ABSTRACT

The cantilever beam magnetometer (CBM) was designed, fabricated and demonstrated its ability to measure the electric field induced magnetization of the ferroelectric/ferromagnetic (FE/FM) heterostructures and electro-elastic effect of 1st order (converse piezoelectric) of piezoelectric materials at room temperature in addition to the conventional measurement of magnetic properties (magnetization, magnetocrystalline anisotropy and magnetostriction (in-plane and out-of-plane) of ferromagnetic materials as a function of magnetic field. In this new design of CBM we have introduced double cantilever beam and demonstrated for simultaneous characterization of two samples under same external parameters (magnetic field or electric field). We have studied thin films of ferrites (Fe_3O_4 and $NiFe_2O_4$) and $BaTiO_4$ (ferroelectric) and their heterostructures using this upgraded CBM. This magnetometer is simple in construction, inexpensive to manufacture and easy to operate. In this thesis, we also present a new mechanical design and fabrication of Liquid Nitrogen (LN_2) flow cryostat for low temperature measurements in CBM set-up and demonstrated the measurements of magnetostriction of $NiFe_2O_4$ thin film in the temperature range of 100 – 300 K. The electro-magnetic transport measurements were carried out on ferrite/semiconductor heterojunctions and found interesting results for device applications. Fe_3O_4/p-Si heterojunction showed backward rectifying property at all temperatures and enhanced giant junction magnetoresistance (JMR) at room temperature (RT). Evidently, the variation and sign change of JMR as a function of electric field is also observed at RT. The origin of electric field dependence of magnetoresistance is explained proposing electronic band diagram of Fe_3O_4/SiO_2/p-Si heterojunction. The Mn and Zn doped $Fe_{3-x}M_xO_4$(M = Mn and Zn)/p-Si heterostructures showed not only an electrical dependent JMR at RT in reverse bias, but also observed the magnitude and sign changes of JMR with manganese and zinc substitutions. The variation of the JMR due to the dopant of different types attributed to the variation of the magnitude of saturation magnetization, as evidenced by M-H measurements. Electronic band structure of the Fe_3O_4/SiO_2/p-Si heterostructure and the p-type degenerate semiconducting (SC) feature of Mn and Zn substituted $Fe_{3-x}M_xO_4$ films are considered to explain the results.

Keywords: Cantilever Beam Magnetometer, Ferromagnetic/Ferroelectric Heterostructure, Magnetostriction, Electric Field Induced Magnetization, Liquid Nitrogen Flow Cryostat, Backward Rectifier