ICANS-XI International Collaboration on Advanced Neutron Sources
KEK, Tsukuba, October 22-26, 1990

Summary of Instrument Workshop on Polarizers and Thin Film Multilayer Devices

W G Williams
ISIS Science Division
Rutherford Appleton Laboratory
Chilton, Didcot, OX11 OQX
United Kingdom

The topics discussed in this session were: the calculation and optimisation of the performance of multilayer polarizers (J B Hayter), the design and performance of a double reflection multilayer polarising monochromator for cold neutrons (T. Ebisawa et al), an experimental investigation of the growth of multilayers (P B Böni et al), the optimisation of the transmission of a double-trumpet neutron beam compressor (R E Lechner and F Mezei), and plans for polarisation work at ISIS (A D Taylor).

The paper by J B Hayter stressed that it is now straightforward to calculate the response or reflectivity of any multilayer structure such as a supermirror. A discrete thin-film multilayer (DTFM) design has been proposed (Hayter and Mook) which uses fewer layers to provide the same response as earlier designs based on continuum arguments. The DTFM also overcomes the reflectivity loss near the critical edge which was a characteristic of earlier supermirror designs. Although excellent supermirrors, with reflectivities extending to $\theta/\theta c(Ni) > 3$ can now be designed and fabricated, it is less straightforward to design mirror-based devices in real (divergent beam) applications. A stacked device, using mirrors with different bandwidths at strategic positions in the structure, has been shown to give a much improved handling of divergent beams compared with a stacked structure containing one type of supermirror.

T. Ebisawa et al presented results on a compact double-reflection polarizing monochromator for cold neutrons. The device contains two stacks of constant layer-spacing $(Fe_{50}Co_{50})$:V bilayers deposited on Si-wafer substrates, and these stacks are inclined to each other at an angle 2θ where θ is the mean reflection angle of the two reflections. The length of the device is only 62mm, and it gives an excellent performance at a neutron wavelength $\lambda = 5.4$ Å : neutron polarization ~98%, neutron yield ~69%.

Although thin film multilayer structures have been fabricated for neutron applications for the past 15 years, there have been few systematic studies of the processes involved in the growth of these structures. Böni et al have now applied the techniques of neutron reflectometry, Auger depth profiling and transmission electron microscopy to investigate the parameters important to the fabrication of constant-spacing Ni/Ti bilayers. They were able to make several important conclusions: high rate sputtered samples were superior to both low rate sputtered samples and evaporated samples, and also the best samples were prepared at low pressure. Their highest reflectivity samples contained amorphous Ti layers and small Ni grain sizes, and they speculated that the ideal multilayer should consist only of amorphous layers.

In the final paper on multilayer devices, Lechner and Mezei showed how a combination of converging and diverging neutron guides fabricated from supermirrors could be used to optimise the flux at the sample position is a double chopper neutron spectrometer. The arrangement is called a double-trumpet beam compressor, and the geometrical dimensions (ie lengths and inclination angles) were optimised using a Monte Carlo procedure for a supermirror with $\theta/\theta c(Ni) = 2$. The transmission and optimised parameters were found to be wavelength dependent over the wavelength range of interest (~2-15 Å), therefore these authors proposed to construct a variable compressor geometry.

The angular range of the reflectivity of supermirrors has meant that most applications up to now have been in the cold and thermal neutron ranges, where these angles are well-matched to the beam divergences normally required in the scattering instruments. Improved supermirror performance has meant however that the concomitant larger beam divergence cannot always be used, particular when one considers the design of real devices (see Hayter). It is perhaps now opportune to exploit the improved supermirror performance in hot and epithermal neutron instruments, where the angular ranges of the reflections are correspondingly smaller.

The paper by A D Taylor on plans for polarization work at ISIS was an exception for the session in that it did not involve an optical device. This concerned the use of a polarised $SmCo_5$ filter in a test experiment to polarize the monochromatic beam in a chopper spectrometer. Previous measurements at ISIS have demonstrated that the selective spin absorption principle of the $SmCo_5$ filter works well in low-flux white beams (POLARIS measurements with ISIS operating at ~3μA), but that the beam heating was prohibitively large at full ISIS current. With the filter placed behind a monochromating chopper, the beam flux is reduced by some 3 orders of magnitude, and this polarizing method should easily be viable. Tests are scheduled for November 1990.