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Improvement of Annealing Stability in Magnetic Sensors Based on Magnetic Tunnel Junction by Using CoFeB/CoFeAlB Sensing Bilayer

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Magnetic tunnel junctions (MTJs) have been widely investigated for the application to magnetic sensor[1]. Recently, we have reported the linear sensing response in the MgO-based MTJs by utilizing perpendicularly magnetized CoFeB sensing layer[2]. However, the linear response disappeared for the MTJs annealed at higher temperatures above 300°C due to the loss of perpendicular magnetic anisotropy (PMA) in CoFeB sensing layer[3]. This limits circuit integration in which back-end-process around 350°C is needed. In this study, we improved an annealing stability in magnetic sensors based on MTJ by using CoFeB/CoFeAlB sensing bilayer.

The stacking structure was Si,SiO_2-substrate/buffer layers/$Co_{40}Fe_{40}B_{20}$ (3)/MgO (2.3)/$Co_{40}Fe_{40}B_{20}$ (0.6)/$Co_{36}Fe_{36}Al_{10}B_{18}$ (0.6, 0.8 or 1.0)/capping layers (in nm), deposited by the DC/RF magnetron sputtering. We varied the thickness of the CoFeAlB layer ($t_{CoFeAlB}$) as described above. The MTJs of 80×40 μm^2 to 20×10 μm^2 were fabricated by photolithography and Ar ion milling process. Post-annealing processes were performed in a vacuum for 1 h at the varying temperatures (T_a) from 275°C to 375°C with the in-plane magnetic field of 1 T. We evaluated the transport property by DC four-probe-method under in-plane magnetic field.

Fig. 1 shows the magneto-resistance curves for the MTJs with $t_{CoFAleB}$ = 0.8 nm and the previously reported MTJs with 1.4 nm-CoFeB sensing layer at T_a = 275°C and 350°C. In the MTJs with Al doping, the linear response remained up to T_a = 350°C while the linear response disappeared in the MTJs without Al doping. This may be attributed to two possible effects. One is that the saturation magnetization at sensing layer reduced by adding nonmagnetic Al, which leads to the decrease of demagnetization energy. The other is that the interdiffusion through sensing layer which degrades PMA was prevented. This improvement of annealing stability is significant for future integration of MgO-based MTJs for magnetic sensor devices with perpendicularly magnetized CoFeB electrode.

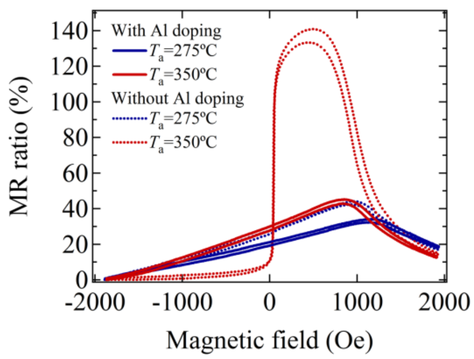

Fig. 1. Magneto-resistance curves for the MTJ with $t_{CoFeAlB}$ = 0.8 nm (With Al doping) and the MTJs with 1.4 nm-CoFeB sensing layer (Without Al doping) at T_a = 275°C and 350°C.

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