Domain Dynamics and Relaxation of Magnetization of Co/Pt Films with Perpendicular Magnetic Anisotropy

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Continuously growing information density and storage capacity associated with enhanced read/write cycle times are characterizing the current advances in magnetic harddisk technology. Recent developments in magnetic storage technology favor the optically assisted write process as a way to reduce the dimension of recorded bits. Furthermore, this kind of technique provides enhanced writing speed by avoiding slower inductive head technology. In this frame, we investigated the magnetization reversal processes induced by thermomagnetic writing procedure with short pulse laser excitation.

The dynamics of magnetic domains and the stability of domains affected by thermal excitations and external magnetic fields are studied by magnetooptic methods. Mainly, magnetooptic Kerr microscopy lateral resolution below 1 μm was applied. The investigations were carried out on Co/Pt thin films which exhibit a strong perpendicular magnetic anisotropy and high magnetooptic response. A typical hysteresis loop with the corresponding domain pattern is shown in fig. 1.

These kind of reversal is described in the framework of a micromagnetic simulation treating the magnetic thin film in terms of a 2D Ising model. The model represents the crystalline grains as single domain Stoner-Wohlfarth particles with uniaxial anisotropy. The interaction of the basic magnetic cells is introduced via dipolar and exchange coupling. It turns out from the simulations that the exchange interaction, which determines the domain wall energy, is reduced by more than 50% against the typical Bloch wall energy.

The thermal relaxation of magnetic domains with external field applied as well as in the remanent state obviously obeys an Arrhenius activation law in a certain regime of reversal speed. In addition, we carried out detailed studies of the morphology of domains. In particular, we are interested in the roughness of domain boundaries. It turned out from the analyses that there is a strong analogy to fractal growth models described by the Edwards/Wilkinson formalism. In comparison, we have
investigated the morphology of domains nucleated thermomagnetically and subsequently expanded by external nanosecond field pulses. Fig. 2 shows a typical series of the domains in a Co/Pt alloy thin film of 20 nm thickness. The roughness coefficient of the initially nucleated domain which mainly originates from the thermal profile of the laser pulse changes remarkable while field pulses expand the domains. After few pulses the roughness coefficient approaches the value determined from pure field driven reversal.

Fig. 2 Domain propagation of thermomagnetically nucleated domains by field pulses

Structural investigations of the samples reveal a typical grain size of the films of the order of 5 to 10 nm. It is reasonably from micromagnetic simulations that the grain boundaries act as very efficient pinning centers due to a chemical modulation of magnetic compounds in the film. The distribution of the pinning centers is responsible for the roughness of the domain boundaries. In addition fluctuations of the magnetization and the dispersion of crystalline axes of the film might also affect the roughness properties.

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