Experimental report

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Title: Study of the in-plane magnetic structure of neutron polarizing multilayer mirrors

Research area: Methods and instrumentation

This proposal is a continuation of 5-54-137

Main proposer: Ryuji MARUYAMA

Experimental team: Thierry BIGAULT
Ryuji MARUYAMA

Local contacts: Thomas SAERBECK
Dirk HONECKER

Samples: Fe/Si multilayers

Instrument	Requested days	Allocated days	From	To
D33	4	4	25/06/2015	29/06/2015
D17 He3 Spin Filter	6	5	18/06/2015	23/06/2015

Abstract:

Neutron polarizing supermirrors are increasingly important devices for polarized neutron scattering experiments and need to have high polarization performance at low external magnetic fields. It is important to understand the in-plane magnetic structure in the magnetization process for further improvement in the soft magnetic properties. Off-specular scattering (OSS) and grazing incidence small-angle scattering (GISAS) measurements with polarized neutrons are unique and powerful tools to study the in-plane magnetic structure in layered systems. The lateral correlation length obtained by OSS and GISAS measurements, combined with X-ray diffraction and hysteresis measurements, is useful to get insight into the mechanism that controls the magnetic properties of multilayers for polarizing supermirrors.

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

Experimental report 5-54-182

R. Maruyama[1], T. Bigault[2], T. Saerbeck[2], D. Honecker[2], A. Wildes[2], C. Dewhurst[2], K. Soyama[1], and P. Courtois[2]

[1]*J-PARC Center, Japan Atomic Energy Agency, 2-4 Shirakata, Tokai, Ibaraki 319-1195, Japan*

[2]*Institut Laue-Langevin, 71 avenue des Martyrs, 38042 Grenoble, France*

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/Ge multilayers with a constant d-spacing, fabricated with the ion-beam sputtering technique, by using D17 and D33, respectively.

Figure 1 shows the result of the OSS measurement with polarization analysis for the Fe/Ge multilayer consisting of 15 bilayers with a d-spacing of 20 nm under an external field of 35 Oe, where the sample is magnetized to 70% of saturation. The

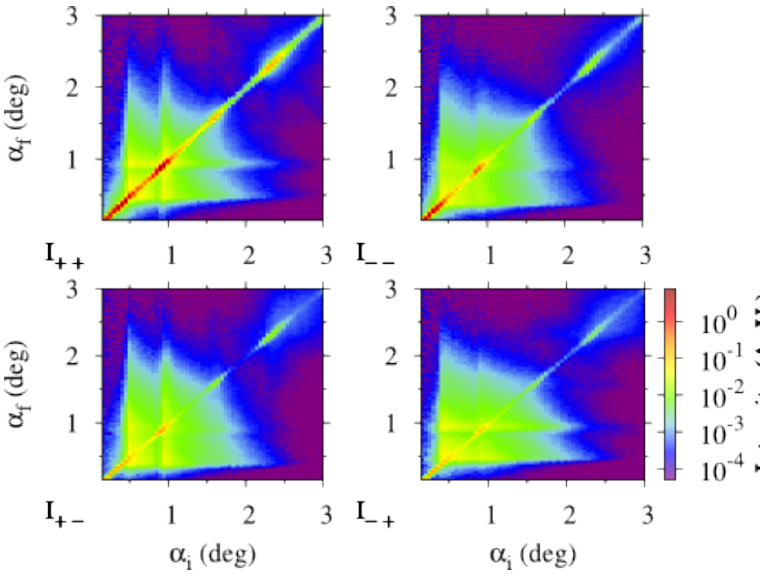

Figure 1: Measured OSS image of Fe/Ge multilayer consisting of 15 bilayers with a d-spacing of 20 nm.

monochromatic beam with an average wavelength of 0.544 nm and a wavelength spread of 5.4% in FWHM was used. Spin-flip magnetic 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.

Figure 2 shows the result of the GISAS measurement with 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 0.60 nm and a wavelength spread of 10% in FWHM was used. The incident angle was chosen as 1.32° 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 2.6 and 1.9° in + + channel, whereas magnetic scattering is seen at an exit angle of 2.2° 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.

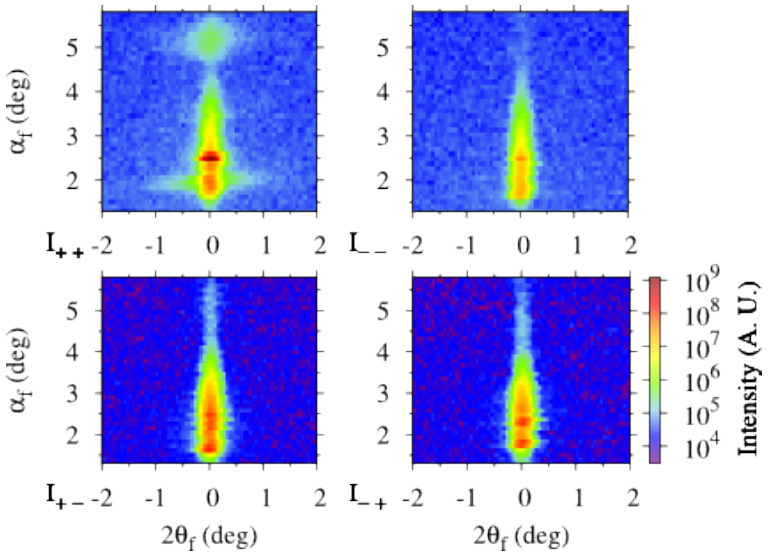

Figure 1: Measured GISAS image for the same sample as Fig. 1.

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