Dependence of GMR of Ni-Co(Cu)/Cu Multilayers on Composition and Number of Layers

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Introduction: Electrodeposited multilayers show lower giant magnetoresistance (GMR) than multilayers deposited by sputtering. Many researchers are trying to improve GMR of multilayers produced by the electrodeposition method. We report GMR in Ni-Co(Cu)/Cu multilayers deposited from a citrate electrolyte by a potentiostatic two-pulse plating method as a function of the thickness of magnetic and nonmagnetic layers and of the number of layers. The effect of composition of the ferromagnetic layer on GMR has been studied.

Experimental: Ni-Co(Cu)/Cu multilayers were deposited on gold coated silicon disks from a citrate electrolyte containing $CuSO_4$, $NiSO_4$, $CoSO_4$ and $Na_3C_6H_5O_7$ in a flow cell by two-pulse plating. The pH of the electrolyte was adjusted to 6. A low pulse of –0.6 V and a high pulse of –2 V vs. copper reference were applied to deposit Cu and Ni-Co(Cu) layers, respectively. The flow rate was 40 cm^3s^{-1}. Magnetoresistance (MR) measurements were carried out at room temperature with magnetic fields up to 8 kOe in the current–in-plane configuration.

Results and Discussion: Fig. 1 shows the MR curves for a Ni-Co(Cu)/Cu multilayer. Since both the longitudinal and transverse components are negative, this indicates a GMR behavior. Fig. 2 shows the MR values measured at H = 8 kOe as a function of the magnetic and nonmagnetic nominal layer thickness. When the magnetic layer is as thin as 20Å, lower GMR is observed. This is possibly due to the discontinuity of the Ni-Co(Cu) layers. However, the decrease of GMR with increasing thickness of magnetic layer is due to the larger contribution of anisotropic magnetoresistance (AMR). The figure also shows that GMR decreases with the increase of nonmagnetic layer thickness.

Fig. 3 shows that GMR increases with the increase of the number of layers of Ni-Co(Cu)/Cu multilayers. A similar effect has been found in electrodeposited Ni(Cu)/Cu[1] and Co(Cu)/Cu[1] and sputter deposited Fe/Cr[2] multilayers. Fig. 4 shows that GMR of Ni-Co(Cu)/Cu multilayers depends on the relative amount of Ni and Co present in the ferromagnetic layer. The extrapolations of the curves suggest that Ni(Cu)/Cu or Co(Cu)/Cu multilayers would show lower GMR than Ni-Co(Cu)/Cu. Therefore, comparable samples of these three types of multilayers were plated under identical conditions and the results, which have been shown in Fig. 3, show that Ni-Co(Cu)/Cu multilayers show much higher GMR than the binary multilayers. Co(Cu)/Cu shows higher GMR than Ni(Cu)/Cu despite structural flaws[3], which occurs due to the dissolution of Co during the deposition process. The presence of Ni decreases Co dissolution in great extent. It acts as 'cement' and traps Co in the alloy[4] forming more stable ferromagnetic layers.

Conclusion: Ni(Cu)/Cu, Co(Cu)/Cu and Ni-Co(Cu)/Cu multilayers, deposited from citrate electrolytes in a flow channel cell, show GMR. GMR of Ni-Co(Cu)/Cu depends on the thickness of both magnetic and nonmagnetic layers. GMR increases with the increase of the number of layers. GMR of Ni-Co(Cu)/Cu multilayers depends on the relative amount of Ni and Co present in the ferromagnetic layer. Ni-Co(Cu)/Cu exhibits much higher GMR than Ni(Cu)/Cu and Co(Cu)/Cu multilayers.

References: 1. S. M. S. I. Dulal, E. A. Charles, L. Peter, I. Bakonyi and S. Roy, "Giant Magnetoresistance in Electrodeposited Cu/Ni, Cu/Co and Cu/Ni-Co Multilayers", Electrochem 2002, September 2002, Preston, UK.
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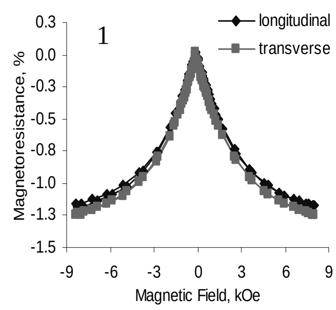

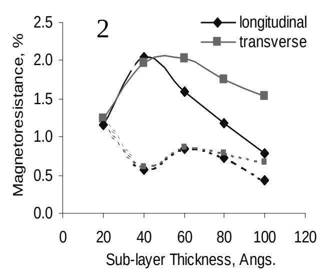

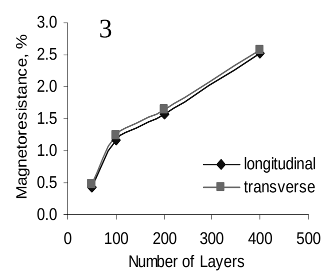

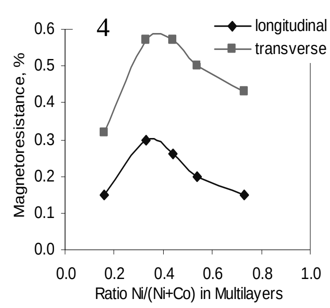

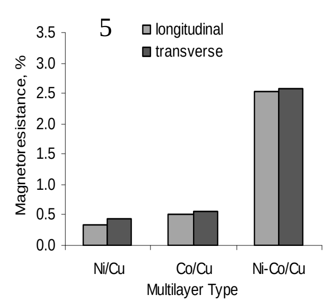

Legends: 1. Magnetoresistance curves of a 100xNi-Co(Cu)(20Å)/Cu(20Å) multilayers.
2. Effects of Ni-Co(Cu) (solid lines) and Cu (dotted lines) layer thickness on GMR of 100xNi-Co(Cu)(20Å)/Cu(20) multilayers.
3. Effect of the number of layers on GMR of Ni-Co(Cu)(20Å)/Cu(20Å) multilayers.
4. Effect of composition on GMR of 50xNi-Co(Cu)(60Å)/Cu(60Å) multilayers.
5. Comparison among GMRs of 100x[Ni(Cu)(20Å)/Cu(20Å), Co(Cu)(20Å)/Cu(20Å) and Ni-Co(Cu)(20Å)/Cu(20Å)] multilayers.