Magnetic damping of NiMnSb half-Heusler alloy film with varying annealing temperature

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Half-metallic Heusler alloys are primitive candidates for application in spintronic devices, such as magnetoresistive random access memory[1], current-perpendicular-to-plane giant magnetoresistance read heads for hard disk drives[2] for their high spin polarization value and large magnetoresistance ratio. Compared to full Heusler alloys, half-Heusler alloys, owing to a large bandgap which helps to suppress thermal activation of electrons over the bandgap, could be advantageous for high-performance magnetoresistive devices. Epitaxially grown NiMnSb[3] (NMS) is a well-known candidate with all-potential properties for such applications. To further investigate the possibilities of this material for application in spintronic devices, the estimation of Gilbert damping (α) is necessary. So, here we report the estimation of α as a function of annealing temperature (T_{annl}) and structural ordering. NiMnSb films were deposited by a co-sputtering method using Ni and MnSb targets in DC-sputtering on a single crystalline MgO (001) substrate. MgO-substrate/ Cr (30 nm)/Ag (40 nm)/NMS (30 nm)/Al (1.5 nm) films were annealed at temperatures in the range from room temperature to 673 K. The estimation of α was done by a time-resolved magneto Kerr effect (TRMOKE) method based on an all-optical two-color pump-probe setup[4]. Out-of-plane X-ray diffraction patterns were measured for all the samples as a function of T_{annl} and NMS (002) and (004) superlattice peaks were clearly observed in all cases. When the T_{annl} increases, the NMS(111) peaks were observed which ensure the formation of $C1_b$ type ordering. Figures 1 (a) and (b) show the degrees of order for $B2$- and $C1_b$-type structures respectively, as a function of T_{annl}. In both cases the degrees of order show maxima at T_{annl} = 573 K and then drop. To evaluate the α as a function of T_{annl}, the resonance frequency (f_r) was measured using TRMOKE microscope. A bias magnetic field ($\mu_0 H_b$) was applied at θ_H = 60°. Using the linearized LLG equation[5] α was estimated as a function of the T_{annl}. The value of α (Fig. 1 (c)) decreases with T_{annl} and shows a minimum value of 0.008 at T_{annl} = 573K where the degrees of order show maxima and then again increases, indicating that the degrees of order of samples have strong correlation with Gilbert damping. Therefore, we conclude the 30 nm thick NiMnSb thin film with T_{annl} = 573K exhibited highly ordered structure and low magnetic damping showing favorable criteria for application in spintronic devices.

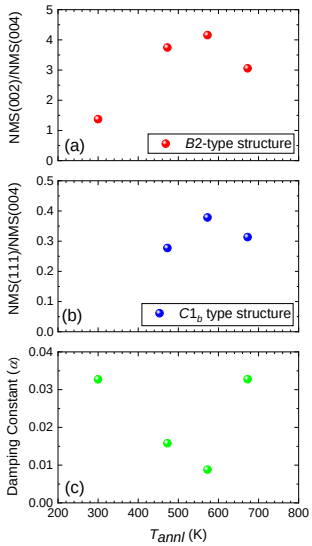

Figure 1: The degree of order considering (a) $B2$-type structure, (b) $C1_b$ type structure and (c) damping constant plotted as a function of annealing temperature (T_{annl}) of NiMnSb thin film.

Reference

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