DEVELOPMENT OF A REMANENT SPIN-POLARIZING NEUTRON BEAM-SPLITTER

J. Stahn and M. Horisberger
Laboratory for Neutron Scattering, ETHZ & PSI, CH-5232 Villigen PSI, Switzerland

A combination of the well known spin-polarizing property of an Fe/Si supermirror and the magnetic remanence caused by anisotropic strain should lead to a remanent spin-polarizing neutron beam-splitter. First steps in this direction are reported.

In a scattering experiment with polarized neutrons the simultaneous determination of both neutron-spin states has the advantages to save time and to probe exactly the same experimental conditions at the sample. A way to realize this is to analyze the neutron beam in front of the detector by separating and then detecting the spin-up and the spin-down contributions. The development of such a beam-splitter based on an Fe/Si or an FeCo/Si supermirror [1] is the aim of the presented work. The requirements for such a device are

- high efficiency, which means high flipping ratios and high reflectivity or transmission for one spin-state only;
- acceptance for a divergent beam;
- acceptance for a polychromatic beam;
- high remanence, high coercitive field;
- compact set up.

The problem for the chosen material combination is that these requirements can not be fulfilled all at the same time. To get an acceptable compromise, the preparation parameters had to be optimized. The supermirrors are prepared using magnetron sputtering with velocity of the substrate, power of the glow discharge and partial pressures of the inert (Ar) and of reactive (O_2, N_2) gases as tuning parameters. The addition of reactive gases will reduce the stress in the supermirror, but at the same time the stress is correlated with the wanted anisotropic magnetic properties [2]. All optimization work was done on multilayer systems, made up by 10 bilayers.

The System Fe/Si shows better magnetic properties compared to FeCo/Si, but interdiffusion of Fe and Si at the interfaces has to be avoided [3]. Good results in preventing the interdiffusion were obtained by introducing a SiO_x layer at each interface. Further investigations on this topic are planned.

After the period of screening and optimizing the preparation parameters a first Fe/Si supermirror ($m = 2$) on Si was manufacted. Figures 1 and 2 show its reflectivity and transmission, respectively. Both were measured on the neutron 2-axis diffractometer TOPSI at PSI using polarized neutrons with a wavelength of 4.73 Å.

The features for small rotation angels ω are caused by geometrical constrains: The 'peaks' around $\omega = 0$ (beam parallel to the surface) come from the direct beam. And the dip at $\omega = 0.2^\circ$ originates form the fact that the beam is not completely illuminating the sample. The reflectivity goes down to 90% at the critical angle for the spin-up state. The transmission data are spoiled by the non-polished backside of the Si wafer.

Based on these first promising results, supermirrors with a higher critical angle for the spin-up state are going to be prepared in the next future.

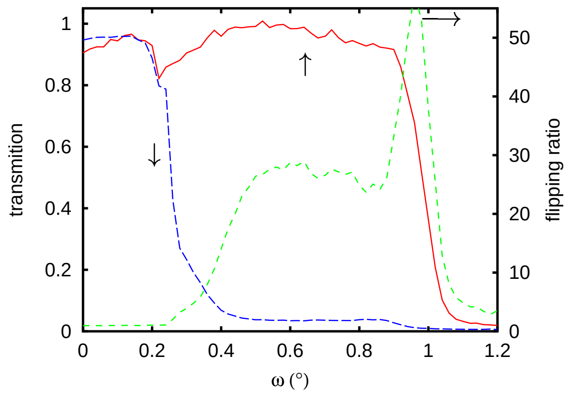

Fig.1: Reflectivity of a $m = 2$ Fe/Si supermirror on Si for spin-up (↑) and spin-down (↓) neutrons. The measurements were performed at $\lambda = 4.73$ Å. On the right the flipping ratio (quotient of the individual reflectivities) is indicated.

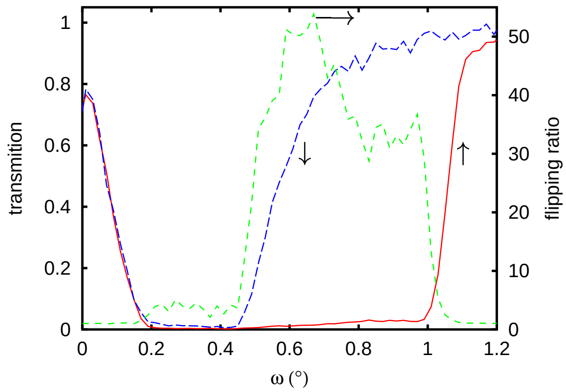

Fig.2: Transmission through the supermirror as a function of the tilt-angle ω.

[1] C. F. Majkrzak et al., SPIE Proceedings **1738**, 90 (1992)
[2] M. Senthil Kumar, P. Böni and M. Horisberger, IEEE Transactions on Magnetics **35**, 3067 (1999)
[3] L. N. Tong et al., Eur. Phys. J. B **5**, 61 (1998)