新規３端子スピン軌道トルク素子の動作実証

Demonstration of a new three-terminal spin-orbit torque device

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Magnetic tunnel junction (MTJ) devices with three-terminal cell structure are promising building blocks for ultralow-power and high-performance integrated circuits due to their high-speed and high-reliability features [1]. The three-terminal devices with spin-orbit torque (SOT) switching were recently proposed and have intensively investigated for a couple of years [2-5]. The SOT devices proposed so far are divided by their structure into two types. Here we propose a new structure of SOT device that combines the advantages of the existing two structures and demonstrate its basic operation.

Figure 1 shows a schematic diagram of the proposed SOT device. The MTJ easy axis is parallel to the direction of write current, *i.e. x*-direction. This is in contrast to the existing devices, whose easy axis is directed to either *z*-direction [2,3,5] or *y*-direction [3,4]. The MTJ with in-plane easy axis in the proposed device makes it easy to obtain large tunnel magnetoresistance (TMR) ratio and small offset fields acting on the recording layer. Moreover, the magnetization switching induced by spin current whose polarization is orthogonal to the easy axis under a static field along another orthogonal direction allows ultrafast write operation, typically less than a few nanoseconds.

The stack of Ta/CoFeB/MgO/CoFeB/Co/Ru/Co was processed into the structure shown in Fig. 1 by electron beam lithography and Ar ion milling. Figure 2(a) shows the MTJ resistance R in response to easy-axis magnetic field (H_X). The thermal stability factor E/k_BT was determined to be 46 by repeating R-H_X sweep. Figure 2(b) and (c) shows R in response to current pulses I flowing in the Ta channel under static fields (H_Z). The current-induced switching is observed, whose direction depends on the sign of H_Z, indicating that the magnetization switching is induced by SOT originating from the Ta channel with negative spin Hall angle. These results indicate that SOT device we proposed here is successfully demonstrated.

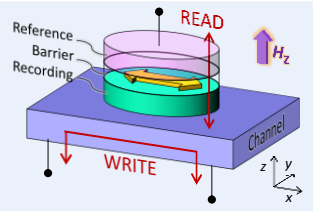

Fig. 1: Structure of proposed device.

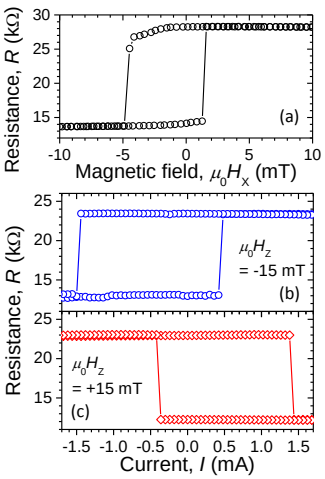

Fig. 2: R-H_X (a) and R-I loops (b,c).

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