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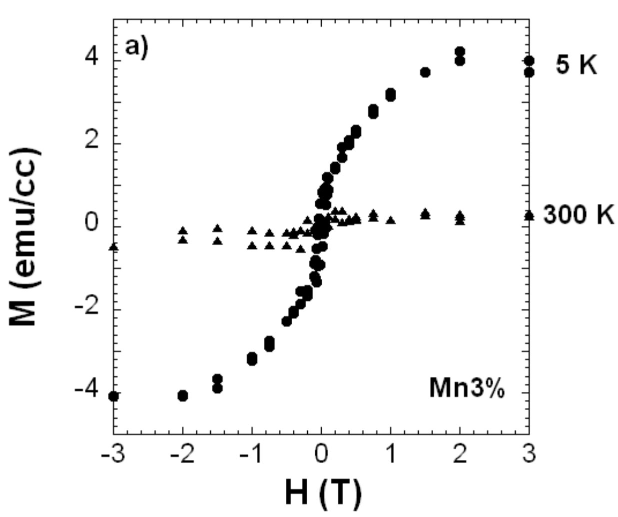
Anomalous Hall Effect in Wide Bandgap Diluted Magnetic Semiconductors *

Y.D. Park
CSCMR & School of Physics
Seoul National University NS50, Seoul 151-747 Korea

Since the first observations of spontaneous magnetization in (In,Mn)As and (Ga,Mn)As, anomalous Hall Effect (AHE) measurements have had a critical role in indirectly relating transport properties to the magnetic properties of diluted magnetic semiconductors (DMS). Without AHE, such novel demonstrations as electrical field control of magnetic properties in DMS would not be possible as direct magnetization measurements would be difficult.[1] Although magnetic ordering temperatures (T_C) for antecedent DMS systems have shown marked increases, wide bandgap DMS show promise for device application due to its relatively high T_C's, both predicted and observed.[2] Initial wide bandgap DMS systems such as (Ga,Mn)N and (Ga,Mn)P, although exhibiting high T_C, suffered from low carrier concentration as unlike (Ga,Mn)As and (In,Mn)As, Mn impurity does not readily act as source of both magnetic impurity and free carriers in the host matrix. Thusly, magnetic ordering mechanism in wide bandgap DMS is thought due to percolating networks of localized spin-polarized carriers.[3] Recently, co-doping of wide bandgap DMS systems with magnetic and either readily acceptor/donor impurities have shown promise in increased magnetic and transport properties.[4]

Magneto-transport properties, especially Hall Effect measurements, of various wide bandgap DMS systems (with and without co-dopant) will be presented. For III-Mn-As DMS, carbon co-doping was found to enhance magnetic properties. For (Al,Mn)(As,C), AHE was observed for temperatures correspond to its magnetic properties. For Mn doped GaN, both n-type and p-type co-dopant schemes, although free carrier concentrations increased, were found not to be sufficient to relate AHE with magnetic properties, as AHE was observed for n-type (GaMn)(NO) samples at very low temperatures only. Along with wide bandgap III-V DMS systems, magneto-transport measurements of various oxides will be presented along with origins of AHE in DMS systems, in general.



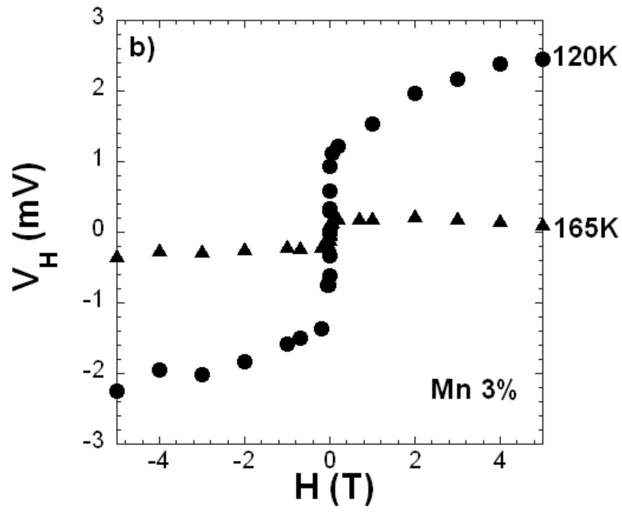


Figure – a) Magnetization as function of applied magnetic field at 5 K and 300 K and b) Hall effect measurement at 120 K and 165 K for AlAs:C co-doped with Mn, ion-implantation dose of 3 x 10^{16} cm^{-2}, corresponding to ~ 3 atm. %.

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1 H. Ohno *et al.*, Nature (London) **408**, 944 (2000); Y.D. Park *et al*., Science **295**, 651 (2002); A.M. Nazmul *et al.*, Phys. Rev. B **67**, R241308 (2003).

2 S.J. Pearton *et al.*, J. Appl. Phys. **93**, 1 (2003); S.J. Pearton *et al*., Mater. Sci. Eng., R. **286**, 1 (2003).

3 M. Berciu and R.N. Bhatt, Phys. Rev. Lett. **87**, 107203 (2001); A. Kaminski and S. Das Sarma, Phys. Rev. Lett. **88**, 247202 (2002).

4 T.H. Fukumura *et al*., Nat. Mater. **3**, 221 (2004); S.R. Shinde *et al*., Phys. Rev. Lett. **92**, 166601 (2004).