Switchable Neutron Beam Polarizers

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Polarizing Fe/Si *supermirrors showing high magnetic remanence were developed at the LNS. They were produced by magnetron sputtering and tested on TOPSI. The first series of 50 supermirrors with* $m = 2.5$ *will build the switchable polarizer for SANS I, a test-device with* $m = 2.9$ *was produced and characterized and will be used as analyzer on TOPSI.*

Within the european network TECHNI we developed Fe/Si supermirrors further with respect to their magnetic remanence. Fe/Si has the advantage of low absorption, allowing for the use of the supermirror in reflectivity and in transmission mode and thus as a neutron switch. By an appropriate choice of the preparation parameters it is possible to reach a high magnetic remanence and a moderate coercitive field strength. These properties allow to use the polarizer magnetized parallel or antiparallel to a weak guide field. It is thus possible to change the polarization of the neutrons by inverting the magnetization of the supermirror, which can be done with a short magnetic pulse. [1]
In 2001 the parameters for the magnetron sputtering was optimized with respect to a hysteresis loop as rectangular as possible. [2] Since the magnetic remanence is caused by stress in the Fe layers via magnetostriction, the complete supermirror has the tendency to peel off of the substrate. Therefore the surface of the substrate has to be very clean which seems to be a problem for the required rectangular cut Si wavers: During the cutting process the surfaces are coated with a protective film. Most of the suppliers removed this film only partially or increased the surface roughness. In the first case the layers peel off, in the latter the reflectivity of the polarizer is very bad. After several failures we were successful in finding rectangular cut Si wavers of low roughness (< 2 Å) with a clean surface, supplied by *Virginia Semiconductors*.

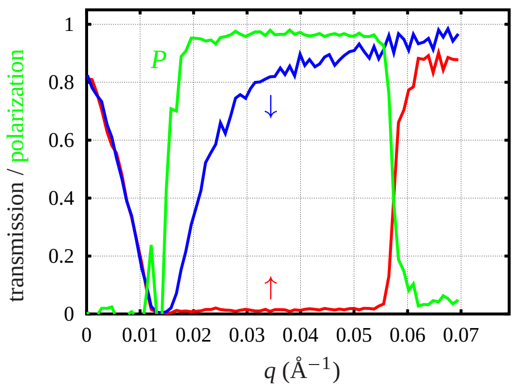

Figure 1: Transmission of the Fe/Si, $m = 2.5$ supermirror for spin up (*red* ↑) and spin down (*blue* ↓) neutrons. The polarizing efficiency *P* is shown in *solid*.

A series of 50 wavers were coated on both sides with a Fe/Si supermirror of 299 layers resulting in a reflectivity for spin up neutrons up to $q \approx 0.055\,\text{Å}^{-1}$ ($m = 2.5$ where m gives the reflectivity relative to that of natural Ni). Figure 1 shows the transmitted intensities for spin up (↑) and spin down (↓) neutrons for such a polarizer together with the polarizing efficiency $P = \frac{\downarrow - \uparrow}{\downarrow + \uparrow}$. For most of the polarizers P is in the range of 95 % to 98 %. These wavers will build the V-shaped polarizer to be inserted in one of the flight tubes of SANS I at SINQ.
Furthermore two Si wavers were coated with 599 layers which led to $m = 2.9$. Figure 2 shows both, reflectivity and transmission for both polarization states, and the polarization efficiency (where for reflectivity $P = \frac{\uparrow - \downarrow}{\downarrow + \uparrow}$). These supermirrors are used as analyzer on TOPSI. Their magnetization can be switched by magnetic field pulses of 400 G produced by a compact electromagnet.
All measurements shown here were performed on TOPSI with $\lambda = 4.74$ Å in a guide field of 15 G.

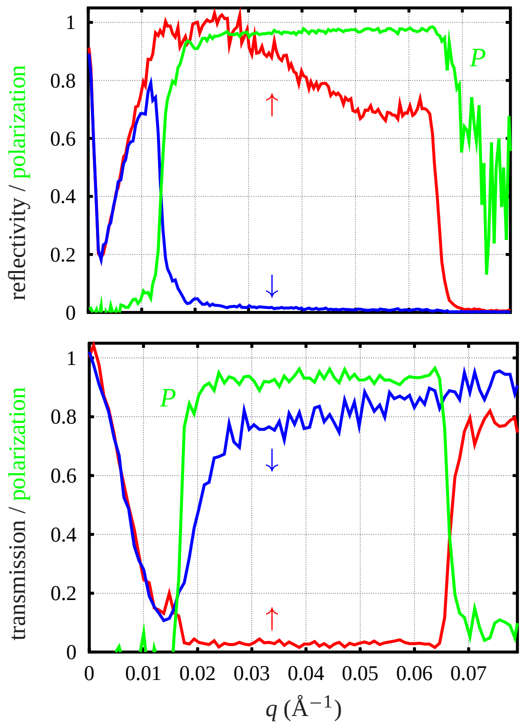

Figure 2: Reflectivity (*top*) and transmission (*bottom*) of the Fe/Si $m = 2.9$ (see figure 1).

[1] J. Stahn, D. Clemens: Proceedings of SPIE **4785**-17 (2002)
[2] J. Stahn, M. Horisberger: PSI Scientific Report 2000 / Volume III, 95.

Work fully performed at SINQ
Instrument: TOPSI