Perpendicular Magnetic Tunnel Junctions using CoPt Alloy and MgO/CoFeB/Pt Electrodes

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Perpendicular magnetic tunnel junction (p-MTJ) is one of the candidates to achieve both high thermal stability and low switching current density in spin-transfer-toque memory devices. Recently, various p-MTJs have been demonstrated using rare-earth transition-metal alloys and Co-based multilayer [1-4]. Because the annealing at high temperature can destroy the perpendicular magnetic anisotropy (PMA) of magnetic electrodes, there has been a limitation in the annealing temperature.

Here we report p-MTJs consisting of CoPt alloy [5] and MgO/CoFeB/Pt electrodes [6], which are robust during high temperature annealing. The MTJ stack consists of Si/SiO2 (300)/ Ta(5)/ Ru(20)/ Co72Pt28(10)/ spacer/ Co40Fe40B20(1)/ MgO(1.6)/ Co40Fe40B20(1)/ Pt(2) (thickness in nm). The MTJs are deposited by magnetron sputtering, and annealed at 400 ℃ for 30 minutes in vacuum without applying magnetic field. The patterned MTJs are prepared by standard lithography, and the tunnel magnetoresistance (TMR) of MTJs is measured by four probe method.

In order to obtain a PMA in bottom electrode, hcp CoPt alloy is co-sputtered using Co and Pt targets [5]. The highest PMA is observed with Co72Pt28 alloy composition. A thin CoFeB layer and a spacer (Pt,Ru) layer are inserted between the MgO tunnel barrier and CoPt PMA layer to obtain a higher TMR.

We have investigated the magnetic hysteresis loop of MgO/CoFeB/Pt structures using magnetometers, and found that the PMA of this structure is strongly dependent on the thickness of both CoFeB and Pt layers. The highest PMA in the top electrode is obtained with the MgO/ CoFeB(1)/ Pt(2) combination. With a 1-nm-thick CoFeB layer and a thicker Pt layer (3-4 nm), the PMA of this electrode is drastically reduced.

The MTJ consisting of CoPt(10)/ Pt(2)/ CoFeB(1)/ MgO(1.6)/ CoFeB(1)/ Pt(2) shows a perpendicular magnetization with well-defined parallel and antiparallel configurations (Fig. 1 (a)). The switching field of the top- and bottom-electrode is 32 Oe and 800 Oe, respectively. The MTJ shows the TMR of 6.8 % with the switching fields corresponding to those in the magnetic hysteresis loop (Fig. 1 (b)).

From this result, it has been shown that the CoPt/spacer/CoFeB/MgO/CoFeB/Pt structure can provide p-MTJs with a very high annealing temperature. The TMR of this MTJ structure can be increased by adjusting the layer thickness and by changing the spacer materials.

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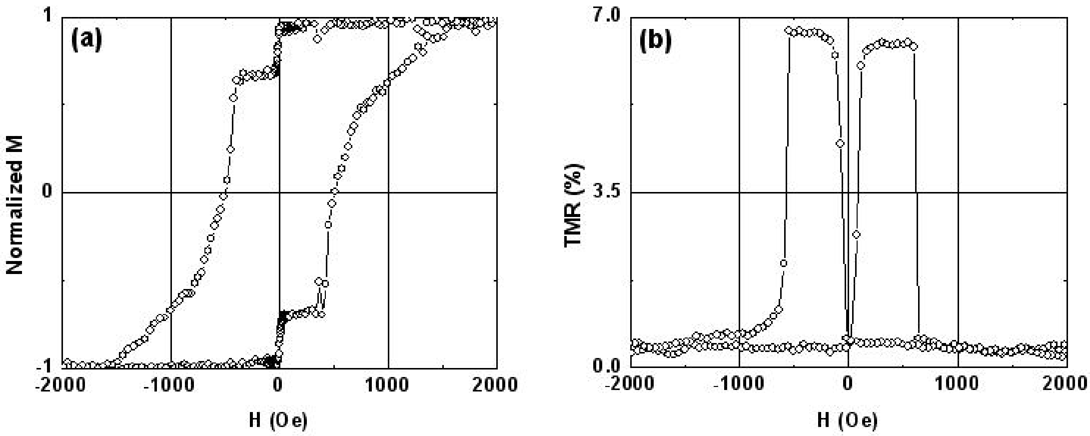

Fig. 1 (a) Hysteresis loop and (b) TMR ratio of a p-MTJ consisting of CoPt (10)/Pt (2)/CoFeB (1)/MgO (1.6)/CoFeB (1)/Pt (2) annealed at 400°C for 30 min. (in nm).