Materials Science & Engineering Thesis Defense

Study Of Doped Magnetic Systems

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abstract

Doping and alloying agents are commonly used to engineer the properties of magnetic materials. This study investigates the effects of doping manganese in thin films of Ni80Fe20 (permalloy) and Ni65Fe15Co20 magnetic systems for low power memory technologies, including those that operate at low temperature. Elemental manganese is anti-ferromagnetic with a Neel temperature of 100 K. When used as a dopant in a magnetic material, it is found to often align its moment in an antiferromagnetic direction. Thus, the addition of manganese might be expected to reduce the overall saturation magnetization (Ms) of the magnetic system. In this study, we show that the use of manganese dopants in Ni80Fe20 (permalloy) and Ni65Fe15Co20 thin films can reduce their saturation magnetization and still retain excellent switching properties. Magnetic properties and transport properties were determined using Vibrating Sample Magnetometer. A 19% decrease in the Ms of (Ni80Fe20)(1-x)Mn(x) thin films and a 36% decrease for (Ni65Fe15Co20)(1-x)Mn(x) thin films for dopant levels of x = 30%. The impact of depositing a ruthenium (Ru) under-layer for (Ni65Fe15Co20)(1-x)Mn(x) system was also studied. The structural (lattice parameters and phases), surface (roughness and topography) and electrical properties (resistivity and mean free path) of the Mn-doped Ni65Fe15Co20 films were determined with X-Ray Diffraction, Atomic Force Microscopy and Four-Point probe technique respectively.The properties were analyzed and Ni65Fe15Co20 system with Ru under-layer with 20 at. % Mn content was found to exhibit the following low-field switching properties at 10 K; Ms~700 emu.cm-3, easy axis coercivity ~10 Oe and hard axis coercivity ~5 Oe, easy axis squareness ~0.9 and anisotropy field ~12 Oe, that are deemed useful for low-power memory applications that could be used at cryogenic temperatures. To determine the transport properties thought these magnetic layers for use in superconductor/ferromagnetic memory structures, a study of the oxidation conditions of Al films was performed in order to produce a reliable aluminum oxide tunnel barrier on top of these films. The production of N-I-F-S (Normal metal-Insulator-Ferromagnet-Superconductor) tunnel junctions will allow for the investigation of the tunneling density of states as a function of ferromagnetic layer thickness, allowing for the determination of important transport parameters relevant to magnetic barrier Josephson junction devices.

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