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Effect of Annealing on Exchange Biasing in [Ni/Mn] Superlattice Based Spin Valves

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1. Introduction

An important issue for spin valve device applications is good thermal stability so that the head characteristics do not change over time and at elevated temperatures [1], which is approximately 100℃~300℃ due to heating by the sense current [2] and electrostatic discharge [3]. Generally the magnetic and transport properties of the annealed spin-valve structures degrade with temperature. The fabrication of a [Ni/Mn] superlattice instead of a NiMn alloy film [4] should enhance the exchange coupling and thermal stability.

2. Experimental

The [Ni(1.8, 2.3Å)/Mn(2.7Å)]$_{40}$ superlattice was grown on a Corning glass (7059) substrate by means of a 3-inch multi-target dc sputtering system that has a base pressure of 2.0×10^{-6} Torr and a working pressure of 5 mTorr. The sandwiched spin valve films consisting of NiFe (100Å)/Cu(30Å)/NiFe(60Å) on the [Ni/Mn] superlattice were sequentially deposited at the rate of 1.5~2.0 Å/s without a uniaxial deposition field. The H_{ex} between the [Ni/Mn] superlattice and the pinned NiFe layer, thermal annealing cycles of 2~4 h at 300℃ were applied under a static magnetic field of 250 Oe.

3. Results and discussions

Figures 1(1), (b), (c), and (d) show a MR measurement and M-H loop of superlattice spin-valves compositions of [Ni(1.8Å, 2.3Å)/Mn (2.7Å)]$_{40}$/NiFe(100Å)/Cu(30Å)/NiFe(60Å) after thermal annealing at 300℃ for 4 h. The MR ratios of spin valves with Ni(1.8Å) and Ni(2.3Å) are as small as 0.6%~1.0% due to the shunting effect of the [Ni/Mn] superlattice and the interdiffusion between NiMn and NiFe, and NiFe and Cu, during thermal treatment. The annealing cycles on the effect, the H_{ex} and H_c of the pinned layer in [Ni/Mn] superlattice based spin valves is of particular interest from an applications point of view. It is shown in Fig. 2. The H_{ex} and H_c of spin valves with a Ni layer thickness of 1.8 Å, 2.3Å increase up to 125 Oe and 110 Oe, 110 Oe and 75 Oe until an annealing cycle number 20, respectively. At cycle number 25, the H_{ex} of spin valves with Ni layer of 2.3 Å rapidly decreases. Since the H_{ex} and H_c of spin valves with Ni layer of 1.8 Å are gradually increase up to cycles 25 and are 95 Oe and 85 Oe until cycle

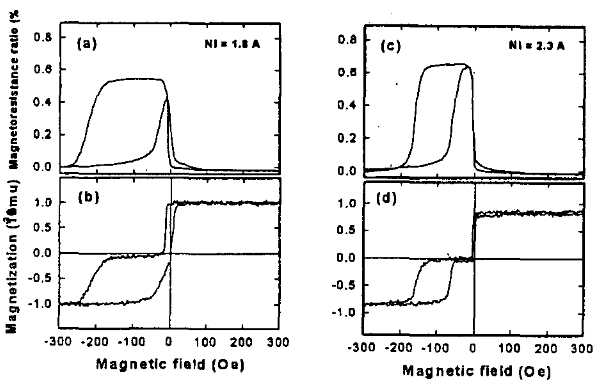

Fig. 1. (a) and (c) MR curves, (b) and (d) magnetization loops versus magnetic field of [Ni(1.8 Å,2.3 Å)Mn(2.7 Å)]$_{40}$/NiFe(100 Å)/Cu(30 Å)/NiFe(60 Å) spin-valves after thermal annealing.

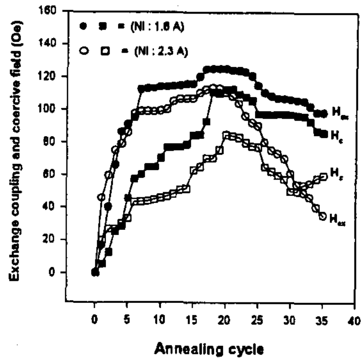

Fig. 2. Exchange coupling field (H_{ex}) and coercive field (H_c) versus annealing cycle for the [Ni(1.8 Å,2.3 Å)/Mn(2.7 Å)]$_{40}$/NiFe(100 Å)/Cu(30 Å)/NiFe(60 Å) spin-valve films.

number 35, the thermal stability of the sample with a pinned Ni layer thickness of 1.8 Å is better than those of 2.3 Å.

4. Conclusions

We have shown that it is possible to make [Ni/Mn] superlattice based spin valves that have high thermal stability. The H_{ex} and H_c of [Ni(1.8 Å)/Mn(2.3 Å)]$_{40}$ /NiFe(100 Å)/Cu(30 Å)/NiFe(60 Å) spin valves are gradually increased until 25 annealing cycles of 300℃ for 2 h. It can be expected that the blocking temperature is over 300℃. It is found that the thermal stability for the spin valves based on [Ni/Mn] superlattice depends on the variation of Ni layer thickness inside an unit cell of the CuAu-I ($L1_0$) structure.

5. References

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