Studies of Unusual Ferromagnetic Materials

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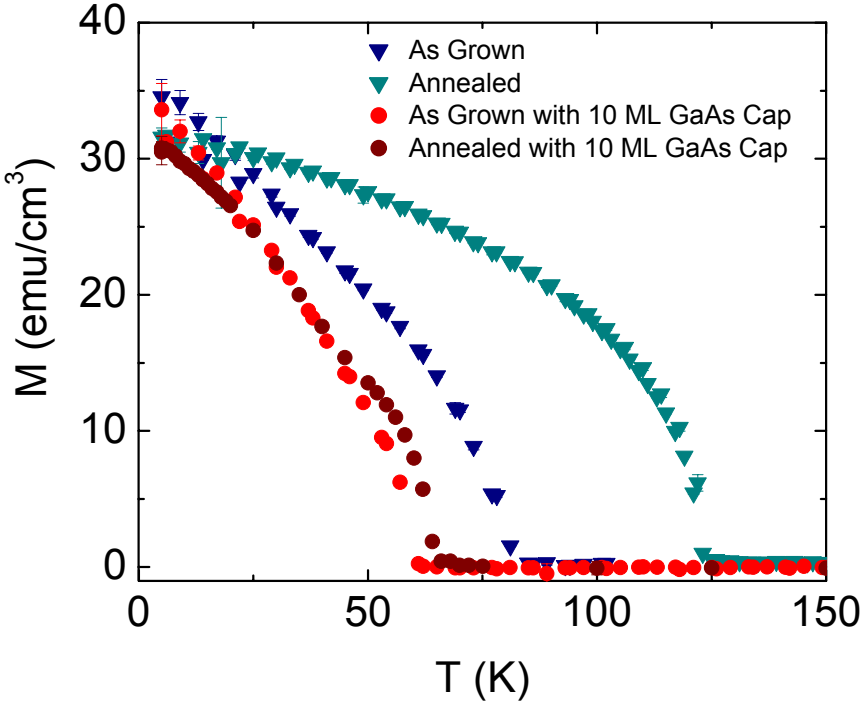
This grant's primary focus has been the study of unusual ferromagnetic materials with a particular emphasis on the properties of magnetoelectronic materials, those in which the electronic and the magnetic properties are closely coupled. These materials are especially promising for so-called "spintronic" applications where the magnetic moment of the electron would be exploited to allow greater device capabilities.

One such material is $Ga_{1-x}Mn_xAs$, in which a few percent of Mn added to the common semiconductor GaAs results in the appearance of ferromagnetism. We have studied the effects of annealing epilayers of this important model ferromagnetic semiconductor, looking at samples of varying thickness and samples on which we grow a thin "capping" layer of GaAs. The thinner samples show a marked enhancement in the onset temperature of ferromagnetism, and, even though the capping layer is typically a small fraction of the thickness of the ferromagnetic epilayer, we find that its presence significantly suppresses ferromagnetism in the as-grown samples and also significantly reduces the physical changes induced by annealing. These effects indicate that $Ga_{1-x}Mn_xAs$ epilayers incorporated in heterostructures will behave differently from single epilayer samples Since this material is of interest for spintronic devices composed of epitaxially grown heterostructures, these data are both of fundamental interest and also have potentially important implications for the design of such devices.



The magnetic moment as a function of temperature for a 50 nm thick film of the model ferromagnetic semiconductor, $Ga_{1-x}Mn_xAs$. The onset temperature of ferromagnetism can be enhanced by annealing, demonstrating that the magnetic properties are significantly controlled by defects. Furthermore, the addition of a thin non-magnetic GaAs cap on the thin film sample both suppresses ferromagnetism and the effects of annealing (Stone et al., Appl. Phys. Lett, 2003)