EFFECT OF MAGNETIC PROPERTIES ON KERR ROTATION ANGLE IN AMORPHOUS NdTbFeCo ALLOYS

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Abstract - Amorphous NdTbFeCo alloys are prepared with different substrate positions and rotation speeds of substrate holder to investigate the effect of magnetic properties on Kerr rotation angle. Angular momentum of the substrate holder induces high squareness of magnetic hysteresis loops in the amorphous alloys. This leads to the fact that the magneto static energy of the hysteresis loops is proportional to remanent rotation angles.

KEYWORDS: KERR ROTATION ANGLE, ANGULAR MOMENTUM, MAGNETO STATIC ENERGY

1. INTRODUCTION

It is well recognized that magneto-optic (MO) recording has been one of the promising candidates for multimedia system. Conventional MO recording materials for the multimedia system are mainly amorphous heavy rare earth-transition metal (HRE-TM) alloys, for example an amorphous TbFeCo alloy. To increase recording density in MO recording, a short wavelength of a SHG (Second Harmonic Generator) green laser beam (532 nm) has been introduced. However, it is pointed out that the reduction of Kerr rotation angle ($\theta_K$) in the short wavelength cannot be avoided in the conventional amorphous alloys, due to heavy rare earth metal in the amorphous alloy. Recently, amorphous light rare earth-transition metal (LRE-TM) alloys attract great attention to solve the reduction of $\theta_K$ of the conventional MO materials in the short wavelength region[1].

To improve carrier to noise ratio (CNR) for read-out performance of the MO recording in the short wavelength, a high $\theta_K$ is strongly demanded in the amorphous recording material. $\theta_K$ can be divided into two parts on a MO hysteresis loop. One is a remanent Kerr rotation angle ($\theta_R$) and the other is a saturation Kerr rotation angle($\theta_S$). The former is more valuable than the latter for the improvement of CNR. In this research, we will add Nd as LRE element into the conventional amorphous TbFeCo alloy and investigate magnetic properties that affect $\theta_K$ in an amorphous NdTbFeCo alloy.

2. EXPERIMENTAL PROCEDURE

Amorphous NdTbFeCo alloys were deposited on glass substrates by DC magnetron sputtering apparatus with Nd, Tb and FeCo targets in Ar atmosphere (4.7 mTorr). The diameter of each target was 50 mm. The positions of the targets from the axis of the substrate holder and the distance between the targets and the substrate holder were 68 mm and 54 mm, respectively. The positions of the substrates were 30, 45 and 60 mm from the center of the substrate holder, and the rotation speeds of the substrate holder were 20, 40 and 50 R.P.M (Revolution Per Minute). To prevent the oxidation of rare-earth elements and enhance the reflection of a laser beam, Al-Ti alloys were sequentially deposited over the amorphous NdTbFeCo alloys. The composition of the amorphous alloy was analyzed by an I.C.P (Inductively Coupled Plasma Spectrometer). Magnetic hysteresis loops and Magnetic torque curves were measured by a V.S.M (Vibrating Sample Magnetometer) up to 14 kOe and a M.T.M (Magnetic Torque Meter) under 14 kOe, respectively. The Kerr rotation angle was measured by a Kerr spectrometer in the wavelength of 532 nm up to 15 kOe.

3. RESULTS AND DISCUSSION

Fig. 1 shows compositional distributions of the amorphous NdTbFeCo alloys with respect to radius of a substrate holder. As the radius of the substrate holder is increased, the compositional deviations in the amorphous alloys show little change in a Nd element from 6.6 to 7.5 at. %, but remarkable variations in a Tb element and a FeCo element from 11.4 to 18.6 at. % and from 82.0 to 73.9 at. %, respectively under the deposition of the same R. P. M. However, the deviations show less than 1 at. % from one another under the same radius with different R. P. M. Because the amorphous NdTbFeCo alloys are ferrimagnetic coupling between Tb and NdFeCo magnetic moments, it is
expected that saturation magnetization ($M_S$) and coercive force ($H_C$) of the NdTbFeCo amorphous alloys in TM-rich region decrease and increase, respectively with the increase of the radius.

This means that the change of $H_C$ in the amorphous alloys is determined not only by the composition but also by R. P. M. and the radius of the substrate holder.

Fig. 3 shows changes in saturation ($\theta_S$) and remanent ($\theta_R$) Kerr rotation angles of the amorphous NdTbFeCo alloys with respect to the radius of the substrate holder. Higher $\theta_S$ and $\theta_R$ at the same radius are obtained in the order of 20, 40 and 50 R. P. M. Because the main contribution to $\theta_K$ of the NdTbFeCo alloy is caused by sub lattice moment of a TM element[2] and $\theta_S$ is proportional to $M_S$[3], $\theta_S$ of the amorphous alloys should be reduced with the increase of the radius, for the decrease of the FeCo element and $M_S$, as shown in Fig. 1 and Fig. 2, respectively. However, $\theta_S$ and $\theta_R$ increase monotonically and drastically respectively with the increase of the radius in the amorphous alloys. Moreover, both of the $\theta_S$ and $\theta_R$ significantly vary at the same radius. There is a controversy in the experimental results between Fig. 1 and Fig. 2, and Fig. 3. Even though the amorphous alloys with small amount of the Tb element possess large saturation magnetization at the radius of 30 mm, it is magnetized with low squareness of magnetic hysteresis loops. On the contrary, the amorphous alloys with large amount of the Tb element retain small saturation magnetization at the radius of 60 mm and it is magnetized with high squareness of magnetic hysteresis loops. It is assumed that $\theta_S$ and $\theta_R$ are not directly proportional to $M_S$, but the degree of the squareness in the magnetic hysteresis loops. Furthermore, variations in $\theta_S$ and $\theta_R$ are also significantly occurred in the amorphous NdTbFeCo alloys of the same radius with respect to R. P. M. This means that both $\theta_S$ and $\theta_R$ are simultaneously affected by the positions of the substrates and R. P. M of the substrate holder during the sputtering deposition. Angular momentum that is consisted of the positions of the substrates and R. P. M of the substrate holder will be introduced to interpret the changes of $\theta_S$ and $\theta_R$ in the amorphous alloys.
Fig. 3: Changes in saturation (θS) and remanent (θR) Kerr rotation angles of amorphous NdTbFeCo alloys with respect to radius of substrate holder.

Fig. 4 plots the changes in θS and θR of the amorphous NdTbFeCo alloys with respect to angular momentum (EAM) of the substrate positions. As EAM increases, both of the θS and θR are proportionally increased. Moreover, the difference between θS and θR is reduced with the increase of EAM. This means that as EAM increases, the squareness of the magnetic hysteresis loop is increased. The EAM during the sputtering deposition plays a major role of change in the magnetization process of the amorphous NdTbFeCo alloys. The NdTbFeCo alloy with the large EAM is suitable for MO recording material due to the large θR. From now on, we will investigate magnetic properties which affect θR.

Fig. 5 shows the comparison of θR with perpendicular magnetic anisotropy energy (KU) of the amorphous NdTbFeCo alloys in terms of EAM. As EAM increases, KU is maintained in a low and constant value until around 800 of EAM but abruptly increased up to maximum KU and then simply decreased. In the calculation of KU, magnetization process is occurred in the homogeneous amorphous structure. It is assumed that the amorphous structure can be changed in structure relaxation by means of EAM. Since the amorphous NdTbFeCo alloys changes their amorphous structure around 800 of EAM, discontinuity in KU of the amorphous alloy is observed. Corresponding to KU, threshold for the increase of θR is appeared around 800 of EAM. The magnetic hysteresis loops over 800 of EAM showed the high squareness of the loops on Fig. 4. In the changed amorphous NdTbFeCo structure, θR is inversely proportional to KU.

Fig. 6 plots comparison in remanent state between θR and magneto static energy (Mr x HC) of the amorphous NdTbFeCo alloys with respect to EAM. θR and (Mr x HC) are coincidentally increased with the increase of EAM. Furthermore, the magneto-optic property of θR is proportional to the magnetic one of (Mr x HC) in the NdTbFeCo alloys. When the amorphous NdTbFeCo alloy is deposited during the sputtering process, atoms sputtered from Nd, Tb, FeCo targets arrive on substrates which are positioned at different radius and R. P. M. The arrived atoms conduct the surfacial mobility depended on degree of the driving
force of the substrates which is proportional to the energy involved in substrates, referred to angular momentum energy. The surfacial mobility causes structure relaxation in the amorphous alloy around 800 of EAM, as shown on Fig. 5. The structure relaxation in the amorphous alloys modifies the magnetization process to high squareness of magnetic hysteresis loops which means high (Mr x HC).

![Graph](image)

Fig. 6: Comparison in remanent state between Kerr rotation angle ($\theta_R$) and magneto static energy (Mr x HC) of amorphous NdTbFeCo alloys with respect to angular momentum of substrate positions

4. CONCLUSIONS

The amorphous NdTbFeCo alloys with the different EAM were deposited in DC magnetron sputtering apparatus to investigate the effect of magnetic properties on $\theta_R$. Comparison $\theta_R$ with (Mr x HC) was well coincided with respect to EAM. The magneto static energy induced by the amorphous structure relaxation was a principal factor to affect Kerr rotation angle in the amorphous NdTbFeCo alloys.

REFERENCES