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Magnetization switching behavior for CoFeB/MgO and CoFeB/Ta multilayer films

Hiroshi Sakurai[1], Akane Shibayama[1], Misaki Adachi[1], Masatoshi Yamazoe[1], Kosuke Suzuki[1], Kazushi Hoshi[1], Kento Haiji[1], Masayoshi Itou[2], Naruki Tsuji[2], Yoshiharu Sakurai[2]
[1]*Gunma University, Kiryu, Japan,* [2]*JASRI, Sayo, Japan*
E-mail: sakuraih@gunma-u.ac.jp

Recently, Ta/CoFeB/MgO/CoFeB/Ta magnetic tunneling junction (MTJ) films with perpendicular magnetic anisotropy (PMA) [1] are interesting because PMA can reduce the critical current for current-induced magnetization switching. It was reported that the PMA comes from the MTJ interface of the films [1]. Therefore magnetization switching of the MTJ interface is a key characteristic of a spintronics device.

Magnetic Compton profile (MCP) measurement can probe the magnetic quantum number m. In addition, MCP measurement can probe spin selective magnetization. Therefore It is possible to measure a spin selective magnetic hysteresis (SSMH) curve and orbital selective magnetization (orbital selective magnetic hysteresis (OSMH) curves) by combining an MCP measurement with a total magnetization measurement based on a vibrating sample magnetometer (VSM) or superconducting quantum interference device (SQUID) magnetometer [2]. In this paper, we report magnetization switching behavior of the SSMH curves, OSMH curves and magnetic quantum number selective SSMH curves for the |m|=0, 1 and 2 magnetic quantum number states for CoFeB/MgO and CoFeB/Ta multilayer films from the view-point of the magnetization switching behavior with the PMA.

MCP measurements were carried out on beamline BL08W at SPring-8, Japan. Elliptically polarized X-rays were monochromatized to be 182.6 keV and focused to a spot of 1×0.8 mm on the sample. The X-ray beams were parallel to the applied magnetic field. The applied magnetic fields were perpendicular to the film plane.

The SSMH curves of the CoFeB/MgO and CoFeB/Ta multilayer films show magnetic shape anisotropy of an in-plane magnetic anisotropy. However, the OSMH curves of the CoFeB/MgO and CoFeB/Ta multilayer films show a step-function-like behavior with rather small magnetization switching fields as if they possess PMA. At the interface of the CoFeB/MgO multilayers, the OSMH curves are related to the SSMH curves trough the |m|= 2 magnetic quantum number states [3]. On the contrary, at the interface of the CoFeB/Ta multilayers, the OSMH curves are related to the SSMH curves trough the |m|= 1 magnetic quantum number states. These facts indicate that the magnetization switching behavior is dominated by orbital magnetization.

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