Magnetic Circular Dichroism Spectroscopy of InMnAs and InMnSb Ferromagnetic Semiconductors

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Introduction

In ferromagnetic semiconductors the spin splitting of the bands, especially the valence bands, are strongly influenced by the spontaneous magnetization and the exchange interaction between localized magnetic moments and the carriers. The difference of the splitting in the valence and the conduction bands reflect itself in different refractive indices for left and right circularly polarized components of the linearly polarized incident laser light. Magnetic circular dichroism (MCD) is used to investigate the evolution of ferromagnetism in several ferromagnetic semiconductors where in case of GaMnAs, Mn and holes produced two spectroscopically distinct contributions revealing an antiferromagnetic Mn-hole alignment in the ferromagnetic state. In this project we plan to probe the MCD of InMnAs and InMnSb structures with the Curie temperature of 300 K [1].

Experimental

In collaboration with Dr. McGill, our MCD measurements were performed using the split coil magnet, allowing the temperature to vary between 15-190 K and fields of up to 31.25 Tesla. The excitation source was a Quartz Tungsten Halogen lamp with the emitted light being passed through a monochromator set to have a bandwidth of 5nm. The light was polarized to 45 degree using a Glan-cube, and the polarization was altered between left and right handed circular polarization by a photo-elastic modulator. The signal was transmitted through a fiber and detected by an InGaAs detector. In order to remove background signals, the MCD presented here is the difference in transmission between right and left handed circular polarizations, averaged over positive and negative fields, and normalized to the intensity of the lamp. The samples studied here are MOVPE grown InMnSb structures grown at the Northwestern University in the group of Prof. Wessels [2].

Results and Discussion

Figure 1 shows an example of the MCD measurements at 15 K as a function of different magnetic fields. The amplitude of the MCD signal increases as a function of the magnetic field. The peaks represent several inter band transitions and we are collaborating with the group of Prof. Stanton at the University of Florida to model the transitions that can provide information about the band structure and the sp-d coupling parameters.

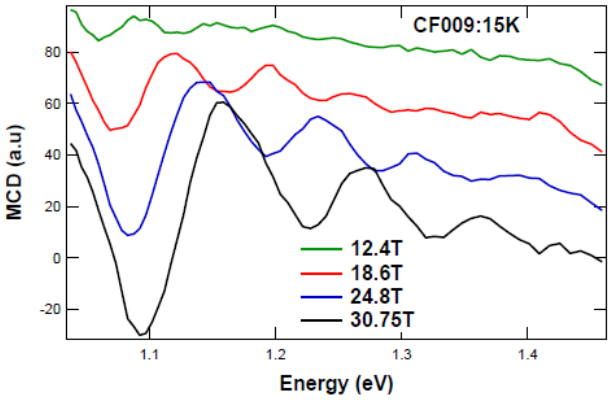

Fig. 1: An example of our MCD measurements on InMnSb with ~4.7% Mn content and a hole density of 2.2×10^{18} cm^{-3}. The intensity of the MCD spectra increases by increasing the magnetic field.

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References

[1] Parashar, N. D., *et al*., Phys. Rev. B **81**, 115321 (2010).
[2] Dobrowolska M., *et al*., Nature Materials **11**, 444 (2012).