Structural changes of FePt films upon rapid thermal annealing

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Rapid thermal annealing (RTA) of Fe/Pt multilayers has recently been introduced as a novel approach to fabricate L1₀ ordered FePt films with (001) texture on amorphous substrates [1]. The mechanisms involved in the (001) texture formation upon annealing were discussed by Kim et al. and it is suggested that tensile in-plane strains during the order/disorder transformation favor the growth of (001) textured grains [2, 3].

In this study, 5 nm thick Fe₅₂Pt₄₈ films deposited via magnetron-sputtering at room-temperature onto thermally oxidized Si substrates were processed by RTA and the influence of the annealing time on the structural properties was investigated with respect to chemical ordering and (001) texture formation. X-ray diffraction patterns obtained in θ-2θ geometry show both fundamental and superstructure peaks related to (001) textured FePt films for all annealing times. Even after a short annealing time of 5 s, the (001) superstructure and (002) fundamental peaks are dominant compared to the (111) reflection and indicate a pronounced (001) texture. After an annealing time of 30 s, the integral intensity of the peaks reaches its maximum corresponding to the best (001) texture quality achieved for the investigated sample series. For annealing times larger than 150 s, additional diffraction peaks appear which can most likely be attributed to silicide formation during the RTA process. The full width at half maximum (FWHM) of the (001) peak was used to extract the perpendicular coherence length, L_{perp}. A value of L_{perp} up to 30 nm which is about 6 times larger than the initial film thickness was found for the longest annealing times and was correlated to a change in the film morphology from continuous to island-like. The intensity ratio of the superstructure and fundamental peak was used to extract the long range chemical order parameter S.

![Figure 1](image)

Figure 1: Dependence of (a) the a and c lattice parameter and (b) the c/a ratio on the annealing time. The values of bulk FePt are indicated.
A constant ordering parameter of $S = 0.88 \pm 0.1$ could be determined for all annealing times. No variation of $S$ with annealing time was observed. By extracting the $c$ and $a$ lattice parameter from the (001) textured grains the tetragonal distortion induced by the RTA process could be determined. After an annealing time of 5 s, the $c$-axis is substantially contracted while the $a$-axis is expanded compared to the bulk values of FePt (Fig. 1 (a, b)). Longer annealing times lead to a relaxation of the lattice parameters towards its bulk values and after an annealing time of 150 s no further change of the lattice parameters is observed. Concerning relevant mechanisms for the formation of the (001) texture, the strong tetragonal distortion is an indication of in-plane strain leading to the energetically favorable growth of (001) oriented grains, with the longer axis of the tetragonal distorted fct lattice pointing in direction of the strain. This finding is in agreement with the proposed effective volume shrinkage occurring during the rapid recrystallization process with the annihilation of defects and grain boundaries [4].

References