Growth and characterization of MnGa thin films on BiSb topological insulator

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Recently, spin injection using giant spin Hall effect in topological insulators (TIs) to ferromagnets (FMs) in TI/FM bi-layer systems, such as Bi_2Se_3/NiFe and $(Bi,Sb)_2Te_3/(CrBiSb)_2Te_3$, has been demonstrated and attracted much attention [1,2]. However, in those studies, the TI materials have small electrical conductivity (~10^4 $\Omega^{-1}m^{-1}$), while the FM layers are either soft NiFe or low-T_C $(CrBiSb)_2Te_3$, which are not suitable for realistic applications. FM with large perpendicular magnetic anisotropy (PMA) on conducting TI bi-layer is highly desired for magnetic memory applications. However, such metallic ferromagnets with high PMA on conducting TI have not been demonstrated so far. In this study, we grow and characterize such a system: the BiSb/Mn_xGa_{1-x} bi-layer. BiSb has large electrical conductivity (10^5 ~ 10^6 $\Omega^{-1}m^{-1}$), while Mn_xGa_{1-x} has large PMA (K_u ~ 15 Merg/cm^3) [3], small magnetization (M_s ~ 400 emu/cm^3) [1], and small damping factor (α < 0.008) [4]. In this study, we demonstrate that Mn_xGa_{1-x} (001) with PMA can be grown on BiSb, despite their difference in crystal symmetry.

We have grown several 7~8 nm-thick Mn_xGa_{1-x} / 20 nm-thick $Bi_{0.8}Sb_{0.2}$ bi-layers on GaAs(111) substrates by molecular-beam epitaxy. Figure 1(a) shows the X-ray diffraction spectrum of several bi-layers with $0.53 \le x \le 0.74$. When x is larger than 0.6, we observed both MnGa(001) and MnGa(100) phase. However, for 0.5 < x < 0.6, peaks of the MnGa(001) phase are dominant, while those of MnGa(100) gradually decrease to the noise level. Figure 1(b) shows the normalized magnetization hysteresis loop of several Mn_xGa_{1-x} layers, measured by magnetic circular dichroism at room-temperature. We observe clear PMA for a layer with x ~ 0.55. These results show that our BiSb/Mn_xGa_{1-x} system is promising for perpendicular magnetization switching using giant spin Hall effect in TI.

References:

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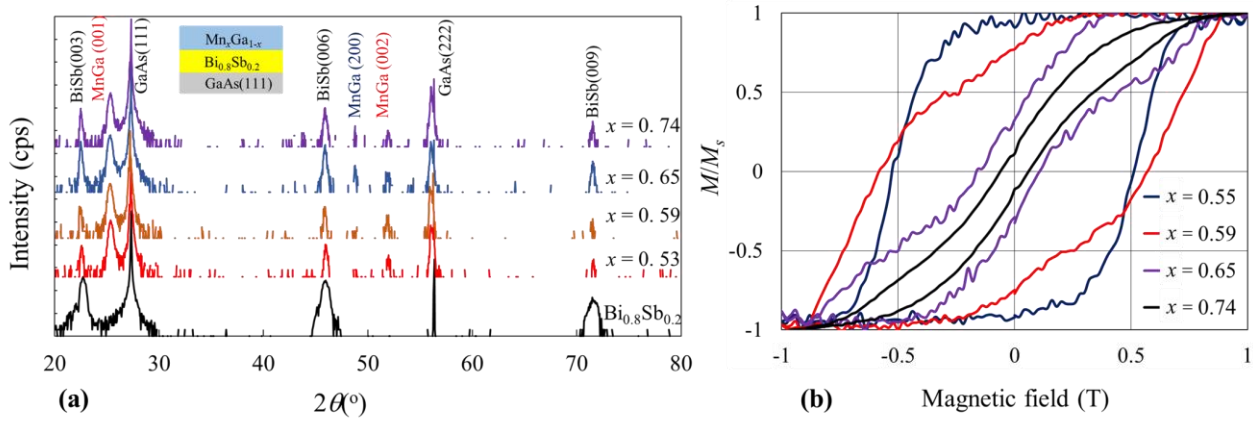

Fig. 1 (a) X-ray diffraction spectrum of several Mn_xGa_{1-x}($0.53 \le x \le 0.74$) / $Bi_{0.8}Sb_{0.2}$ bi-layers grown on GaAs(111) substrates (inset), and (b) their normalized magnetization hysteresis loops, measured by magnetic circular dichroism at room-temperature.