III-N Based Dilute Magnetic Semiconductors for Spintronics Applications

Y. D. Park*
Center for Strongly Correlated Materials Research
& School of Physics
Seoul National University, Seoul, Korea 151-747

J.S. Lee, S.-Y. Lee, Z.G. Khim, Eunsoon Oh
School of Physics
Seoul National University, Seoul, Korea 151-747

G.T. Thaler, M.E. Overberg, C.R. Abernathy, S.J. Pearton
Department of Materials Science and Engineering
University of Florida, Gainesville, FL 32611

J.-H. Kim, F. Ren
Department of Chemical Engineering
University of Florida, Gainesville, FL 32611

First observations of ferromagnetic ordering in III-Mn-V compound semiconductors have initiated much renewed interest in dilute magnetic semiconductors (DMS). Incorporation of ferromagnetic properties promises to add new dimensionality and functionality to already well-established semiconductor electronic devices.[1] Although first observed DMS[2] with ferromagnetic ordering, InMnAs and GaMnAs, suffer from low ferromagnetic ordering temperatures (Tc < 110 K), their discovery and attempts to fully understand their ferromagnetic origins had set forth theoretical works[3] that predict promising and truly applicable properties for GaN based DMS. Realization of such material has been accomplished by varying techniques such as diffusion of Mn in GaN film, ion-implantation, and epitaxial growth using molecular beam epitaxy.[4] For functional devices, ion-implantation and epitaxial growth promise to be most easily suited. We report on the magnetic properties of epitaxial (Ga,Mn)N prepared by molecular beam epitaxy. The films show magnetic signals at and above room temperatures from magnetic hysteresis loops and magnetic temperature dependence measurements using Superconducting Quantum Interference Device (SQUID) magnetometer. We will also present incorporation of (Ga,Mn)N DMS layer as a spin-injection source for an InGaN based light emitting diodes (LEDs) and discuss various issues incorporating DMS, specifically (Ga,Mn)N, for spintronics applications.

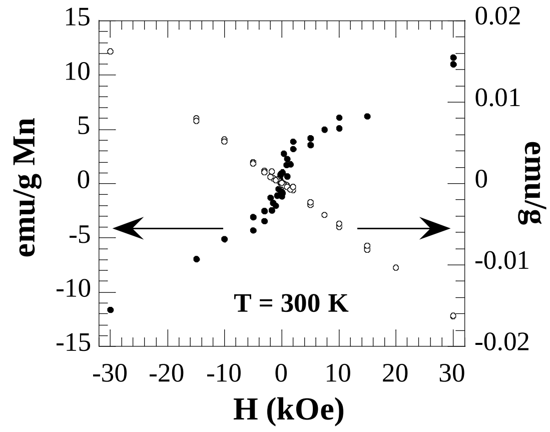

Figure 1 – Magnetization (emu/g) vs. Applied field for $(Ga_{1-x},Mn_x)N$ (close circle) and sapphire substrate (open circle).

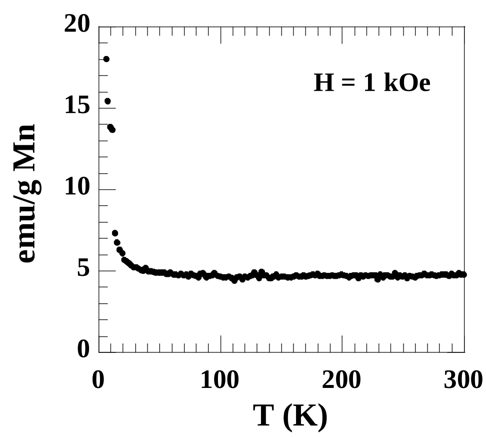

Figure 2 – Magnetization (emu/g) vs. Temperature (K) (5K – 300K) for $(Ga_{1-x},Mn_x)N$. After careful background subtraction, significant magnetization persists up to 300 K. Low temperature ordering is attributed to possible Mn-Mn nearest neighbor interactions.

* Supported by SNU Research Foundation and Samsung Electronics Endowment through CSCMR.

[1] S.A. Wolf *et al.*, *Science* **294**, 1488 (2001).
[2] H. Munekata, H. Ohno, S. von Molnar, A. Segmüller, L. L. Chang, and L. Esaki, *Phys. Rev. Lett.* **63**, 1849 (1989); H. Ohno *et al.*, *Appl. Phys. Lett.* **69**, 363 (1996).
[3] T. Dietl *et al.*, Science **287**, 1019 (2000).
[4] M.L. Reed *et al.*, *Appl. Phys. Lett.* **79**, 3473 (2001); M.E. Overberg *et al.*, *Appl. Phys. Lett.* **79**, 1312 (2001); N. Theodoropoulou *et al.*, *Appl. Phys. Lett.* **78**, 3475 (2001).