Introduction

Incorporation of transition metals such as Mn to III–V semiconductor compounds exhibits ferromagnetism in addition to conventional semiconductor properties. Itinerant carriers are known to be responsible for the ferromagnetism in these semiconductors. Finding of a ferromagnetic semiconductor (FMS) opened a new research area of spintronics for which electronic charge and spin can be controlled by changing external conditions. We tried to investigate impurity levels of three different kinds of Mn doped compound semiconductor epilayers (InP, GaAs, ZnO). Among them, InP is one of representative compound semiconductors because it has good optical properties. GaAs:Mn systems are most intensively investigated among the DMS family. We prepared neutron-transmutation-doped (NTD) GaMnAs epilayers for magneto-PL measurements. The last one is ZnO:Mn/Fe epilayers. Recently many research groups investigate ZnO semiconductor for white LED and flexible display applications. Mn(Fe)-doped ZnO system is also a good candidate for high Curie temperature DMS.

Experimental Results and Discussion

To prepare GaAs system, we first made NTD GaAs and then implant Mn ions using 200 keV ion implant machine. Magneto-PL shows two broad peaks in low magnetic fields, which are neutral donor to neutral acceptor pair (DAP) transition (~1.40 eV) and its phonon replica (1.37 eV). This broad DAP indicates that the sample quality is poor. It is reported that a good quality sample shows doublet transition behavior - DAP and (e,Mn) transitions and they exhibit different magnetic field dependency. In contrast, poor quality sample does not show any magnetic field behaviors up to 15 T. [1] In this experiments, we found that even for a poor quality sample, a broad DAP transition exhibits doublet splitting in high magnetic fields. Therefore, we conclude that conduction band to deep acceptor transition (e, Mn) is a general optical transition behavior for GaMnAs system.

For InP epilayers (doped with Zn), Hall measurement shows p-type conductivity with carrier concentration of 2.0×10^{18} cm^{-3}. For Mn doping, Mn was evaporated on top of InP:Zn epilayers in a MBE machine and a high temperature (650 °C) thermal treatment was followed. For magneto-PL measurements, we observe a band-related transition which shows a simple diamagnetic behavior to ~45 T. We will prepare new samples for future experiments in pulsed magnetic fields.

We try to measure magneto-PL transitions of Mn-doped ZnO bulk single crystals. However, due to low laser power along with short data acquisition time (<2 ms/spectrum) in pulsed magnetic fields, we are not able to observe PL spectra. As seen in Fig. 2, Fe doped ZnO is a good candidate for future magnetic fields study.

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