MAGNETO-OPTICAL IMAGING OF DOMAIN FORMATION IN MnBi (Al,Si) THIN FILMS

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Introduction

Domain formation processes are studied by means of polarization microscopy in MnBi thin films doped with various contents of Al and Si. Recent investigations /1/ turned out that MnBi is still a very promising material for magneto-optical storage media. Detailed investigations revealed the essential magneto-optical and structural properties of Al doped MnBi /2/ for this applications.

Extremely high Kerr-Rotation up to 2° and appropriate values for the coercivity strongly favour this material for MO data storage. Substantial improvements in sample preparation technique /3/ yield results , which overcome earlier problems related to lateral magnetic inhomogeneity and coarse grained polycrystallinity.

Experimental

In our experiments we used a modified polarization microscope to visualize the magnetic domain pattern of MnBi(Al,Si) samples with very high spatial resolution. We were able to identify structures in the size down to 1 micrometer. The images are picked up with a extremely sensitive full frame CCD-Kamera with slow scan readout and variable integration time. The digitized pixel data are numerically processed in a powerful image processing system. Contrast enhancement, image correlation and realtime area determination with automatic contrast adjustment, filtering and background subtraction is performed during measurements.

The samples are prepared by coevaporation of Mn and Bi and additional separate layers of Al and SiO. By annealing the samples over few hours good homogeneity is reached and the grain size of the polycrystalline sample is reduced substantially below $1\ \mu\text{m}$ /3/. The doping of MnBi samples with Al and Si does not affect the strong perpendicular anisotropy, but leads to an improved microstructure which is essential for the stable formation of low diameter cylindrical domains. Furthermore the Kerr rotation is effectively enhanced. The overall sample thickness is about 200 nm prepared on glass substrates. To avoid the influence of chemical perturbations on the sample surface we always inspected the domain patterns from the substrate side of the sample. Polar magnetic fields up to 0.5 T were generated by means of a specially designed coil with iron core, which can be accessed by the microscope optics through a narrow hole.

Experimental Results and Discussion

Fig. 1 shows a typical hysteresis loop which is obtained by analysing a selected area of the sample from a series of domain pattern images using the image processing equipment. The integral Kerr intensity I_K on the y scale corresponds to the net magnetization of the area of interest. Points

Fig. 1 Hysteresis loop of $\text{MnBi}_{0.6}\text{Al}_{0.4}\text{Si}$ determined from domain pattern analysis

3 and 6 identify the coercivity field where the areas of up and down domains are almost exactly balanced. At points 1 and 4 opposite magnetic saturations of the sample are obtained.

Several samples with different amounts of Al doping were investigated, and from the hysteresis loops the strong influence to the coercive field is obtained. A more refined analysis of the domain pattern images as shown in fig. 1 revealed the existence of gradually contrast reduced areas which seemed to remain stable in the film.

Additionally, the time dependence of the shape of the hysteresis loops exhibits interesting features in different time regimes. High speed measurements of semiconductor laserdiode excited domain formation by curie-point writing in an external bias field were performed by means of a novel double pulse technique, which used two pulsed lasers for excitation and readout.

References

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