Time resolved measurement of Joule-heating-induced magnetization dynamics in magnetic tunnel junctions

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It is essential to conduct high speed and low-power-consumption magnetization switching for magnetic random access memory using magnetic tunnel junctions (MTJs). Switching by changing magnetic anisotropy is an effective way to control magnetization direction. It is reported that magnetic anisotropy can be changed by voltage [1], which is known as voltage-controlled magnetic anisotropy (VCMA). Magnetization switching induced by nanosecond-order pulse voltage is also reported [2]. Moreover, we have reported that Joule heating in MTJs induces magnetization dynamics through temperature dependence of the magnetic anisotropy [3]. In this study, we study the response time of the Joule-heating-induced magnetization dynamics in MTJs.

We investigated the magnetization dynamics driven by pulse voltage in time-domain measurement. Figure 1 shows the film structure of the MTJ with a diameter of 120 nm. We applied pulse voltage to the MTJ and reflected pulse voltage was measured by oscilloscope. In Fig 2, reflected pulse signal from MTJ under two different bias voltage is shown. Sign of voltage change at t = 0 ns reverses at positive and negative applied voltage, which represents these torques are indifferent to signs of applied voltage and thus are attributed not to spin-transfer but to magnetic anisotropy change. From this result, we are able to know that response-time of the heat induced magnetization dynamics can be as fast as about 200ps.

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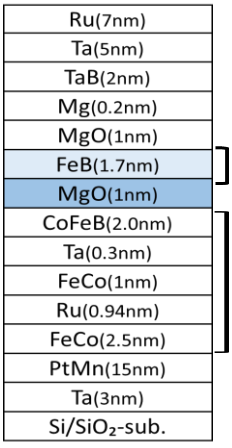

Fig.1: Device structure

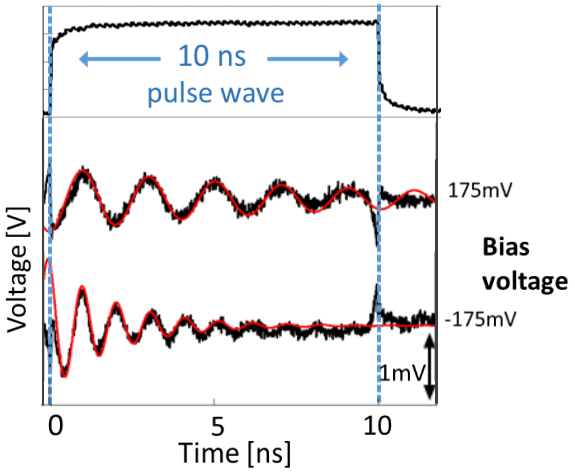

Fig.2: Reflected signal from MTJ

[1]T. Maruyama *et al.*, Nat. Nanotechnol. **4,** 158 (2009). [2]Y. Shiota *et al.*, Nat. Mater. **11**, 39 (2012). [3]M. Goto *et al.*, JSAP Autumn meeting 2017.