D-5

Controlling carrier types in $MnGeAs_2$ and $MnGeP_2$ thin films

Jeongyong Choi[1]*, Sunglae Cho[1,2], Sungyoul Choi[3], Young-Hun Hwang[1]
[1]Department of Physics, University of Ulsan
[2]Nanodevice Research Center, Korea Institute of Science and Technology
[3]Tera Electronic Device Team, Electronics and Telecommunications Research Institute

The research for promising ferromagnetic semiconducting materials, whit high magnetic moments and high Curie temperature (T_C), is of the utmost importance spin-dependent electronic devices. We have synthesized a new semiconductor, $MnGeAs_2$, whose crystal structure is chalcopyrite, which are "genealogically" related to the more familiar tetrahedral coordinated zinc-blende materials. It showed ferromagnetism with T_C = 340 K, and magnetic moment per Mn at 5 K of 3.42 μ_B, comparable to the calculated 3.2 μ_B. The calculated plane wave (FLAPW) method shows an indirect energy gap of 0.06 eV.[1]

Here we will present the structural and magnetic properties of $MnGeAs_2$ thin films grown on GaAs(100) using molecular beam epitaxy. The growth temperature was 350 ℃ and the growth rate of Mn and Ge were 0.25 Å/s under arsenic ambience. Structural properties were investigated using RHEED, XRD, AFM, and TEM studies, resulting in the chalcopyrite crystal structure of $MnGeAs_2$. The temperature dependent resistance results strongly support the presence of ferromagnetic phase transition around 340 K determined in magnetization measurement. On the other hand, we observed an anisotropic magneto-resistance and an anomalous Hall effect in n-type ($\sim 10^{20}$ cm^{-3}) $MnGeAs_2$ thin film, indicating the presence of spin polarized electron carriers in $MnGeAs_2$.

Magneto-transport properties will be discussed in detail. $MnGeP_2$ show a p-type. It is well known that various native defects such as group II and V vacancies and antisite defects are present in II-IV-V_2 chalcopyrite with densities up to 10^{20} cm^{-3}. The p-type behavior of $MnGeP_2$ may arise from native point defects such as cation Mn and Ge vacancies and antisite defects: Mn_{Ge} and the n-type carrier for $MnGeAs_2$ from anion As vacancies and antisite defects: Ge_{Mn}.

These defects were depending on the ratio of ambient P and As for the growth of $MnGeP_2$ and $MnGeAs_2$ thin films. In this talk we will present the efforts on controlling the carrier types and carrier concentrations in $MnGeP_2$ and $MnGeAs_2$ thin films.

Reference

[1] S. Cho *et al.*,, Solid State Commun. **129** (2004), p. 609.