRh films will be probed with superconducting quantum interference device (SQUID) magnetometry, magnetic force microscopy, x-ray diffraction, reflectivity and magnetic circular dichroism (XMCD).

Preliminary results from SQUID magnetometry measurements on the varied- thickness films shows a linear increase in the AF-FM transition temperature (upon heating) with increasing film thickness, accompanied by a narrowed thermal hysteresis. These results suggest that the critical activation energy required for the onset of the AF-FM transition decreases with decreasing film thickness while the barrier to transformation of FM-AF transition increases. XMCD experiments indicate differences in the Fe spin and orbital magnetic moments of films. Furthermore, substitution of Au into the FeRh lattice decreases the transition temperature, broadens the thermal hysteresis and increases the sensitivity of the transition to applied magnetic field. These preliminary results confirm the sensitivity of the magnetostructural transition in FeRh to extrinsic parameters.