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THERMOMAGNETIC SWITCHING EXPERIMENTS ON GdTbFe FILMS

J. H. Crasemann, H. Heitmann, M. Rosenkranz and K. Witter


Abstract. - The switching behavior of amorphous GdTbFe magneto-optic storage layers has been investigated as a function of compensation temperature. Films with Curie temperature ranging from 420 K to 495 K and compensation temperatures ranging from 200 K to 420 K exhibit writing behavior with carrier-to-noise ratio up to 61 dB. Outside this range poor quality films are obtained.

Introduction

Amorphous rare-earth transition-metal (RE-TM) magneto-optical (MO) films are used for high density data storage memories [1]. The films are ferrimagnetic, having a Curie temperature, $T_C$, and compensation temperature, $T_{comp}$, where $T_{comp}$ can be influenced by proper relation between RE and TM content. In GdTbFe films, which will be investigated here, $T_C$ is determined by the relation of Gd and Tb. Carrier-to-noise ratio (CNR) up to 60 dB on MO-films has been reported [2, 3]. Direct overwrite with no additional external magnetic fields was also observed [4] and models developed [5, 6]. Domain shape and size irregularities affect the packing density and CNR of storage media. The correlation between switching parameters and magnetic quantities is not well established yet. Therefore, it is necessary to understand the basic mechanisms of domain switching to optimize the performance of the system.

Experimental

Evaporated MO storage layers based on amorphous GdTbFe are studied. For optical and chemical purposes the MO-films are sandwiched in a trilayer film configuration on a glass substrate with photopolymerization lacquer pregroove structure. The films were characterized by vibrating sample magnetometer and torque measurements, obtaining temperature dependent information on the saturation magnetization, $M_s$, Curie temperature, $T_C$, and compensation temperature $T_{comp}$. Writing and erasing experiments were performed on a magneto-optic recorder by means of laser modulation in an external magnetic field up to 80 kAm$^{-1}$. The switching sensitivity, signal, and noise level are investigated in dependence on the magnetic properties of the films.

Results

Thermomagnetic switching of MO-disks is dependent on a variety of parameters, like external magnetic field, laser power, $T_C$, $T_{comp}$, temperature profile in the film, and so on. Figure 1 shows the dependence of optimum external magnetic switching field as a function of $T_C - T_{comp}$, where optimum field is determined with respect to minimum write noise. The composition of all films shown was chosen in such a way, that $T_C$ was kept in the range of 420 K to 495 K, and the compensation temperature was obtained by variation of the RE-TM ratio. With increased $\delta T_{comp} = T_C - T_{comp}$ the required optimum external magnetic switching field decreases. Figure 2 shows the behavior of the write noise at optimum external field as a function of $\delta T_{comp}$. A $\delta T_{comp}$-range of 80 to 300 K allows for writing with low noise quality. For $T_{comp}$ values in the vicinity of Curie temperature or below 50 K the write noise levels of the films shown are drastically increased.

Discussion

The energy terms controlling thermomagnetic switching are external magnetic field energy, demagnetizing field energy, and wall energy [7]. The forces...
strongly influenced by the temperature dependence of
the coercive force. At low compensation temperature,
$T_{\text{comp}}$, the coercive force is only little dependent on
the radius with respect to the laser spot center. Under
such condition microscopic fluctuations of $H_c(r,T)$,
due to microscopic composition inhomogeneities, al-
low formation of irregular shaped domains, increasing
the noise level [8]. If the compensation temperature is
close to the switching temperature, small fluctuations
in $T_{\text{comp}}$ are assumed to create strong pinning centers,
causing increased domain jitter, resulting in elevated
noise level. Under such conditions the coercive force
is a strong function of position and time. As a result
of our investigations we found that optimum switching
conditions are obtained at compensation temperatures
between 100 K and 300 K below Curie temperature.

\[ \frac{dE}{dr} \]
acting on domain walls depend on tempera-
ture and thus via the temperature distribution on the
disk as well as on domain size as on the position of
the laser spot. The temperature distribution is not
centrosymmetric due to the relative motion of laser
spot and disk. Domain wall motion is possible un-
less the coercive force overcomes the sum of the above
mentioned forces. The higher the compensation tem-
perature ($\delta T_{\text{comp}}$ small) is, the lower is the saturation
magnetization, $M_s$, and thus the resulting forces [5]
supporting domain dormation. Therefore higher ex-
ternal magnetic fields for proper writing conditions to
obtain minimum noise, which is a probe for domain
regularity [8], are requested. The write noise level is

\[ \text{Write noise as a function of the difference of Curie}
\text{and compensation temperature.} \]

Fig. 2. – Write noise as a function of the difference of Curie
and compensation temperature.

\[ \text{[1] Hartmann, M., Jacobs, B. A. J. and Braat,}
\text{J. J. M., Philips Tech. Rev. 42 (1985) 37.} \]
\[ \text{[2] Tanaka, F., Tanaka, S. and Immamura, N., Jpn}
\text{J. Appl. Phys. 26 (1987) 231.} \]
\text{Trans. Mag. MAG-23 (1987) 171.} \]
\[ \text{[6] Savage, C. M., Marquis, F., Watson, M. and}
\text{Meystre, P., Appl. Phys. Lett., to be published.} \]
\[ \text{[8] Zeper, W. B. and Spruijt, A. M. J., J. Appl. Phys.}
\text{63 (1987) 2141.} \]