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Magnetic and Thermal Properties of Ta/Mo Double Underlayer for Spin Valves Applications

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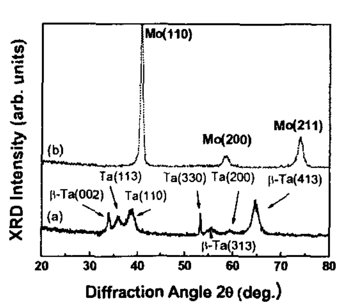
Electronic transport and scattering phenomena in spin valve structures have been examined and their microstructure and boundary materials have been reported to influence the magnetic properties. These spin valve devices are extending their application to various magnetic sensor application as well as the giant magnetoresistance (GMR) devices of current perpendicular to plane(CPP) mode [1]. To fabricate the spin valve devices, the crystalline structures of each thin films are related with magnetic properties of spin valve devices. The Ta/Mo underlayer is very useful for crystalline seed layer, the properties of spin valve structure with Ta/Mo double underlayer exhibit good MR ratios and high enough coupling fields.

In this study, we have investigated the change of magnetic and thermal properties of spin valve of Ta(10 Å)/Mo(8.5 Å) and Ta(10 Å)/Mo(25.5 Å) thin film with those of Mo underlayers [2]. Spin valve samples were deposited on Si substrates by using DC magnetron sputtering system. The spin valve samples with sample size of 0.5 inch x 0.5 inch were deposited with line width of 200um and 500um, respectively. The spin valve structure is Si/SiO_2/Ta(10Å)/Mo(xÅ)/CoFe(28Å)/Cu(22Å)/CoFe(18Å)/ IrMn(65Å)/Ta(25Å). Figure 1 show the XRD pattern of Ta and Mo thin film for as deposited states. Fig. 1(a) shows small peaks are occurred. Fig. 1(b) shows the (110), (200), (211) oriented α-Mo peak occurs at 40.5°, 57.2°, and 73.7° and Mo peaks are more crystallized than Ta. Thus, we used Ta/Mo double layer for spin valve structure as an underlayer. Figure 2 shows the MR ratio of spin valves having double underlayers made with various Mo thickness as a function of annealing temperature. The MR ratio of the spin valves does vary much with different mono underlayer made with Mo thickness 0 to 25.5 Å. The MR ratio increases from 7.78 % to 8.51 about 0.7 % with annealing temperature of up to 200 °C. After then, the MR ratio decreases to 3.04 % as the annealing temperature is further increased to 300 °C.



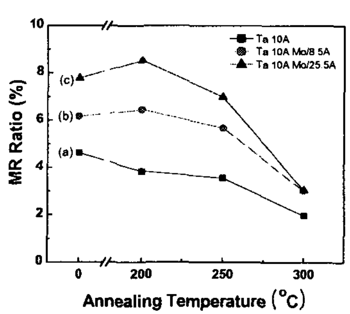


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Figure of merits of magneto-optic spatial modulators with magneto-photonic crystals

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Magneto-optical spatial light modulator (MOSLM) is a real-time programmable device for modulating the 2-dimensional optical signals at high speed. Although a MOSLM could be realized successfully using single magnetic layer with transparency, the low Faraday rotation might be a big limitation for practical application in the case of thin film type MOSLM, because the contrast of pixel is directly proportional to the Faraday rotation of magnetic layer showing the enhancement of Faraday Effect is the most important key to practically realize the thin film type MOSLM. On the other hand, it is well known that the large enhancement in linear and nonlinear magneto-optical responses of the magnetophotonic crystal (MPC), which is occurred from the light localization in magnetic defect layer [1, 2]. The enhancement of Faraday rotation could be predicted to occur theoretically and proved experimentally using nano-sized periodic structures. We have developed the new type of magneto-optical spatial light modulator (MPC-MOSLM) fabricated by combining 1-dimensional magnetophotonic crystal and micro-patterned drive-lines. It must be notable that the transmittance could be decreased at the same time with increase of the Faraday rotation showing some trade-off relation when a MPC is used in MOSLM. In this study, we have optimized the MPC structure with the figure of merit $F = T \cdot \sin(2\theta_F)$ %, where T and θ_F are transmittance and Faraday rotation angle respectively. Figure 1 shows the figure of merits of magneto-photonic crystals, which were in magneto-optic spatial modulators. It was known that the optimum k was 4 in the case of dual cavity while the optimum k was 5 in the case of single cavity. Both the magneto-optic spatial light modulators with single cavity and dual cavity showed over 5 times larger Faraday rotations than that with single magnetic layer.

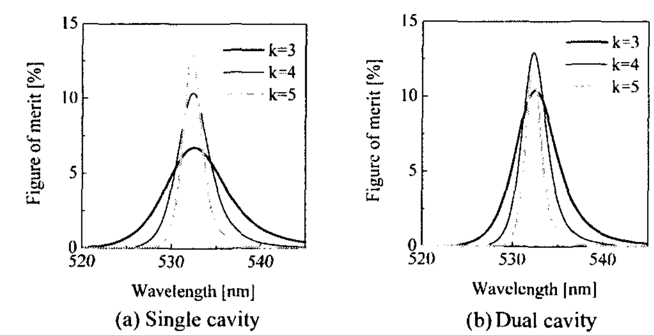

Fig. 1. Figure of merits of Magneto photonic crystal with single (a) or dual (b) cavity. k is represents the pair number of dielectric multilayer.

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