Structural characterization of magnetic thin FePt films

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Today, information is stored digitally on magnetic storage devices. Driven by the enormous amounts of data, one of the current research aims is to increase the storage density of magnetic hard disk media. Therefore it is necessary to reduce the area covered by one information unit (bit). The concept of patterned media, where one bit is represented by a single nanostructure, is an approach to decrease the respective area [1]. Using materials with high uniaxial perpendicular magnetic anisotropy is another requirement for further increasing of the information density in magnetic storage devices. FePt or CoPt alloys in their chemically $L1_0$ ordered phase and (001) orientation exhibit this anisotropy providing sufficient thermal stability [2]. We currently combined patterned media and materials with high uniaxial perpendicular magnetic anisotropy. We used SiO_2 particles on Si-wafers providing the nanostructured pattern which was then covered with FePt films by sputtering at room temperature and the transformation into the $L1_0$ phase was performed by a subsequent rapid thermal annealing (RTA) process [3].
Planar FePt films as well as films deposited on SiO_2 particles have been investigated within this beam-time. The main goal of investigating planar films is a better understanding of the preparation process and its parameters with respect to the homogeneity of the films, orientation of the crystallites and magnetic properties. The orientation of the crystallites and the homogeneity of the films deposited on SiO_2 particles have been also measured.
The FePt films were sputtered onto Si(100)-wafers with a 100 nm thick thermally grown amorphous SiO_2 top layer. The deposited films reveal a fcc lattice without any ordering of the atom species. During a RTA process the disordered structure transforms into the ordered $L1_0$ phase. A linear gradient in the film thickness was produced on one of the samples using an ion beam etching process applied directly after the deposition which allowed a detailed study of the thickness dependence of the structural transformation process.
The X-ray diffraction experiments were carried out at HASYLAB beam-line G3. The energy of the incident radiation was chosen to be 8047 eV which is equivalent to the Cu-K_α-radiation used at our own laboratory equipment. Using a LaB_6 powder sample the calibration of goniometer and radiation energy was verified. In total 22 samples have been studied using gracing incidence as well as θ-2θ-geometry.

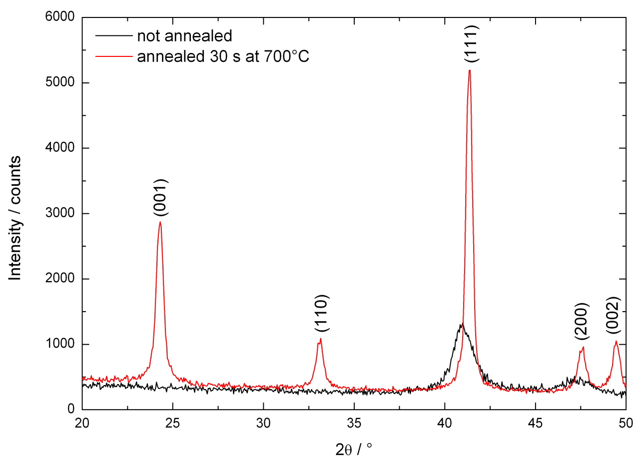

Figure 1: θ-2θ X-ray diffraction patter of a 20 nm planar FePt film

The influence of the annealing temperature and layer thickness on the modification of the structure of planar films has been studied. Figure 1 shows a comparison of two scans of the sample with the gradient in the film thickness before and after annealing. The measurement of the sample without annealing shows two peaks corresponding to (111) and (200) orientation. The two broad peaks indicate the presence of small crystallites. The diffraction pattern of the annealed sample exhibits all possible peaks. In comparison with the measurement of the as grown sample, the peaks became narrow which indicates an increase in the size of the crystallites. Since the relative intensities of the peaks measured compare to the calculated intensities, the conclusion can be drawn, that the crystallites exhibit statistical orientation. This result may be caused by the ion-etching process.
Figure 2 shows an overview of two samples with a 3 and 20 nm thick FePt layer. The relative intensities of the peaks measured indicate a preference of the desired (001) orientation. Furthermore a shift of the peak positions dependent on the layer thickness can be observed. A comparable peak shift could be observed at the sample with the thickness gradient.

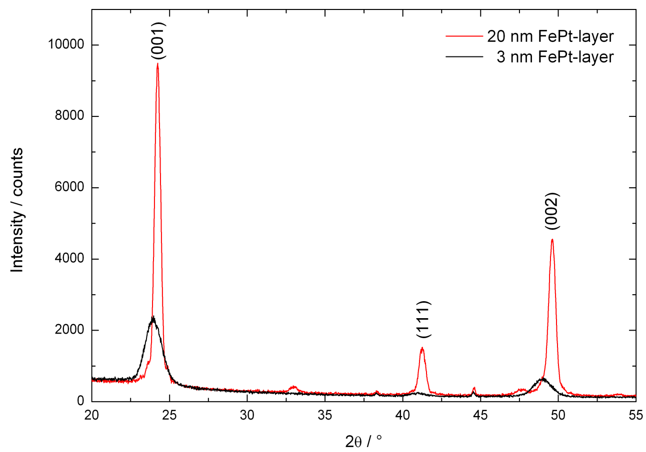

Figure 2: Overview of two samples with different layer thicknesses after annealing

Different sizes of SiO_2 particles (range: 10 nm - 7,8 μm) covered with FePt films with two thicknesses of 3 and 20 nm have been also studied. Space resolved measurements of the annealed samples using the MAXIM camera have shown a dewetting of the planar films as well as of the films deposited on SiO_2 particles at higher annealing temperatures. Further investigation of this phenomenon is necessary.

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