MAGNETO-TRANSPORT STUDIES OF FERROMAGNETIC (Ga,Mn)As HETEROSTRUCTURES

Abstract

by

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A magneto-transport study is presented of the (Ga,Mn)As thin films and their heterostructures grown in ultra-high vacuum molecular beam epitaxy (UHV MBE) chamber. The study includes the investigation of the anomalous Hall effect (AHE) in (Ga,Mn)As epilayers, as well as the investigation of planar Hall effect (PHE) in (Ga,Mn)As-based heterostructures. The heterostructures include the exchange-bias (EB) structures composed of (Ga,Mn)As/MnO, and magnetic tunneling junction (MTJ) structures in which two ferromagnetic (Ga,Mn)As layers are separated by non-magnetic GaAs spacer.

In the AHE study, experiments were carried out on a series of samples with various Mn concentrations x, ranging from 1.4% to 8%. Results indicate that samples with $x < 3\%$ are insulating while those with larger x are metallic. We found that for the insulating samples the transport mechanism at low temperature is a phonon-assisted hopping, and we observed a sublinear relationship between the traverse resistivity ρ_{xy} and the longitudinal resistivity ρ_{xx}. For the metallic samples, we found that there is a competition between the intrinsic component of the AHE, which dominates at low

temperatures, and the extrinsic component, i.e., the one related to impurity scattering, which dominates at elevated temperatures.

For (Ga,Mn)As-based heterostructures (both EB structures and MTJ structures), we investigated the response of the magnetization of the (Ga,Mn)As layers to the sweeping magnetic field taking advantage of the PHE technique. The high sensitivity of PHE to the direction of magnetization allowed us to track the magnetization reversal process in a more appropriate way. Results obtained on the EB structures show that the interfacial coupling is of ferromagnetic (FM) type, yielding an effective EB field up to 150 Oe, which changes the magnetization reversal process and domain wall structures in the (Ga,Mn)As profoundly. Moreover, the interfacial coupling increases the Néel temperature of the MnO layer compared to its intrinsic value (110K). We also found that in MTJ structures, the interlayer exchange coupling (IEC) between two (Ga,Mn)As layers oscillates between the FM type and antiferromagnetic type as a function of the spacer thickness.