Tuning the magnetic properties and surface morphology of $D0_{22}$ $Mn_{3-\delta}Ga$ film by N doping

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Recently, tetragonal Mn-based alloys such as $L1_0$ and $D0_{22}$ Mn-Ga alloys [1] have been of great concern in search of new magnetic alloy systems with low Gilbert damping, low saturation magnetization M_s, and high perpendicular magnetic anisotropy K_u for potential applications such as a next generation spin transfer torque-magnetic random access memory. In this work, we present tuning the magnetic properties and surface morphology of $D0_{22}$ $Mn_{3-\delta}Ga$ using a small amount of N doping [2]. 50 nm thick N-doped MnGa films were prepared by RF reactive sputtering technique on an MgO(001) single crystalline substrate at 480°C substrate temperature with the varied 0−0.66% N_2 flow rate percentage (η) relative to Ar 30 sccm for two Mn_3Ga and $Mn_{2.5}Ga$ compositions. N-doped Mn-Ga films all exhibited the gradual reduction in M_s up to 33−50% with the increasing N_2 flow rate as in Fig. 1 (a). In particular, N-doped $Mn_{2.5}Ga$ case revealed the single $D0_{22}$ structural phase formation with the high $K_u \approx 1$ MJ/m^3 between η = 0−0.66% range despite the gradual reduction in magnetization, while N-doped Mn_3Ga showed coherent growth of two $D0_{22}$ + $E2_1$ composite phases which results in the further reduction in M_s and $K_u < 1$ MJ/m^3, as in Fig. 1 (b). In addition, N doping in both Mn_3Ga and $Mn_{2.5}Ga$ caused the smoothening of the surface morphology with the increasing film thickness up to 50 nm even with the use of the minimum η of 0.25%, as shown in the inset of Fig. 1, which represents the modification of the film growth mode from Volmer-Weber type of $D0_{22}$ Mn-Ga case at this high 480°C growth temperature. Therefore, these results suggest that a small amount of N doping is an effective way of tuning the magnetic properties of $D0_{22}$ $Mn_{3-\delta}Ga$ films in addition to obtaining a flat surface at high growth temperature. This work was partly supported by Samsung Electronics.

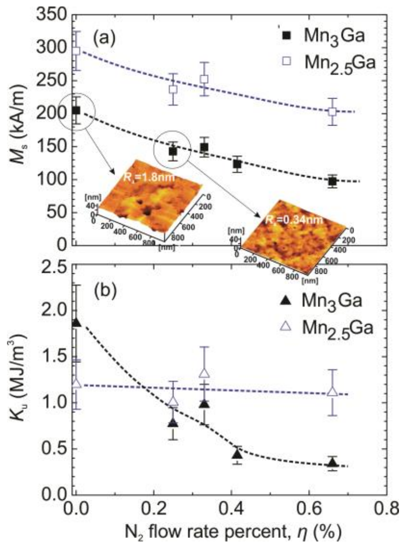

Fig. 1. (a) Saturation magnetization M_s and (b) perpendicular magnetic anisotropy K_u of 50 nm N-doped Mn_3Ga and $Mn_{2.5}Ga$ with respect to the varied N_2 flow rate percent (η). The inset figures show the surface images taken by atomic force microscopy for η = 0% and 0.25% Mn_3Ga cases.

References:

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