

MAGNETIC CIRCULAR DICHROISM OF A DILUTE FERROMAGNETIC ALLOY (NI-MN)

K.R. Podolak¹, K.N. Altmann², T.R. Norman² and R.F. Willis¹

¹ Dept. of Physics, Penn. State, 104 Davey Lab., University Park, PA 16801

² Dept. of Physics, Elon University, 100 Campus Drive, Elon, NC 27244

There is much interest and debate concerning the origin of ferromagnetism in dilute alloys of $\text{Mn}_x\text{Ga}_{1-x}\text{As}$ and other magnetically doped semiconductors [1]. The Mn acts as an acceptor introducing itinerant holes into the semiconductor. The ferromagnetic (FM) coupling between the magnetic Mn^{2+} is thought to be via RKKY screening by the itinerant hole gas [2]. This coupling induces FM order at concentrations less than 10%, but increasing antiferromagnetic (AFM) disorder at higher concentrations. The Curie temperature T_C increases to a maximum of a few hundred K at around 8% alloying.

What has not been appreciated is that a similar behavior is observed in dilute alloys of $\text{Mn}_x\text{Ni}_{1-x}$, Figure. The mechanism of this spin-hole induced ferromagnetism is not understood. Semiconductors have a severe materials problem. The Mn can substitute at lattice sites interstitially with a finite-size energy gap. In Ni, the Mn atoms replace

Ni atoms and form a random alloy. The itinerant ferromagnetism is due to a gas of spin-holes. At low concentrations, the Mn increases the density of these spin-holes such that the average magnetization per atom increases along the -45° branch of the Slater-Pauling curve. At about 10% concentration, the nature of the FM coupling changes.

In an effort to understand this behavior, we have measured magnetic circular dichroism at the SRC at port 123 with the MCD chamber. Samples were epitaxially grown in UHV on Si(100) with a $\text{Cu}(30 \text{ \AA})/\text{Ni}_{1-x}\text{Mn}_x(100 \text{ \AA})/\text{Cu}(30 \text{ \AA})$ trilayer where x is the percent Mn desired for each sample. Calculations were performed to determine the magnetic moment at various saturation fields [3]. Results of these calculations will be presented.

The SRC is operated under Grant No. DMR-0084402.

References:

- [1] K.W. Edmonds, P. Boguslawski, K.Y. Wang, R.P. Campion, S.N. Novikov, N.R. S. Farley, B.L. Gallagher, C.T. Foxon, M. Sawicki, T. Dietl, M. Buongiorno Nardelli, & J. Bernholc, "Mn interstitial diffusion in (Ga,Mn)As," *Phys. Rev. Lett.* **92**, 037201 (2004).
- [2] T. Dietl, H. Ohno, F. Matsukura, J. Cibert, D. Ferrand, "Zener Model Description of Ferromagnetism in Zinc-Blende Magnetic Semiconductors," *Science* **287**, 1019 (2000).
- [3] T. Boske, W. Clemens, C. Carbone, and W. Eberhardt. "Circular magnetic x-ray dichroism of 3d impurities in Ni." *Physical Review* **B49**, 4003 (1994).

