Abstract

The thesis presents the results of the study of the growth and the characteristics of magnetic impurity doped Ge and Cu for spintronics and GMR applications.

Ge nanowires were fabricated on Au-coated Si (100) substrates using vapor-liquid-solid (VLS) technique. Temperature dependent photoluminescence spectra of Mn-doped nanowires showed dominant impurity emissions due to transition from an intermediate $^{4}\mathbf{T_1}$ to $^{6}\mathbf{A_1}$ ground state of Mn^{2+} in Ge nanowires. The magnetic hysteresis loop showed paramagnetic to ferromagnetic transition with decreasing temperature. Temperature dependent electrical resistivity indicated the formation of Mn related acceptor level in Ge at 0.159 eV from the valence band.

We have fabricated self-assembled magnetic semiconducting GeMn nanowires (NWs). Temperature dependent clustering or precipitation of Mn-rich phase in Ge matrix were studied. Structural and magnetic measurements showed that nanometer-sized Mn-atomic clusters of 3-4 nm in diameter were formed in precipitate-free GeMn NWs (precipitate-free clustered NWs) at 600 ^{o}C, whereas nanometer-sized Ge_3Mn_5 precipitates of 8-10 nm in diameter were formed in cluster-free Ge NWs (cluster-free precipitated NWs) at 900 ^{o}C. Precipitate-free clustered NWs showed magnetic transition temperature (T_C) of ~108 K and blocking temperature (T_B) of ~110 K, whereas cluster-free precipitated NWs showed T_C and T_B of ~293 K and ~275 K, respectively.

We have synthesized Ge-based magnetic diode composed of a Mn-doped Ge film grown on lightly As-doped Ge on silicon substrate. p-$Ge_{1-x}Mn_x$/n-Ge heterostructure behaves like a conventional diode under forward and reverse bias and works like a spin valve below Curie temperature (~50 K) under zero (B=0) and nonzero (B=300 mT) magnetic field at forward bias (+2 Volt). A hysteretic behavior of p-n junction current with small coercive magnetic field implies the non-volatility of the diode. Thus, a single element of p-$Ge_{1-x}Mn_x$/n-Ge on silicon substrate deserves non-volatility, rectification and spin valve like functionality.

$Cu_{0.95}Co_{0.05}$ ribbon samples were prepared by melt spinning method to perform systematic investigations on structural and transport properties as a function of annealing temperature. X-ray diffraction (XRD) study showed that the ribbons were polycrystalline with a strong <200> texture along the surface normal of the as-quenched $Cu_{0.95}Co_{0.05}$

sample. The compressive stress was observed in as-quenched ribbon, which relaxed upon annealing. The resistivity decreased towards the bulk value of Cu upon annealing, which was higher in as-quenched ribbon. The compressive stress and higher resistivity in as-quenched ribbon could be attributed to the incorporation of Co atoms/particles in Cu matrix. The magnetic measurement showed that the ribbon behaves as superparamagnetic at room temperature, but ferromagnetic at 5 K. The grown ribbon showed GMR effect, which was 4% for as-quenched sample, which could be enhanced to 27% upon annealing at 550 °C. The enhancement of GMR was attributed to the increment of the number density of Co-rich Cu particles upon annealing.

Keywords: Dilute magnetic semiconductor. spintronics, hysteresis, resistivity, memory.