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Junction Area Dependence of Tunneling Magnetoresistance

Sang-Suk Lee*, Chang-Man Park**, and Shan X. Wang**

* Dept. of Computer and Electronic Physics, Sangji University, KOREA

** Dept. of Materials Science and Engineering, Stanford University, USA

Introduction

Spin-dependent tunnel junctions with high tunneling magnetoresistance (TMR) are potentially applicable in nonvolatile memories or high areal density read heads [1,2,3]. However, one of the crucial factors strongly limiting their application as read heads is the large resistance, which results in large shot noise and consequently degrades signal-to-noise ratio [3].

In this study, the junction resistance and TMR were further lowered down to ~100 $\Omega\mu m^2$ and highered up to 17% by using ultrahigh vacuum deposition, respectively. This paper treats several origins of junction area dependence for tunneling resistance on the basis of experimental results.

Experimental Results

The junctions with size from 4 to 80 μm^2 and below 1 μm^2 were fabricated by using conventional photolithography and e-beam lithography process, respectively. Figure 1 shows an optical microscope picture of the junction (a) and film structure (b). The bottom-type TMR multilayer films with a structure of Ta5/NiFe10/Ta5/NiFe10/FeMn10/NiFe2/CoFe/2/AlO_x1/CoFe3/NiFe20 (thickness in nm) were deposited by ion beam and magnetron sputtering system with base pressure of 10^{-9} Torr. The AlO_x formed by 20 min *in situ* natural oxidation without any vacuum break.

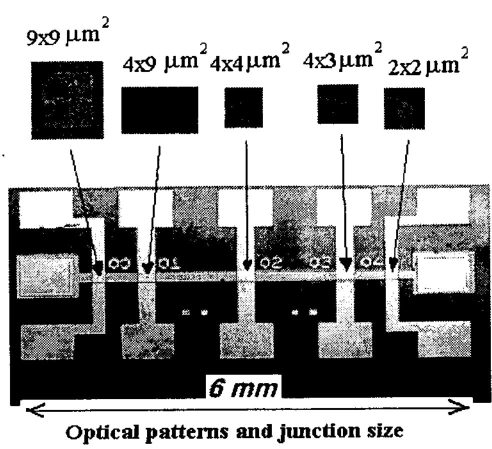

FIG. 1(a)

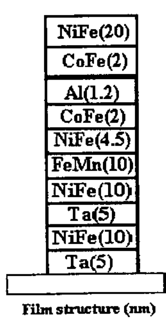

FIG. 2(a)

Discussion

The as-deposited junction showed TMR of 15% at room temperature with resistance of 24.3 Ω, which is obtained the resistance-magnetic field (*R*-*H*) curve with a larger plateau for an as-deposited 2×2 μm^2 junction. The anneal process was carried out at 185℃ for 1h in vacuum (10^{-7} Torr) with magnetic field of 5 kOe. As shown in Fig. 2, one can see that the TMR increase to 17%, while the junction resistance maintains almost constant. These results compare with other group's one, which are an unstable R-H curve of the as-deposited junction, a higher enhanced TMR after anneal process, and an increased junction resistance. It should be noted that the junction resistance and TMR dependence versus area in Fig. 2, suggests the various origins for naturally oxide AlO_x barrier properties of spin-dependent tunneling (SDT) junction due to the channeling effect, the sheet resistance, the interface roughness, and the demagnetized domain wall motion. This suggestion will be supported by the analysis of high resolution tunneling electron microscope (HRTEM).

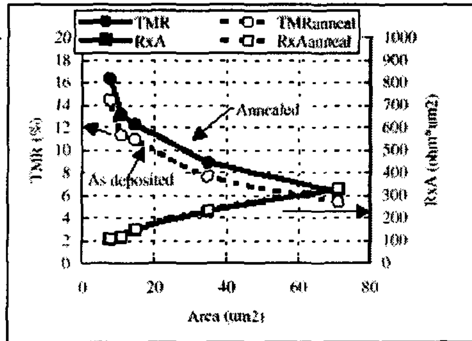

FIG. 2. Area vs RxA and TMR of CoFe inserted SDT

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