A8

Novel (Pt/Co/Pt/Ni) multilayers for magneto-optical recording media

KAIST G.Srinivas and Sung-Chul Shin

1. Introduction

The Curie temperatures, T_c, of the widely studied Co-based multilayers [1-3] for use as magneto-optical storage media, especially for applications with blue laser light, are between 250 and 400°C depending on preparation conditions. The optimal disk writing temperatures are between 150 and 200°C. Recent attempts to reduce the T_c of Co/Pt multilayers involved increasing the thickness of platinum layer or adding elements such as Re, Os, Ni, Tb etc. to the cobalt layer [2,3], which leads to changes in the saturation magnetization, Kerr rotation, interfacial structure, and anisotropy energy etc.. In a novel approach we tried to combine the attractive features of Co/Pt and the low T_c feature of Ni/Pt multilayers in (Pt/Co/Pt/Ni) multilayers.

2.Experiment

(Pt/Co/Pt/Ni) multilayers with same number of repeats of 20 were deposited by dc magnetron sputtering on Corning glass substrates under a base pressure of about 1 x 10^{-6} Torr and sputtering Ar gas pressure of 7 mTorr. The power applied to each of these targets was 30 W. The target to substrate distance was three inches. The dwelling time each substrate spent under the target was controlled and monitored using a microprocessor-based stepping motor which drove the substrate table. The thickness of one of these materials (Pt, Co, Ni) was varied while that of others was fixed. Low angle x-ray diffraction of these multilayers was studied to investigate the integrity of multilayer structure, thickness of the sublayers and total layer, and the details of the interfaces. The Kerr loops at a wavelength of 5320 Å and the spectral dependence of the Kerr rotation were measured using a Kerr spectrometer based on a photo-elastic modulator. The Curie temperature was determined by monitoring the Kerr rotation at a wavelength of 3000 Å (since Kerr rotation was observed to be maximum at this wavelength) in the temperature range of 290 K and 600 K. The magnetization was measured using a vibrating sample magnetometer.

3. Results and Discussion

The coercivity, loop squareness ratio,saturation magnetization, M_s, of (Pt/Co/Pt/Ni) multilayers are summarized in Table I. It can be observed from Table I that as expected, M_s increases with increasing t_{Ni} or t_{Co} and decreases with increasing t_{Pt}. We have observed that T_C increases with increasing t_{Ni} (for same t_{Pt} and t_{Co}) or increasing t_{Co} (for same t_{Pt} and t_{Ni}). Increase in t_{Pt} for same t_{Co} and t_{Ni} was observed to reduce T_C. It can be observed from Table I that T_C of these multilayers are between 135 and 330°C. With increase in t_{Co} or t_{Ni} the net magnetization of the multilayer is expected to increase which should thereby lead to an increase of T_C. The Kerr spectrum exhibited a monotonic increase in the Kerr rotation with decreasing wavelength, as observed in Co/Pt multilayers. The increase in the Kerr rotation at shorter wavelengths can be associated with the contribution from magnetically polarized platinum atoms, similar to that observed in Co/Pt multilayers. We observed that the Kerr rotation increases with increasing Ni layer thickness for the same Co and Pt layer thicknesses. This could be due to the increase of total magnetization and thereby the Kerr rotation. The trends of the magnetic and magneto-optical properties of (Pt/Co/Pt/Ni) appear to be combination of the properties of equivalent coupled Co/Pt and Ni/Pt multilayers. The published data on Ni/Pt multilayers indicate that multilayers with $t_{Ni}/t_{Pt} < 1/3$ have very low Curie temperatures and are paramagnetic at room temperature, while multilayers with $t_{Ni}/t_{Pt} > 1$ are ferromagnetic and T_c increases with increasing t_{Ni}/t_{Pt} [4,5]. Co/Pt multilayers are ferromagnetic in nature over a large range of t_{Co}/t_{Pt} and the Curie temperature increases with increasing t_{Co}/t_{Pt}. Therefore, if one considers (Pt/Co/Pt/Ni) multilayers as coupled Co/Pt multilayers (with high T_c) and Ni/Pt multilayers (with low T_c), the results of the Kerr spectra, magnetization, coercivity, and T_c measurements could be easily understood.

Table I. Coercivity H_c, Saturation magnetization M_s, squareness ratio r, and Curie temperature T_c of (Pt/Co/Pt/Ni) multilayers deposited on glass substrates with 100-Å thick Pt underlayers.

Sample	H_c (Oe)	r	Ms (emu/cc)	Tc (°C)
$(2.3\text{-Å}Pt/3\text{-Å}Co/2.3\text{-Å}Pt/3\text{-Å}Ni)_{20}$	383	0.65	270	135
$(2.3\text{-Å}Pt/3\text{-Å}Co/2.3\text{-Å}Pt/5\text{-Å}Ni)_{20}$	426	0.78	303	180
$(2.3\text{-Å}Pt/3\text{-Å}Co/2.3\text{-Å}Pt/7\text{-Å}Ni)_{20}$	418	0.6	316	215
$(2.3\text{-Å}Pt/5\text{-Å}Co/2.3\text{-Å}Pt/3\text{-Å}Ni)_{20}$	522	0.76	354	230
$(2.3\text{-Å}Pt/5\text{-Å}Co/2.3\text{-Å}Pt/5\text{-Å}Ni)_{20}$	570	0.75	445	270
$(2.3\text{-Å}Pt/5\text{-Å}Co/2.3\text{-Å}Pt/7\text{-Å}Ni)_{20}$	415	0.5	406	330
$(4.6\text{-Å}Pt/5\text{-Å}Co/4.6\text{-Å}Pt/3\text{-Å}Ni)_{20}$	750	1	221	205
$(4.6\text{-Å}Pt/5\text{-Å}Co/4.6\text{-Å}Pt/5\text{-Å}Ni)_{20}$	740	1	308	250
$(4.6\text{-Å}Pt/5\text{-Å}Co/4.6\text{-Å}Pt/7\text{-Å}Ni)_{20}$	644	0.77	304	305

Conclusions

In conclusion, we have prepared (Pt/Co/Pt/Ni) multilayers and studied their magnetic and magneto-optical properties. These multilayers exhibit very attractive features of low Curie temperature between 150 and 300°C, enhancement of the Kerr rotation at lower wavelengths, negligible Kerr ellipticity, which make them ideal alternatives for magneto-optical storage.

References

1. P.F.Carcia, Proc. MORIS'94, J.Magn.Soc.Jpn. **19, S1, 5** (1994).
2. S.Hashimoto and Y.Ochiai, J.Magn.Magn.Mater. **88,** 211 (1990).
3. S.Hashimoto, A.Maesaka, K.Fujimoto and K.Bessho, J.Magn.Magn.Mater. **121,** 471 (1993).
4. R.Krishnan, H.Lassri, M.Porte, M.Tessier and P.Renaudin, Appl.Phys.Lett. **59,** 3649 (1991).
5. R.Krishnan, H.Lassri, S.Prasad, M.Porte and M.Tessier, J.Appl.Phys. **73,** 6433 (1993).