INVESTIGATION OF MAGNETOTRANSPORT PROPERTIES IN III-Mn-V FERROMAGNETIC SEMICONDUCTORS

Abstract

by

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III-Mn-V ferromagnetic semiconductors—GaMnAs, InMnAs, InMnSb, and GaMnSb—are studied experimentally using electrical transport techniques, with emphasis on resistivity, anomalous Hall effect (AHE), anisotropic magnetoresistance (AMR), and planar Hall effect (PHE). All III-Mn-V samples were grown by low temperature molecular beam epitaxy (LT-MBE). The structures of the samples are as follows: (i) GaMnAs/GaAlAs heterostructures and GaAlAs/GaMnAs/GaAlAs quantum wells modulation-doped by Be atoms in GaAlAs layers; (ii) InMnAs grown on InAlAs/AlSb buffer layers; (iii) a new narrow-gap ferromagnetic semiconductor InMnSb grown on InSb/CdTe substrates; (iv) GaMnSb epilayers grown on ZnTe or GaSb buffer layers; (v) two structurally different forms of GaMnAs alloys (i.e., random and digital alloys); and (vi) GaMnAs films grown on vicinal GaAs substrates. Measurements of resistivity in III-Mn-V alloys serve to establish the Curie temperature, and to provide an indication of whether the specimen is metallic or insulating. Anomalous Hall effect measurements are used to establish the presence of ferromagnetic order and to investigate the scattering mechanisms (skew or side-jump) in III-Mn-V alloys.

The planar Hall effect (PHE), an effect stemming from anisotropic magnetoresistance, is used to investigate the transitions in orientation of the in-plane magnetization

that accompany the process of magnetization reversal, in order to probe magneto-crystalline anisotropy, and to obtain insight into the effect of domain wall pinning on these transitions. The in-plane anisotropy fields determined via PHE provide compelling proof that the samples can be satisfactorily described by the Stoner-Wohlfarth single magnetic domain model.

A striking asymmetry is observed in magnetic field dependence of the planar Hall resistance in GaMnAs films grown on vicinal substrates, caused by the superposition of PHE and AHE. This asymmetry reflects the effect of magneto-crystalline anisotropy in GaMnAs, that confines the magnetization **M** to a preferred crystal plane rather than to the plane of the film, which in vicinal samples gives rise to a non-zero component of **M** normal to the sample plane. This asymmetry allows one to obtain four distinct zero-field resistance states in vicinal GaMnAs films that depend on the history of the experiment, making it of potential interest for building a unique four-state memory device.