D3 reflectrometer demonstration

Neutron Reflectometry –a tool for studying surfaces & interfaces

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This experiment is designed to demonstrate the practical aspects of neutron reflectometry. Students will learn the basic components of a reflectometer (see Figure 1), how to align the sample with the beam to achieve required precision (often in the range of a few micrometers in position and one or two thousandths of degree in orientation), and what kind of information about the sample could be assimilated simply by looking at the raw data (i.e. as obtained from the instrument without normalization) prior to detail quantitative analysis. Another topic the students will tackle in this demo is the experimental and theoretical aspects of polarized neutron scattering for studying magnetic materials. The instrument will be setup with the incident beam spin-polarized by a supermirror, and the reflected beam spin-analyzed by a Cu_2MnAl Heusler alloy crystal. Students will gain experience with the devices such as magnetic guides, adabetic field gradients and neutron spin flippers, used to control and manipulate a quantum spin as if it were a classical vector!

Various kinds of samples, with or without magnetic scattering, are available for the purpose of demonstration. However, we will focus on one particular sample, a NiCo/Cu multilayer, which will serve well to demonstrate all the aspects of unpolarized and polarized neutron reflectometry.

The sample, prepared by sputter deposition on a Si substrate, has the following artificial layer structure:

$Si/Ni_{80}Co_{20}\ 50Å[/Cu\ 20Å/Ni_{80}Co_{20}\ 15Å]_{x\,n}$ with bilayer repeat $n = 12$

Here, the layer thicknesses given in Angstrom are nominal. Cu, of course, is non-magnetic while NiCo alloy is magnetic, making the entire stratum an artificial magnetic/non-magnetic multilayer with nanometer dimensions.

This particular sample has been used for one of our published work "Spin polarized neutron scattering study of NiCo/Cu multilayers" by Mao et al. (J. Appl. Phys. **79**, 4769-4771, 1996). Figure 2 reproduces one of the key results, where the main panel shows the measured the two non-spin-flip channels separately (squares) and the sum of the two spin-flip channels shifted down by three orders of magnitude (circles) while the inset shows the sample schematically in a spin-flop state.

Figure 1. Schematic view of D3 reflectrometer.

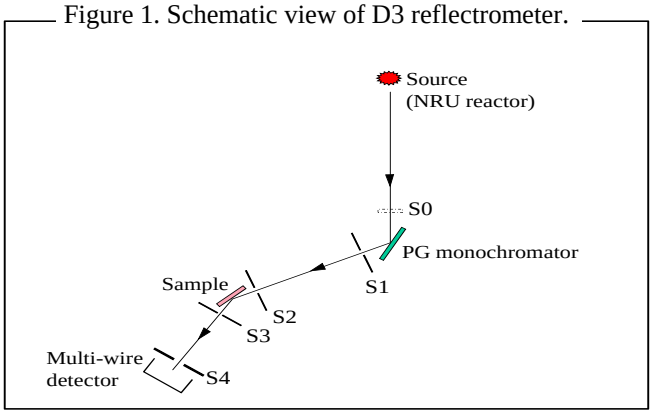

Figure 2. Observed polarized reflectrometry pattern.