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Magnetic sensors based on MgO-magnetic tunnel junctions with perpendicular magnetized CoFeB sensing layer

Tohoku Univ.[1], DENSO CORP.[2]

°Takafumi Nakano[1], Mikihiko Oogane[1], Hiroshi Naganuma[1], Toshifumi Yano[2], Kenichi Ao[2] and Yasuo Ando[1]

E-mail: Takafumi_Nakano@mlab.apph.tohoku.ac.jp

Spin valves and magnetic tunnel junctions (MTJs) have been widely used as magnetic sensors because of their high sensitivity, low power consumption, and micro size. In order to achieve the linear and reversible response to a magnetic field, we align the magnetization of a soft sensing layer and a hard reference layer to be perpendicular to each other. This cross configuration is obtained by utilizing perpendicular magnetized anisotropy (PMA) materials[1, 2]. Recently, CoFeB electrodes for MgO-based MTJs have been attractive material exhibiting high tunnel magneto-resistance (TMR) ratio and large PMA[3]. In this study, we demonstrated the linear resistive response of MTJ sensors with a perpendicular magnetized CoFeB sensing layer.

The stack-structure was Si,SiO_2-substrate/Ta (5)/Ru (10)/$Ir_{22}Mn_{78}$ (10)/$Co_{75}Fe_{25}$ (2)/Ru (0.85)/ $Co_{40}Fe_{40}B_{20}$ (3)/MgO (1.3)/$Co_{40}Fe_{40}B_{20}$ (t_{CoFeB})/Ta (5)/Ru (8) (in nm), deposited by the DC/RF magnetron sputtering. We varied the thickness of the CoFeB sensing layer (t_{CoFeB}) from 1.2 to 1.6 nm to tune its PMA. The MTJs of 80 x 40 μm^2 to 20 x 10 μm^2 were prepared by 1 inch photolithography process and annealed at 300°C for 1 h in the magnetic field of 1 T. We measured the transport property by DC four-probe-method.

Figures 1(a)-(c) show the magneto-resistance curves. For the MTJ with t_{CoFeB} = 1.6 nm, typical TMR curve was observed and the TMR ratio was 161 %. This indicates the magnetization of the CoFeB sensing layer was in-plane magnetized. With decreasing t_{CoFeB}, its PMA increased, and the linear resistive response was observed for t_{CoFeB} less than 1.4 nm. In these MTJs, the perpendicular configuration of the easy axis between the sensing layer and the reference layer was obtained. For t_{CoFeB} = 1.4 nm, the magnetic field sensitivity was evaluated as 0.025 %/Oe. This value is considerably larger than that in previously reported sensors with sensing layers of PMA materials[1].

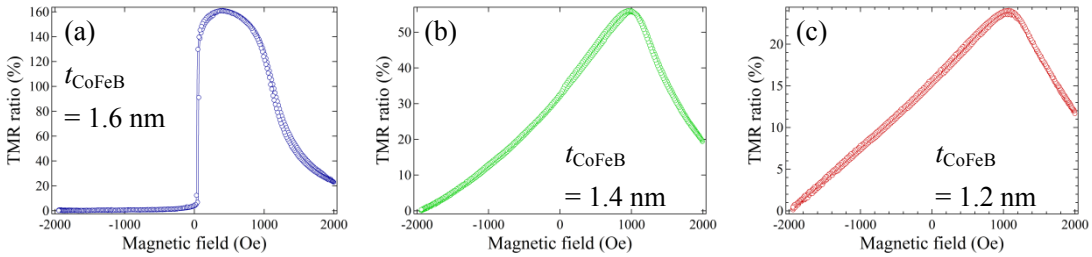

Figure 1. (a)-(c) Resistance vs. applied magnetic field for MTJs with various CoFeB thickness.

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[3]S. Ikeda, *et al.*, Nature. Mater. **9**, 721 (2010)