Thermal stability of 1X/X nm magnetic tunnel junctions with interfacial or shape anisotropy at high temperature

[1]RIEC, Tohoku Univ. [2]WPI-AIMR, Tohoku Univ. [3]CSRN, Tohoku Univ. [4]CSIS, Tohoku Univ. [5]CIES, Tohoku Univ.

○(D)J. Igarashi[1], K. Watanabe[1], B. Jinnai[2], S. Fukami[1-5] and H. Ohno[1-5]

E-mail: jigarasi@riec.tohoku.ac.jp

Shape-anisotropy magnetic tunnel junction (MTJ) is a promising candidate for spin-transfer torque magnetoresistive random access memory (STT-MRAM) at 1X- and X-nm generations[1]. Conventional interfacial-anisotropy MTJ with a CoFeB/MgO structure[2] allows to reduce the MTJ size down to 20 nm while keeping high thermal stability factor $\varDelta$[3, 4]; however, further scaling beyond 20 nm is challenging due to an insufficient anisotropy energy density[4]. Recently, high $\varDelta$ at such small region was shown to be achieved utilizing shape anisotropy of a cylindrical MTJ[1, 5]. From both fundamental and application points of view, it's important to study energy barrier E for shape-anisotropy MTJ at elevated temperatures. In this study, we measure temperature dependence of $\varDelta$ of the shape- and interfacial-anisotropy MTJs below 1X nm in order to understand the mechanism of variation in E with temperature for the two types of MTJs.

Figure 1 shows temperature dependence of Resistance-field (*R-H*) curves for interfacial- and shape-anisotropy MTJs at various temperatures. The interfacial-anisotropy MTJ becomes superparamagnetic at 423 K (150 °C), whereas the shape-anisotropy MTJ (D = 5.0 nm) keeps hysteresis up to 423 K (150 °C). We evaluate $\varDelta$ and effective magnetic anisotropy field H_K^{eff} with changing temperature from a switching-probability measurement using pulsed magnetic field H[6]. We find that $\varDelta$ for the shape-anisotropy MTJs is larger than that for the interfacial-anisotropy MTJ at all the studied range of temperatures even in much smaller size. These results indicate that the shape-anisotropy MTJ has a potential to extend the scaling limit of the interfacial-anisotropy MTJ for wide-temperature applications.

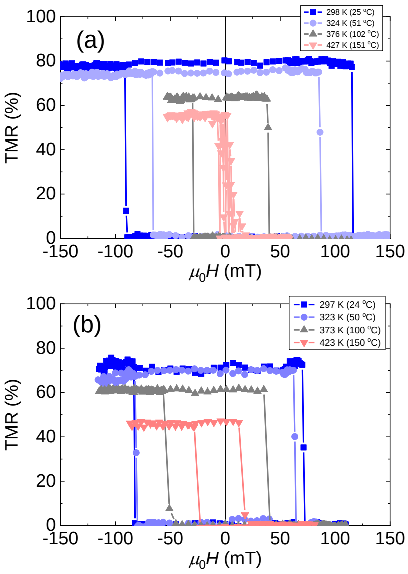

Fig. 1 Temperature dependence of *R-H* curves for interfacial- ((a), D = 16.3 nm) and shape-anisotropy MTJs ((b), D = 5.0 nm).

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