ESRF	**Experiment title:** Reflectometry on FeCo single and multilayer	**Experiment number**: ME – 217
Beamline: BM 20	**Date of experiment**: from: 28.02.01 to: 03.03.01	**Date of report**: 30.08.01
Shifts: 9	**Local contact(s)**: Dr. N. Schell, Dr. A. Bauer	*Received at ESRF:*

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Report:

Experiment ME-217 was carried out at beamline BM20 of the ESRF. The focus of this experiment was the determination of layer thicknesses and layer roughness of FeCo/SiO_2 multilayers. The experiment is part of a strategyfonds project of the Helmholtz Society which aims at an optimization of multilayers for microinductor applications. The multilayers are produced by magnetron sputtering at Forschungszentrum Karlsruhe, Germany.

In order to link the magnetic properties of the microinductors to their multilayer structure, the dependence of layer thicknesses and layer roughness of the FeCo- and the intermediate SiO_2 layers had to be determined with respect to their dependence on the deposition parameters such as the sputter power and the argon partial pressure. This could only be done non-destructively by reflectometry experiments using synchrotron radiation. By performing further experiments in the laboratories at the HMI Berlin the crystallographic structure of the layers, their morphology, texture and residual stress state was characterized.

The reflectometry experiments were performed on the 6-circle-diffractometer at BM20 using a szintillation detector (detector slit width = 12mm, detector slit height 0,22mm). The energy of the monochromatic synchrotron radiation was set to 7,1 keV, near to the absorption edge of the FeCo compound. For the determination of the layer thicknesses, layer roughness and layer densities specular scans were performed in ω-2θ-geometry in the range of the critical angle of total reflection. For the evaluation of the experimental data simulations were carried out using different models of the multilayer structure. Results of the experiments and the subsequent modeling are given in tab.1.

Tab. 1: Deposition parameters, residual stresses, magnetic properties, layer thickness and roughness from simulations of the FeCo-/SiO_2 multilayer system

	FCS6Z1	FCS6Z4	FCS6Z5	FC6Zn6	FC6Zn7
sputter power FeCo P [W]	100	100	100	300	200
sputter power SiO_2 P [W]	300	100	300		
argon partial pressure p [mbar]	0,006	0,006	0,006	0,006	0,006
residual stresses [MPa]	-690	-860	-880	230	-70
saturation magnetization [T]	2,31	2,27	2,32		
coerzivity [T]	0,01732	0,01606	0,00342		
total layer thickness [Å]	4800	5000	5000	5600	5165
FeCo layer thickness [Å]	5*500	5*500	7*500	5*500	5*500
SiO_2 layer thickness [Å]	5*500	5*500	7*250	5*500	5*500
FeCo layer thickness [Å], model	493	478	504	468	516
SiO_2 layer thickness [Å], model	503	546	263	578	579
FeCo roughness [Å], model	51	27	29	45	20
SiO_2 roughness [Å], model	11	7	10	11	11
oxide layer thickness [Å], model	100	74	74	62	67

The layer thicknesses of the FeCo layers and the SiO_2 layers are in good agreement with the specification of 50nm ±10%. But, the reflectometry tests showed that an oxide coating on the sample surface is present, which has not been detected before and which might influence the magnetic properties. This is still under investigation.

The experimental results show further on, that there is a roughness difference between the FeCo and the SiO_2 layers. In order to link this to the morphology of the layers additional transmission electron microcopy tests were performed at HMI (fig.1, 2).

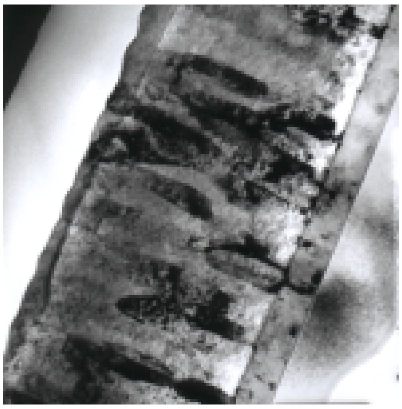

Fig. 1: *FeCo single layer with Ti bond coat on the Si-substrate the columnar grains grew through the whole layer [N. Wanderka, M. Macht HMI Berlin]*

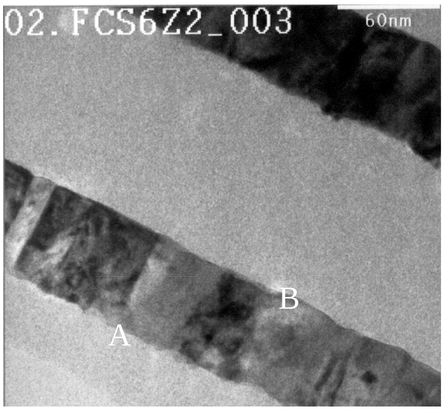

Fig. 2: *Columnar layer growth of FeCo-/SiO_2 multilayer FCS6Z2 (A = FeCo-SiO_2 interface, B = SiO_2-FeCo interface) [N. Wanderka, M. Macht HMI Berlin]*

The TEM micrographs indicate that the reason for he roughness differences of the layers is that the morphology of the FeCo layers is columnar whereas the SiO_2 layers grow up nondirectionally.

The experiments further reveal a significant influence of the sample position in the deposition chamber on the lateral homogeneity of the layer thickness and thus the magnetic performance.