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Magnetic properties of L21- ordered $\text{Mn}_{3-x}\text{Fe}_x\text{Ga}$ epitaxial thin films

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In this work, fabrication of $\text{Mn}_{3-x}\text{Fe}_x\text{Ga}$ epitaxial thin films by using an ultra-high vacuum electron beam evaporation system, clarifying the relationship between composition of Fe, magnetic properties, crystal structure and film thickness were studied. The epitaxial growth of L21- ordered Mn-Fe-Ga thin films has been confirmed on the MgO (001) single crystalline substrate by using in-situ RHEED for all the samples. The a-axis was calculated by performing a lattice spacing analysis using RHEED patterns. From XRD, the L21(004) fundamental peak shift to the high angle side was confirmed as the film thickness decreased, which show that the c-axis becomes smaller. Decreasing of the c-axis and increasing of the a-axis was confirmed as the film thickness decreased from XRD and RHEED analysis, respectively. As the film thickness was reduced ($t_{\text{Mn-Fe-Ga}} = 20 - 1 \text{ nm}$), increase of saturation magnetization (M_s) and magnetic anisotropy (K_u) are confirmed for all Mn-Fe-Ga thin films in which Fe is added to Mn-Ga. At $t_{\text{Mn-Fe-Ga}} = 1 \text{ nm}$, the maximum extremely large $K_u = 20.1 \text{ Merg/cm}^3$ at $x = 1.5$ and maximum $M_s = 878 \text{ emu/cm}^3$ at $x = 2.5$ are confirmed. These results could be explained by the addition of Fe to Mn-Ga and the lattice distortion from the substrate into the film. Therefore, it was shown that the L21- ordered $\text{Mn}_{3-x}\text{Fe}_x\text{Ga}$ epitaxial thin film is one of the magnetic materials having the perpendicular magnetization film which is suitable for the MTJs application.

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