ESRF	**Experiment title:** Systematic x-ray study of the thickness dependence of critical phenomena in epitaxial FeCo single crystal films	**Experiment number:** SI-343
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Report:

FeCo binary alloy films are a model system for phase transitions in the Ising universality class. Modern MBE film growth techniques allow one to study the thickness dependence of critical phenomena associated with the order-disorder transition in such films in order to explore the temperature region where the correlation length reaches the film thickness. A crossover to twodimensional critical behavior and peculiar order-parameter profiles are predicted.

The samples have been grown by MBE onto MgO(001) substrates at elevated temperatures. In the course of the experiments some of them have been overgrown by an MgO cap layer. After growth the films have been transferred into a mobile UHV chamber and carried to the ESRF. The measurements have been carried out at the TROIKA I station using Si and Diamond(111) monochromators in asymmetric Laue geometry and a Rh-coated mirror in order to suppress higher harmonics. In this long-term proposal we measured in total six films ranging from 340 to 50 Å in thickness in five measuring campaigns. For each film we scanned Crystal Truncation Rod profiles along the surface normal (see inset of Fig. 1) including the (001) superlattice reflection (white), the (002) fundamental bcc reflection (black) and the MgO(002) substrate peak (gray). The sample temperature was kept between 800 and 1050 K by means of radiation heating and feedback control by an optical pyrometer; the bulk transition temperature T_c is 1000 K. Typical lscans through the (001) superlattice reflections of a 300 Å thick sample are shown in Fig. 1. Oscillations due to the finite thickness of the films are visible as well as a pronounced asymmetry of the CTR profiles. Preliminary evaluation of the data gave the following results, which can be devided into two groups: results related to the x-ray scattering process and thermodynamic properties of the sample.

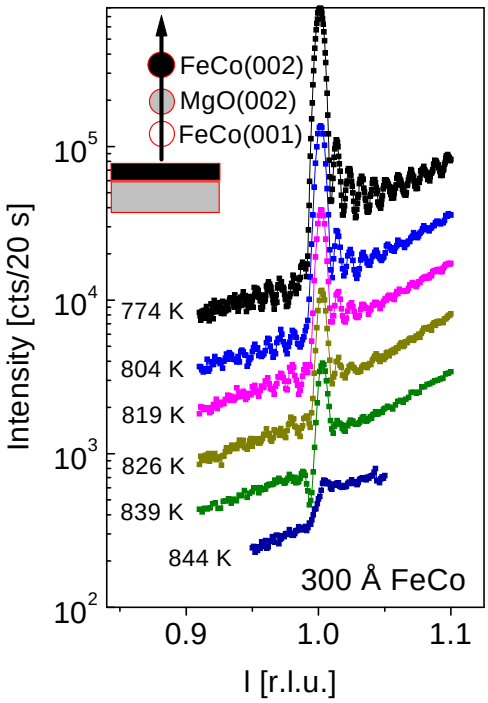

Figure 1: Temperature dependence of the (00l)-rod for a 300 Å thick FeCo film on MgO(001).

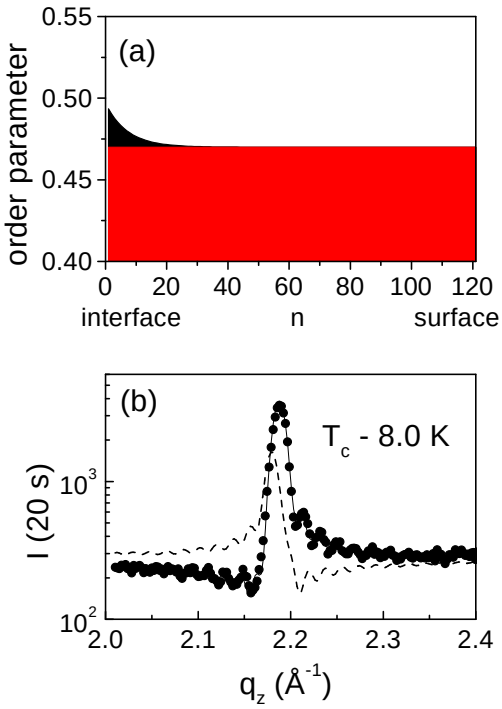

Figure 2: (a) Order-parameter profile and lscan (b) from a 300 Å sample. The straight line in (b) is a fit to the data corresponding to the model in (a).

1. The asymmetry of the lscans originates from the interference of the substrate CTR with film thickness oscillations and can be used to extract the phase information about the stacking sequence of the Fe and Co lattice planes. Fig. 2 shows an order-parameter profile vs. depth in the film together with the measured data. The straight curve in (b) corresponds to a layering scheme starting with Co, the dashed curve assumes Fe as the first layer starting from the substrate.

2. Although an order-parameter *profile* exists, which makes an analysis using model calculations necessary, the peak intensity of the (001) reflection already gives a flavour of the behavior of the mean order parameter in the sample. Fig. 3 summarizes the data for the 300 and the 100 Å sample. The peak intensities as a function of the reduced temperature show deviations from the 3d-Ising behavior with a critical exponent β (straight lines) starting at crossover temperatures t* (arrows).

A more detailed analysis of the data for all samples will be presented in a longer report which is currently under preparation.

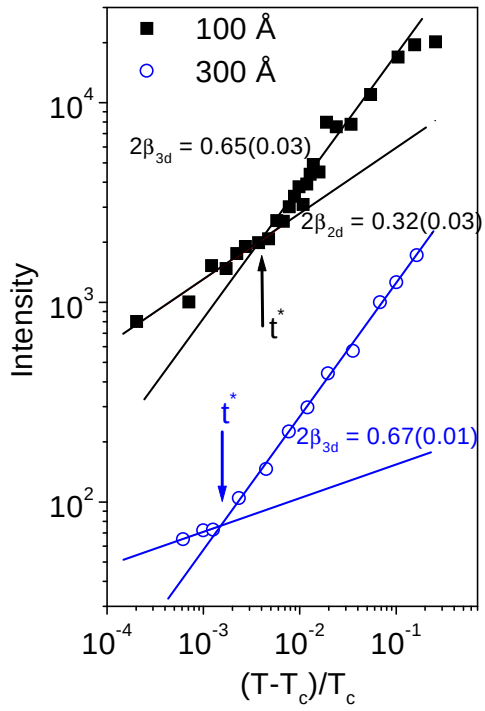

Figure 3: Peak intensity of the (001) reflection vs. reduced temperature for two samples. Lines are linear fits to the data.