MAGNETORESISTANCE AND MICROSTRUCTURE OF MAGNETIC THIN FILM MULTILAYERS

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Abstract

The magnetic properties and the magnetoresistance in correlation with microstructural properties of [NiFe(t)/Cu(s)/NiFe(t)] and [NiFe(t)/Mo(s)/NiFe(t)] multilayers have been investigated. The thickness (t) of permalloy (Ni 80%Fe 20%) layers was ranged from 4 to 12 nm, while the copper and molybdenum layers (s) was ranged from 3 to 8 nm. The multilayers exhibit magnetoresistive properties correlated with microstructure and roughness at the interface of permalloy film and cooper or molybdenum layer. By decreasing of the NiFe layer thickness and by increasing of the non-magnetic interlayer thickness, the influence of interfacial intermixing effects on magnetic properties become more important. Although the thickness of layers has the leading part for magnitude of Giant Magnetoresistance effect, the microstructural properties of interfaces and the grain boundaries scattering must not be neglected.

1. Introduction

The magneto-transport properties of ferromagnetic/nonmagnetic/ferromagnetic multilayers are dependent of the thickness of thin films, the roughness and the nature of thin film. Giant Magnetoresistance (GMR) effect results from two factors:
(1) spin dependence of the electronic band structure of a defect-free system, and
(2) spin dependence of scattering potential [1].

The aim of this paper is to investigate the influence of nature and microstructure of spacer-layer and influence of interface roughness on the magnetoresistance properties of the multilayers [NiFe(t)/Cu(s)/NiFe(t)]_{n} and [NiFe(t)/Mo(s)/NiFe(t)].

2. Experimental

Four types of samples are considered in this paper:
1) Si/SiO_{2}/Permalloy Ni 80%Fe20% monolayer films
2) Si/SiO_{2}/Py (10 nm)/Cu (4 nm)/Py(10 nm) in which Py is Ni_{80}Fe_{20}.
3) Si/SiO /Py(10 nm)/Mo(6 nm)/Py(10 nm)

4) Si/SiO₂/[Py(10 nm)/Cu (4 nm)]ₙ/Py(10 nm)

Permalloy Ni₈₀Fe₂₀% monolayer films were deposited, with thickness in range 4-100 nm, using high vacuum evaporation with a base pressure of 10⁻⁷ Torr, on Si/SiO₂ substrates. During deposition the magnetic field of 15 kA/m was applied in the plane of the substrates in order to induce an easy magnetization axis in the films. The multilayers were prepared by R.F. sputtering at a base pressure of 10⁻⁷ Torr and an argon pressure of 1.5 mTorr (target to substrate distance is 100 mm). As substrates we used Si (100) single-crystal wafers, cut to a size of 5x10 mm², with a thickness of 0.5 mm. Prior to insertion into the sputtering machine, the substrates were chemically etched using a 2% HF solution to have a flat surface and then oxidized.

The permalloy layer thickness (t) was changed from 4 to 12 nm, while the copper and molybdenum layers thickness (s) was changed from 3 to 8 nm. The number of layers n for multilayer [Ni₈₀Fe₂₀ (10nm)/Cu (4nm)/Ni₈₀Fe₂₀ (10nm)]ₙ was up to 10.

3. Results

The magnetization measurements were performed at room temperature using a vibrating sample magnetometer (VSM). The magnetoresistance effect measurements were performed at room temperature in four-point contact geometry with the contacts in line, using a DC current of 10 mA. The magnetoresistance measurements of permalloy (Ni₈₀Fe₂₀) films were made for two configurations: a) magnetic field applied parallel to the current direction and b) magnetic field perpendicular to the current direction. The magnetoresistance (MR) is defined as the variation $\Delta R=(R_H-R_0)$ of the resistance due to magnetic field normalized by the resistance $R_0$ at zero magnetic field: $MR=\frac{\Delta R}{R_0}$.

The magnetic properties of Si/SiO₂/Py(10 nm)/Cu (4 nm)/Py (10 nm) trilayer has presented in figure 1. The magnetic field is applied in the film plane, directed along the easy axis.

Figure 1. Magnetization curve measured at room temperature for NiFe (10 nm)/Cu (4 nm)/NiFe (10 nm) trilayer with magnetic field applied in the film plane directed along the easy axis.