Enhancement of spin-dependent transport in magnetic tunnel junctions with Mn-modified ultrathin MnGa electrodes

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Mn-Ga alloy films have a large perpendicular magnetic anisotropy (PMA), small saturation magnetization (M_s), and small damping constant[1], thus it is potentially attractive for spin-transfer-torque (STT) applications, such as magnetoresistive random access memory (STT-MRAM) with high recording density and STT-oscillator/diode devices with the operation frequency of THz range. Recently, we discovered B2-ordered CoGa as an excellent growth seed layer for ultra-thin L10-orderedMnGa films and demonstrated that the perpendicular magnetic tunnel junction (p-MTJs) using ultra-thin MnGa electrode with the tunnel magnetoresisitance (TMR) ratio of 3.1% at room temperature [2,3], and the magnetization switching using spin Hall effect of the CoGa layer were also performed.[4] Here we report the Mn-modified surface as an electrode of MnGa further enhancing both TMR and PMA for the p-MTJs. The MTJ stacking structure studied here were MgO(001) substrate/Cr(40)/CoGa(30)/MnGa(1)/Mn(t_{Mn}=0, 0.6)/Mg(0.4)/MgO(2)/CoFeB(1)/Ta(3)/Ru(5) (thickness is in nm), which were fabricated using an ultrahigh-vacuum sputtering system with a base pressure of less than 1×10^{-7} Pa. The TMR curves for the MTJs at room temperature are shown in Fig. 1. The MTJs without the Mn modified-surface shows the TMR ratio of 3.7%. On the other hand, the TMR ratio for the MTJs with the Mn modified surface increases up to 18%, which is much higher than that for the p-MTJs with the 3-nm-thick MnGa layer reported previously [3]. In addition, the PMA constant for the MTJs with and without the Mn modified-surface were estimated to be 1.7 and 6.2 Merg/cm^3, respectively. The pure Mn layer with few mono-layer in the MnGa/MgO interface was confirmed by the High-angle Annular Dark Field Scanning TEM image of MTJ stacking structure. X-ray magnetic circular dichroism and the first-principles calculation also exhibit the difference in Mn line shapes between with and without Mn modified surface and in TMR ratio, respectively. These results indicate that the Mn modified-surface strongly changes the interfacial spin-dependent electronic structures of MnGa, and useful for the development of future STT-applications.

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Reference

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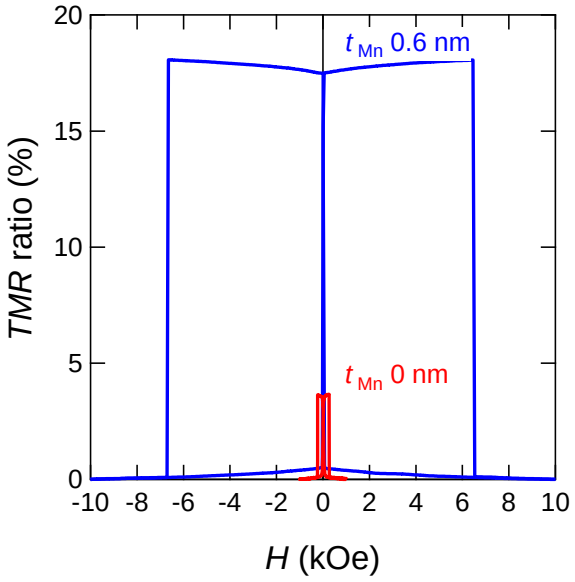

Fig.1 TMR curve for the MTJs with t_{Mn}=0 and t_{Mn}=0.6 nm measured at room temperature