Structure and magnetic properties of epitaxial Fe-Ga thin films

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Information transport and processing using magnons have gained considerable attention in the field of spintronics. The magnons with short wavelengths enable high integration. Magnons can be generated and converted back by electronic signals. Moreover, usage of wave allows the operations with vector rather than scalar variables [1]. Hybridization of magnons with phonons has recently been considered as a powerful tool for spin control, which will open a new way for controlling the magnon. In a previous study [2], strong magnon-phonon coupling was observed in the surface patterned Fe-Ga films on GaAs single crystal substrate by employing the optical means. However, the previous study did not focus on the fundamental magnetic properties including magnetostrictions for the epitaxial Fe-Ga thin films although the magnetostriction property is closely related with the magnon-phonon coupling strength. Thus, in order to study the mechanism of magnon-phonon hybridization, it is crucial to systematically investigate the structure and the magnetic properties of epitaxial Fe-Ga thin films deposited on single crystal substrates.

This study focuses on the effect of Ga concentration on structure and magnetic properties of epitaxial Fe-Ga films. The Fe-Ga films were deposited on GaAs(001) and MgO(001) single crystal substrates by magnetron sputtering using $Fe_{50}Ga_{50}$ and Fe targets. For comparison, the Fe-Ga films were also deposited on thermally-oxidized Si substrates. The GaAs(001) substrates were rinsed in 36% HCl for 3 minutes followed by rinsing in ultra-pure water for 30 seconds before annealing at 400 ℃ for 30 minutes to remove the oxidized layers. The $Fe_{80}Ga_{20}$, $Fe_{75}Ga_{25}$, $Fe_{70}Ga_{30}$ and $Fe_{50}Ga_{50}$ layers were epitaxially grown on GaAs(001) and MgO(001) at the substrate temperature of 400 ℃. On the other hand, the Fe-Ga films deposited on thermally-oxidized Si substrates showed the polycrystalline growth. The optical cantilever method was employed to characterize the magnetostriction property of the Fe-Ga layers in the [110] direction. The epitaxial Fe-Ga films grown on GaAs(001) and MgO(001) show larger magnetostriction than the polycrystalline Fe-Ga films on the thermally-oxidized Si substrates. Saturation magnetostriction in the Fe-Ga [110] direction reaches a maximum of 145 ppm for $Fe_{70}Ga_{30}$ deposited on MgO(001), which is of the same order as that of bulk Fe-Ga [3]. In the presentation, we will discuss the relation between structure and magnetostriction property.

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