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Re-Orientation Behaviour of c-Variant FePt Thin Films

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1. Introduction

The magnetocrystalline and thermal stability of $L1_0$-FePt makes this alloy suitable for ultrahigh density recording. The possible impact on data storage devices makes a detailed knowledge of the dynamic processes essential for selectively designing alloys with diverse physical properties. Various experiments with bulk $L1_0$-FePt dealing with diffusion and ordering dynamics have been performed [1-3]. Up to the present, free (001)-surface-limited layers of $L1_0$-ordering systems were simulated by removing the periodic boundary conditions in c-crystallographic direction [4]. New simulations show that the c-variant of the $L1_0$ superstructure (easy axis of the magnetization out of plane of the thin film yielding the technologically desired magnetic axis) is unstable in the layers. The monoatomic planes spontaneously re-orient creating a- and b-variants domains (easy axis of the magnetic field in the film plane) [4], as shown in figure 1.

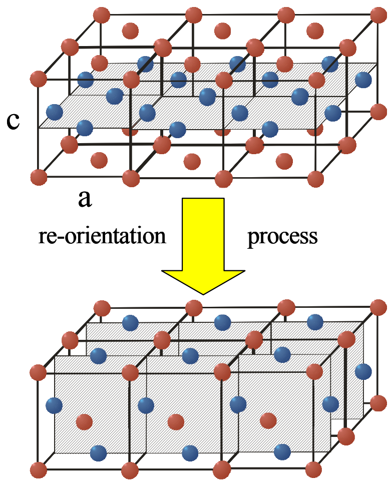

Fig.1: Sketch of the reorientation process in the $L1_0$-phase of FePt. The blue atoms indicate Fe, whereas the red atoms indicate Pt. The crystalline axes are indicated by ‘c’ and ‘a’.

2. Experimental

Recent experiments show evidence of this re-orientation behaviour within the $L1_0$ structure of FePt thin films. The experiments were done on FePt thin films via conversion electron Mössbauer spectroscopy (CEMS). The samples were prepared as ^{57}FePt(50 nm) / MgO(001). All samples were grown at 623 K with molecular beam epitaxy at a pressure of less than 5 x 10^{-11} Torr. The thin films were characterised with high resolution x-ray diffraction and the CEMS showing that the samples have the $L1_0$-

phase and out of plane magnetization. Detailed analysis of the CEMS spectra allowed to determine the occurrence of the different $L1_0$ variants in the structure of the FePt thin film samples: c-variant, a- and b-variants as well as a random mixture of all the three. We performed a stepwise annealing procedure at 773 K, 848 K and 898 K, each for a different sample, followed by CEMS characterisation. The picture arising from our first results is as follows: for relatively low temperatures the re-orientation takes place, The substrate (which supports the formation of the c-variant), induces a saturation of the re-orientation effect, as shown in figure 2. For higher temperatures the mobility of atoms increases. The substrate effect increases, leading to higher amounts of c-variant and earlier saturation. The formation of a random mixture of all variants may act as an intermediate state. Real relevance of the random mixture of variants is still not clear.

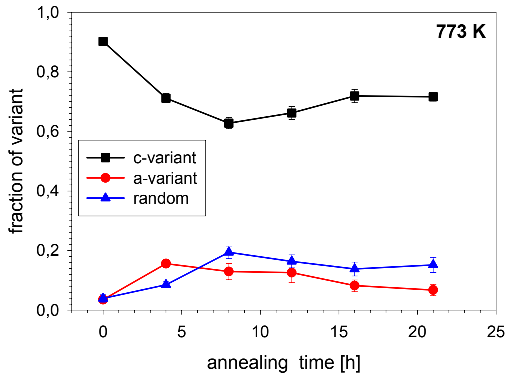

Fig. 2: Fraction of the different variants in a FePt thin film evolving in time for annealing at 773 K. The re-orientation effect saturates after long annealing times.

3. Conclusion

Simulations predict that a re-orientation of the c-variant to a- and b-variant phases in $L1_0$-ordered FePt can occur. We found experimental evidence for this ordering behaviour by investigating an annealed FePt thin film by means of CEMS. The re-orientation effect saturates for long annealing times depending on the annealing temperature.

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