Tunneling magnetoresistance of nano-scale magnetic tunnel junctions

S. Y. Park[*1,2], **K. Rhie** [1], **J. H. Lee**[1,2], **I. J. Shin**[2], **K. H. Shin**[2], and **B.C. Lee**[2]

[1] Department of Physics, Korea University, Chochiwon, Korea
[2] Nano Device Reseach Center, KIST, Seoul, Korea
[3] Department of Physics, Inha University, Incheon, Korea

*Corresponding author: e-mail: krhie@korea.ac.kr, Phone: +82-11-430-4595,

Recently, the magnetic tunnel junction (MTJ) has drawn much interest partly due to possible applications in magnetic random access memory (MRAM). The cell size is a critical issue for the high density MRAM, and active research has been conducted on junction patterning methods to reduce the cell size [1]. In this paper, we report on successful fabrication of nano-scale MTJs by the formation of insulating layers outside the junction area. The MTJs were grown by using DC magnetron sputtering, and the base pressure was below 1.0×10^{-7} Torr. The structure was Ta(50Å)/NiFe(20 Å)/PtMn(150 Å)/CoFe(18 Å)/Ru(9.5 Å)/CoFe(28 Å)/AlO_X(10 Å)/CoFe(15 Å)/NiFe(30 Å)/Ta(100 Å)/Ru(100 Å), and patterning of 140 nm×140 nm size junctions was carried out after annealing. When MTJs were patterned by dry etching using ion milling only, the tunneling magnetoresistance (TMR) was less than 5 % because of the damage to the junction edge during the process. In order to avoid this problem, we used the following recipe. The bottom electrode of MTJ was made by using (dry etching) ion-beam milling with a photo mask. After 140nm×140nm memory cell was patterned by e-beam lithography, other parts except the junction was oxidized by ICP-RIE machine and passivated by AlO_X layer so that the top and bottom electrodes were not short-circuited. If the AlO_X layer is too thick, it is difficult to carry out the lift-off process with the photo resist (PR). Thus, the passivation of AlO_X layer was performed with two steps. Firstly, 10 nm thick AlO_X was grown on 140nm×140nm ER and the junction was made by lift-off. Secondly, 50 nm thick AlO_X was grown on 10μm×10μm PR and lift-off was done. Finally, 100 nm thick Al layer was grown for the top electrode. The MR curve is shown in Fig. 1 and the TMR was 31 %, which is much higher than that of MTJs of this size fabricated by a conventional method.

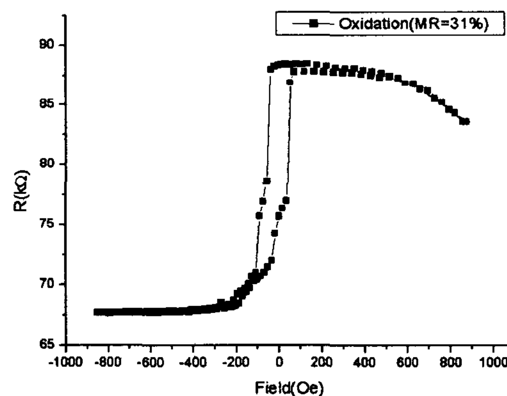

Fig. 1. MR curve for 140 nm ×140 nm MTJ

References

[1] W. J. Gallagher, S. S. P. Parkin, Yu Lu, X. P. Bian, A. Marley, and K. P. Roche, J. Appl. Phys. 81(8), (1997).