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LASER-WRITING AND PHOTOEMISSION-READING ON EPITAXIAL MAGNETIC THIN FILMS

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Abstract. - Thermomagnetic writing and reading has been performed successfully with epitaxial perpendicularly magnetized Fe-films grown on Cu (001). The films had fcc-structure and were only a few monolayers thick. For the reading of the magnetically stored information by spin-polarized photoemission and for the thermomagnetic writing the same pulsed UV-excimer-layer was used.

Perpendicular recording is an extensively explored technique for high-density information storage [1]. Important advances have been made by developing erasable magneto-optical recording media based on amorphous alloys of heavy rare earths and ferromagnetic 3d-transition-metals. In this paper experiments on a new perpendicular recording medium are discussed: epitaxial iron films of a few monolayer (ML) thickness.

Up to 14 ML of iron grow epitaxially on Cu (001) in the fcc phase and are ferromagnetic [2]. At low temperature a remanence magnetization perpendicular to the plane of the film is observed for films thicker than 2 ML. Figure 1 shows a typical polarization curve \( P(H) \) measured at 30 K for a 9 ML fcc-Fe film on Cu (001) with the spin-polarized photoemission technique. \( H \) is the magnetic field applied perpendicularly to the film plane. The coercivity decreases rapidly as function of temperature, as shown in figure 2 for a 10 ML film. The low density of inhomogeneities and the high remanent polarization make these films suitable for basic investigation of the magnetization reversal during thermomagnetic recording.

The magnetic properties of the Fe/Cu (001)-films were investigated by spin-polarized photoemission using a conventional Hg-Xe-lamp [2, 3]. For thermomagnetic writing, i.e. local reversal of the magnetization and subsequent reading by spin-polarized photoemission, the focussed beam of a KrF-excimer laser was used [4]. The laser (EMG 100, Lambda Physics) has a pulse duration of 16 ns and a maximum pulse energy of 250 mJ. The ultraviolet radiation (\( \lambda = 248 \) nm) can be directed with a series of dielectric mirrors and prisms perpendicularly onto the sample surface. Two computer controlled step-motors steered the motion of a 45°-deflection prism in two perpendicular directions thereby scanning the laser beam in steps over the sample surface. All the components of the focusing optics are placed outside the UHV-system to facilitate the adjustment. However this implies a long focal length of more than 1 m inside the vacuum. Therefore the minimum diameter of the focus becomes about 100 \( \mu \)m using the \( 1/e \) definition for the intensity. In most metals the photon energy of the KrF-laser (\( h\nu = 5 \) eV) is sufficient to excite electrons in a single step above photothreshold. Consequently reading of the magnetic information is feasible by measuring the spin-polarization of the electrons emitted by a single laser pulse. As the photoemission process is practically instantaneous, the duration of the reading process is determined by the duration of the laser pulse. Obviously, the laser-induced spin-polarized photoemission experiment gives the information of an ultrafast magnetometer.

Fig. 1. - Polarization curves \( P(H) \) measured at 30 K for 9 ML fcc Fe on Cu (001). \( H \) is the applied magnetic field perpendicular to the plane of the film.

Fig. 2. - Temperature dependence of the coercive field \( H_c \) for 10 ML fcc Fe film on Cu (001).
Thermomagnetic writing on a 6 ML fcc Fe/Cu (001)-film was performed by local heating of the film in an applied field. The film had a coercivity of 710 Oe at \( T = 30 \) K. Heating occurred in the focus of the UV-excimer laser by adjusting the pulse energy. The state of the magnetization ("up" or "down") of the irradiated area was checked by measuring the spin-polarization of the photoemitted electrons. After creation of a reversed domain, the laser-focus was scanned in discrete steps over the sample surface at reduced intensity. Again, monitoring at each step the spin-polarization of the photoelectrons it was possible to resolve the previously written magnetic information.

The magnetic domains in these films were stable. The demagnetizing energy which favors spontaneous domain formation becomes essentially zero for films of only a few ML thickness. In addition the high perpendicular magnetocrystalline anisotropy is accompanied by a correspondingly large wall motion coercivity which is proportional to the measured coercivity \( H_c \) of figure 2, see reference [5].

Thermomagnetic writing with epitaxial perpendicularly magnetized Fe films has been shown to be feasible. Further studies concerning the magnetic properties of these films are in progress, in particular the investigation of the thermomagnetic writing process using picosecond laser pulses.

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