Buffer layers dependence of magnetic properties for C38-type MnGaGe films

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In the society of Internet of Things (IoT), the demand for memory devices is becoming increasingly high especially for nonvolatility and high-working-speed. Among various memories, magnetoresistive random access memory (MRAM) attracts numerous attentions for its non-volatile attribute, high read-write speed and so on. Especially, since CoFeB has been found to be suitable as electrodes of perpendicularly magnetized magnetic tunnel junctions (p-MTJs) [1], related researches are in full swing. However, the uniaxial magnetic anisotropy energy (K_u) of CoFeB is ~ 2×10^6 erg/cm^3, and materials with larger K_u are desired for the small, e.g. < 20 nm diameter, MTJs in giga-bit class MRAMs from the thermal stability requirement. In addition, reducing the saturation magnetization (M_s) of electrode materials is also an important issue. In order to solve these problems, we are focusing on C38-type MnGaGe ordered alloy films. In our previous work, epitaxially grown $Mn_{33}Ga_{36}Ge_{31}$ films which are close to the stoichiometry were deposited on MgO (100) substrates directly. The maximum value of K_u was ~ 8×10^6 erg/cm^3 in the sample with a 100-nm-thick $Mn_{33}Ga_{36}Ge_{31}$ layer annealed at 500 ºC [2]. In addition, perpendicular magnetization was achieved for the thickness of $Mn_{33}Ga_{36}Ge_{31}$ layer down to 10 nm. However, the squareness of the magnetization curves was poor, which was probably because of relatively large orientation dispersion. In this presentation, we will report the latest progress of optimization of $Mn_{33}Ga_{36}Ge_{31}$ films with various buffer layers.

The stacking structures of this work was MgO (001) substrate/buffer layer(s)/ $Mn_{33}Ga_{36}Ge_{31}$ (t)/MgO 2 nm/Ta 5 nm. t was varied from 100 nm to 5 nm. All the metallic layers were deposited by using an ultrahigh-vacuum magnetron sputtering system, and the MgO layer was deposited by using an electron beam evaporation system. The samples using Cr buffer layer exhibited perpendicular magnetization down to t of 50 nm. Although XRD profiles exhibited a relatively high degree of (001) orientation, diffractions from (110) planes also remained for the out-of-plane measurements of the Cr buffer samples. Samples using other buffer layers will be discussed in the presentation.

This work was partially supported by the Murata Science Foundation and Cooperative Research Project of CRDAM-IMR, Tohoku Univ. MS and TK thank Issei Narita for technical supports.

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