RE-ORIENTATION BEHAVIOUR OF C-VARIANT FePt THIN FILMS

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INTRODUCTION

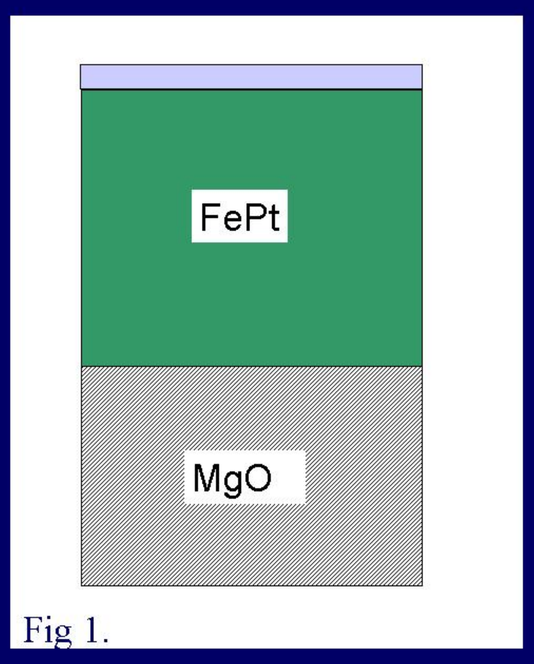

Fig 1.

Epitaxial grown thin FePt film
... FePt enriched with ^{57}Fe
…cover layer Pt

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, Fig. 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-variant domains (easy axis of the magnetic field in the film plane) [4], as shown in Fig. 2.

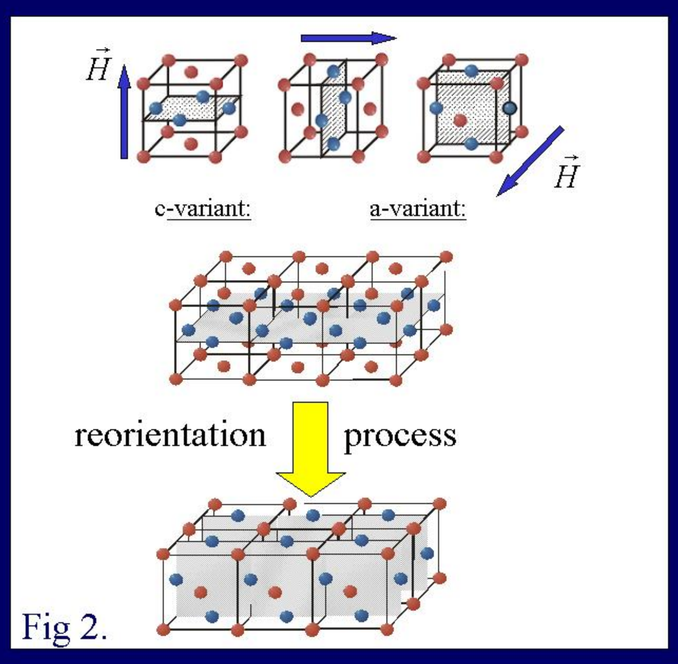

Fig 2.

$L1_0$-FePt forms a- and c-variant domains. They are the basis of the reorientation processes within thin films .

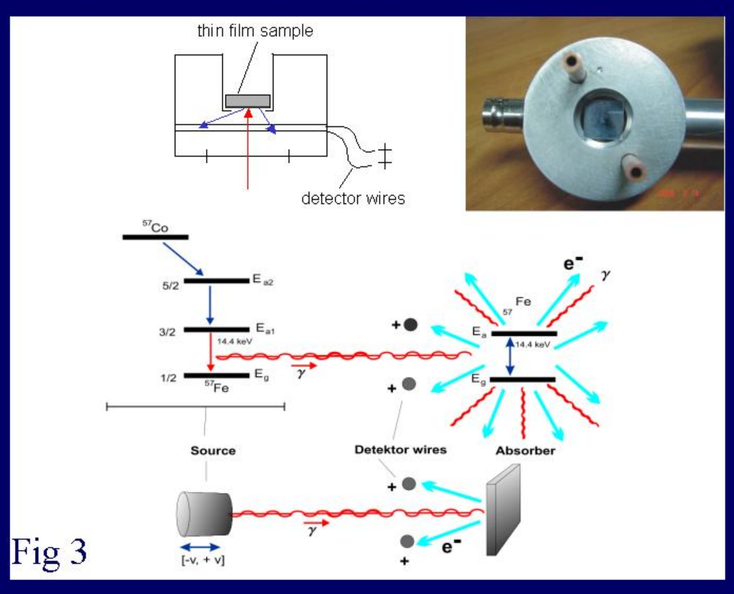

Fig 3

CHARACTERISATION & MEASUREMENT

Simulations were done with the Monte-Carlo Method and show a saturation of the re-orientation effect, Fig. 4. The effect seems to be thickness-dependent.

The experiments were done on $L1_0$-FePt thin films, Fig. 1 via conversion electron Mössbauer spectroscopy (CEMS), Fig. 3. The samples were prepared as ^{57}FePt(50 nm) / MgO(001) with molecular beam epitaxy at 623K. The samples initially have out of plane magnetization (c-variant). The CEMS analysis show that the thin films are composed of different $L1_0$ variants: c-variant, a- and b-varians as well as a random mixture of all three, Fig. 5.

The samples were stepwise annealed at 773 K, 848 K and 898 K, each for a different sample, followed by CEMS characterisation. In Fig. 6 It can be seen that the re-orientation starts, reverses and finally saturates at a certain fraction of variants, differing for the different temperatures.

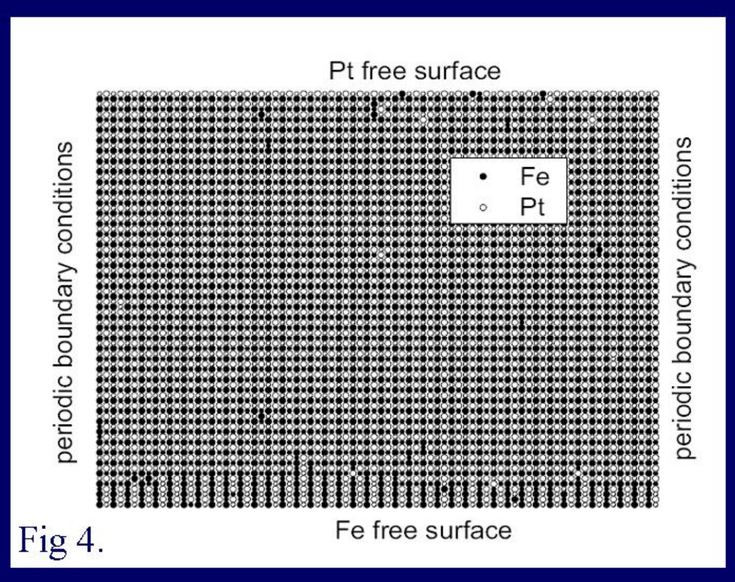

Fig 4.

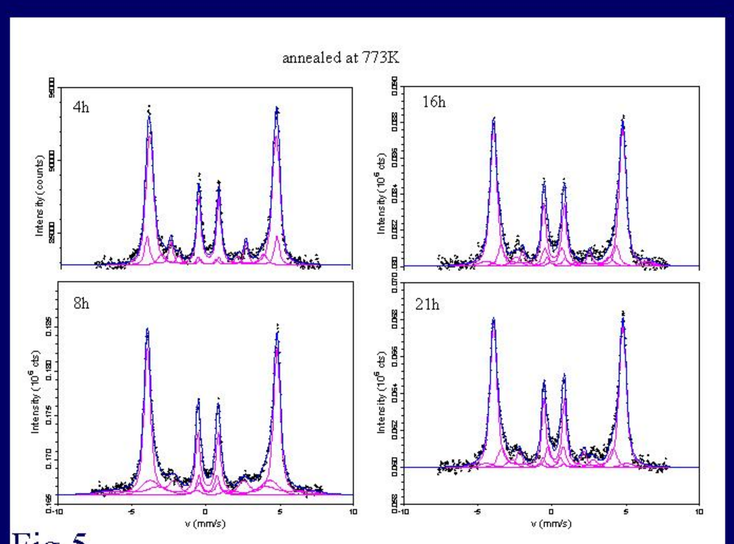

Fig 5.

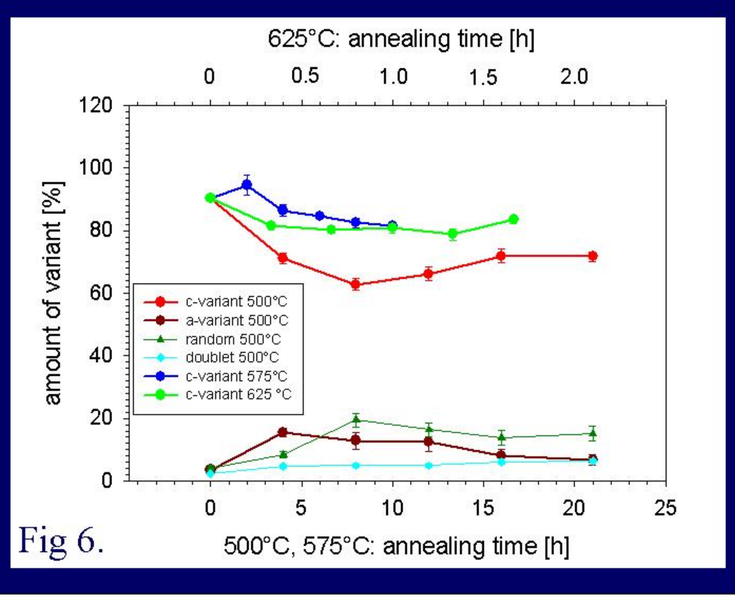

Fig 6.

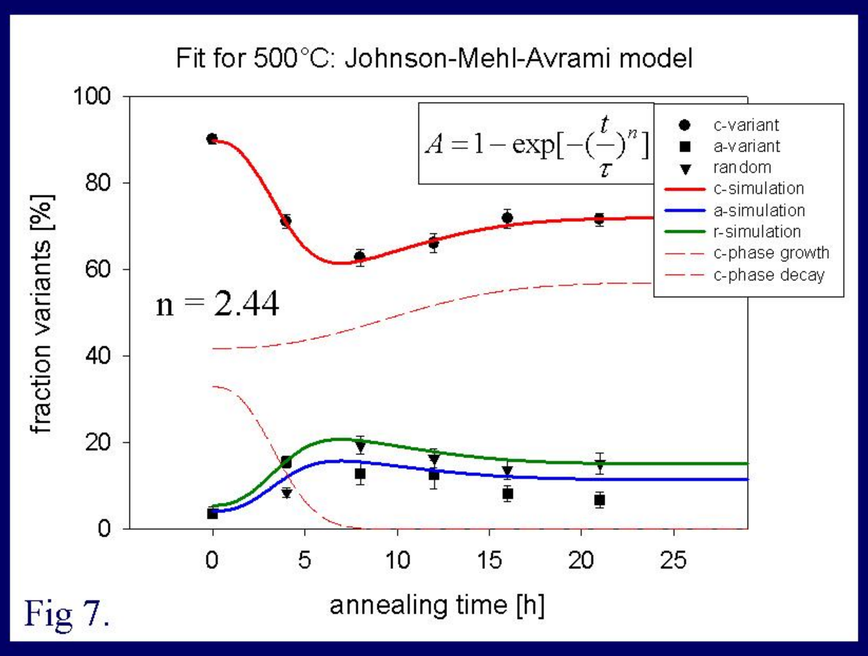

Fig 7.

Interpretation

The picture arising from the first results is as follows: for relatively low temperatures the re-orientation takes place. The substrate (which supports the formation of the c-variant via the enhanced magnetocrystalline anisotropy), induces a saturation of the re-orientation effect, as shown in the figure for the measurement results. For higher temperatures the mobility of atoms increases. The ordering effect of the substrate increases, leading to higher amounts of c-variant, see Fig. 6. The re-orientation effect seems to saturates after long annealing times, in agreement with the simulations.

Fig.7. Shows a simultaneous fit of all variants with a Johnson-Mehl-Avrami model for phase transitions [5]. For 500°C the critical exponent n = 2.44. This indicates a diffusive driving mechanism [1, 2], see Fig. 8.

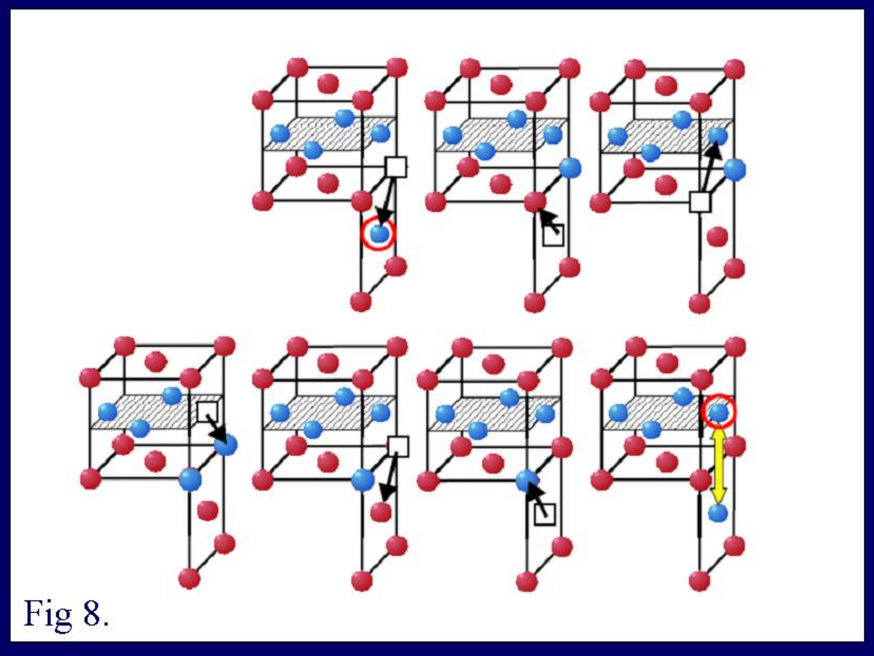

Fig 8.

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