Antiperovskite ferromagnetic MnGaN films with perpendicular magnetic anisotropy

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The search of new perpendicular magnetic materials such as $D0_{22}$ Mn_3Ga[1] with low magnetization (M_s), high spin polarization (P) [2], low Gilbert damping α [3] and high perpendicular magnetic anisotropy (PMA)[4] has been of great concern in order to establish a high performance and high thermal stability of perpendicular magnetic tunnel junction (p-MTJ) for a future spin transfer torque (STT)-magnetic random access memory (MRAM) device. In this work, we report the newly-found ferromagnetic (FM) MnGaN exhibiting perpendicular magnetic anisotropy (PMA) with the a cubic antiperovskite $E2_1$ structure [5].

Mn-Ga-N films were prepared by RF reactive sputtering technique with N_2 flow rate percent (η) relative to 30 sccm Ar gas and a $Mn_{60}Ga_{40}$ sputtering target. 50 nm thick MnGa-N films were grown on an MgO(001) substrate with varied substrate temperatures. The films were evaluated by X-ray diffraction (XRD), atomic force microscopy (AFM) and scanning transmission electron microscopy (STEM).

The film grown at 480°C and η = 1% showed a single phase $E2_1$ antiperovskite (an Mn_3GaN structure) and epitaxial growth with (001) orientation, confirmed by XRD and a nano-beam diffraction (NBD) pattern of STEM as shown in the inset (a) of Fig. 1. The composition was determined to be $Mn_{67}Ga_{24}N_9$, showing an N deficient composition. Figure 1 shows the magnetic hystereses of the film at 300 K. Interestingly, the film shows ferromagnetism with a relatively high Curie temperature up to 740 K and PMA characteristics regardless of the antiferromagnetism in stoichiometric Mn_3GaN bulk. M_s of 80 kA/m was also observed, which was lower than the value of a $D0_{22}$ $Mn_{2.4}Ga$ (η = 0% case) film (200 kA/m). The spin polarization evaluated using a point contact Andreev reflection spectroscopy (PCAR) reveals the relatively high spin polarization of 57%, as seen in the inset (b) of Fig. 1. In addition, the MnGaN film was found to exhibit very smooth surface morphology with the average roughness of 0.4 nm. These results suggest ferromagnetic $E2_1$ MnGaN will be a promising PMA material for future STT-MRAM application. This study was partly supported by Samsung Electronics.

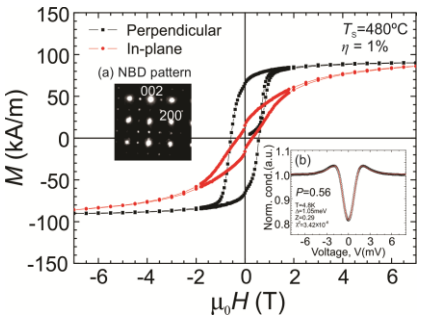

Fig.1. Magnetic hystereses of 50 nm MnGaN film measured at 300 K. Inset (a): NBD pattern, (b) conductance curve of PCAR measurement.

References:

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