Experimental Report

23/05/2014

Proposal: **5-54-137** **Council:** 10/2012

Title: Study on in-plane magnetic structure of neutron polarizing multilayermirrors

This proposal is a new proposal

Researh Area: Methods and instrumentation

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Samples: Fe/Si, Fe/Si/Ge/Si, and FeSi/Si multilayers on Si substrate

Instrument	Req. Days	All. Days	From	To
D33	4	4	27/06/2013	01/07/2013
D17 He3 Spin Filter	6	6	16/05/2013	22/05/2013

Abstract:

Neutron polarizing supermirror is increasingly important device for polarized neutron scattering experiments and needs to have high polarization performance at low externnal magnetic field. It is important to understand in-plane magnetic structure in the process of magnetization for further improvement in soft magnetic properties. Off-specular scattering (OSS) and grazing incidence small-angle neutron scattering (GISANS) measurements with polarization analysis are unique and powerful tool to study the in-plane magnetic structure in layered systems stated above. The lateral correlation length obtained by OSS and GISANS measurements is useful to get insight into the mechanism that controls the process of magnetization for polarizing supermirrors, combined with the data of x-ray diffraction and hysteresis measurements.

Study on in-plane magnetic structure of neutron polarizing multilayer mirrors

Experimental report 5-54-137

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Neutron polarizing supermirror is one of the most important optical devices for polarizing neutron beam. To meet a variety of research demands, polarizing supermirrors need to display high polarizing efficiencies at low external field. For further improvement in the magnetic properties, it is important to study the in-plane magnetic structure of the magnetic multilayer consisting of the polarizing supermirror in the process of magnetization. Off-specular scattering (OSS) and grazing-incidence small angle scattering (GISAS) measurements with polarization analysis are unique and powerful techniques to observe correlations of small magnetic objects in the layered systems. In this experiment, OSS and GISAS measurements have been performed for Fe/Si multilayers with a constant d-spacing by using D17 and D33, respectively.

Figure 1 shows the result of the OSS measurement with polarization analysis for the Fe/Si multilayer consisting of 15 bilayers with a d-spacing of 20 nm under an external field of 68 Oe, where the sample is magnetized to 70% of saturation. The monochromatic beam with an average wavelength of 0.555 nm and a wavelength spread of 4.0% in FWHM was used. The scattering due to roughness correlation is located under the

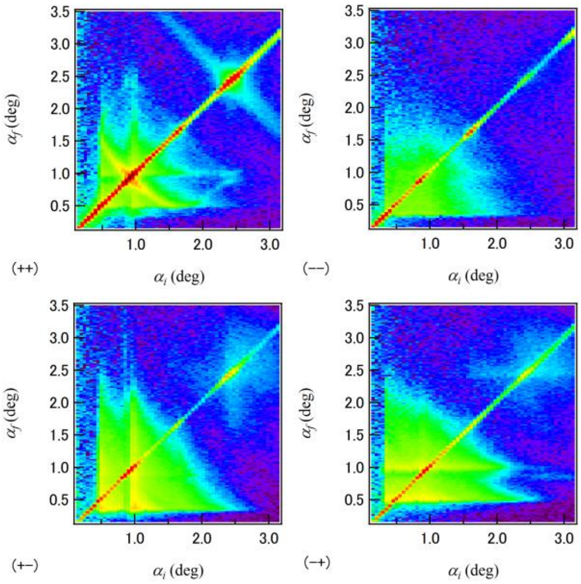

Figure 1: Measured OSS image of Fe/Si multilayer consisting of 15 bilayers with a d-spacing of 20 nm.

condition of $\alpha_i+\alpha_f$=2.0 and 4.9° in ++ channel. Contrary to this, the spin-flip scattering is spread over the wide range of incident and exit angle in +− and −+ channels because the fluctuation of the magnetization is not correlated vertically. Intense magnetic scattering is observed where the incident and exit angle corresponds to the critical angle and Bragg condition for spin-up state. This result demonstrates that the polarization analysis allows us to separate the scattering due to the fluctuation of magnetization in the domains from that due to the interface roughness correlation.

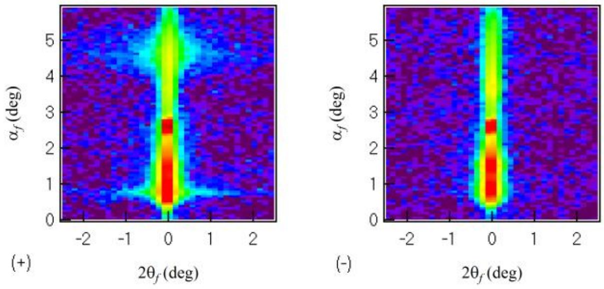

Figure 2: Measured GISAS image of Fe/Si multilayer consisting of 15 bilayers with a d-spacing of 20 nm.

Figure 2 shows the result of the GISAS measurement without polarization analysis for the same sample. An external field is kept at the same value as the above. The monochromatic beam with an average wavelength of 0.80 nm and a wavelength spread of 10% in FWHM was used. The incident angle was chosen as 2.6° because the ratio of the spin-flip and non-spin-flip scattering becomes large when the exit angle corresponds to the first Bragg condition in − channel. Specular reflection and roughness scattering are observed at an exit angle of 2.5 and 4.5° in + channel, whereas magnetic scattering is seen at an exit angle of 1.5° in – channel. GISAS data are consistent with that of OSS. The size of the magnetic domains lying on the layer can be determined by the peak width of the magnetic scattering in $2\theta_f$ direction.

The precise analysis of the data with simulation is currently performed, which would lead to a good understanding of the magnetic properties of the sample.