Experimental report

25/12/2018

Proposal: 5-54-225 **Council:** 10/2016

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

Research area: Methods and instrumentation

This proposal is a continuation of 5-54-182

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Experimental team: Ryuji MARUYAMA

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Samples: Fe/Ge multilayers

Instrument	Requested days	Allocated days	From	To
D33	4	3	23/03/2018	26/03/2018
D17 He3 Spin Filter	6	4	15/03/2018	19/03/2018
D22	0	0		

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 of the in-plane magnetic structure of neutron polarizing multilayer mirrors

Experimental report 5-54-225

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Neutron polarizing supermirror is one of the most important optical devices to polarize a neutron beam. Soft magnetic properties play a critical role in the performance of a polarizing supermirror because they need to display high polarization efficiencies at low magnetic fields to meet a variety of research demands. In order to obtain soft magnetic properties, it is important to understand what controls the magnetic properties of the magnetic multilayer consisting of polarizing supermirrors. The magnetic properties of multilayers with a polycrystalline grain size less than the ferromagnetic exchange length can be explained by the random anisotropy model (RAM), i.e. competition between the exchange interaction between neighboring spins and the local magnetocrystalline anisotropy. This experiment is aimed to verify whether this model is valid for our system by observing the in-plane magnetic structure using polarized neutron off-specular (OSS) and grazing-incidence small-angle scattering (GISAS) measurements.

Figure 1 shows the result of the OSS measurement performed using the polarized neutron reflectometer D17. The sample was an

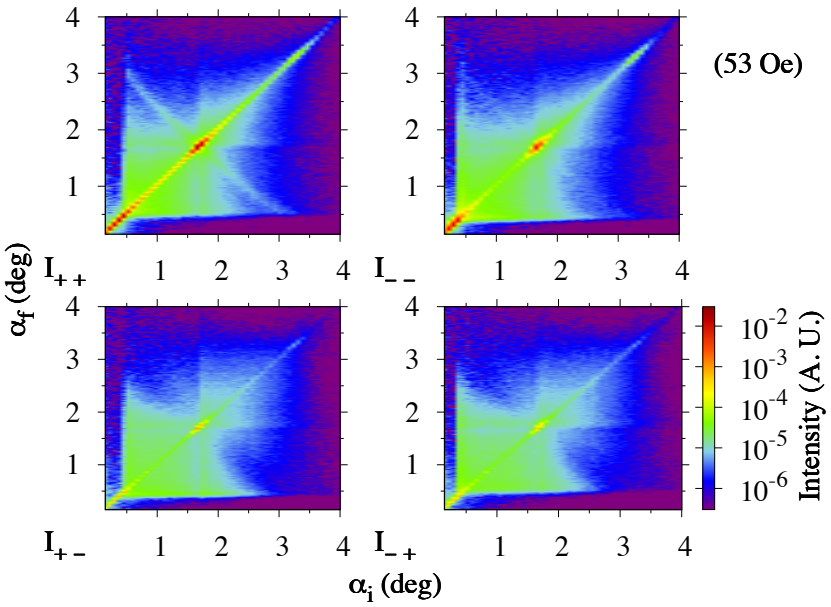

Fig. 1: Measured OSS images of Fe/Si multilayer of 30 bilayers with a thickness of 10 nm.

Fe/Si multilayer of 30 bilayers with a bilayer thickness of 10 nm which was fabricated by the magnetron sputtering system at the ILL. Since an applied field of 53 Oe was not strong enough to saturate it, intense magnetic scattering was observed over a wide area of α_i-α_f space for all four spin channels. Polarized neutron GISAS measurement was performed using the small-angle diffractometer D33. Figure 2 shows the GISAS images under the same value of the external field. These measurements were performed under different field strengths which were chosen from the hysteresis data. A quantitative data analysis using a simulation based on the distorted wave Born approximation gives the lateral correlation length corresponding to 1/2 of the length of areas where spins are aligned to the same direction. The dependence of the size of the coupled area on the field strength obtained by the data analysis would be useful to verify whether the RAM is valid for our system.

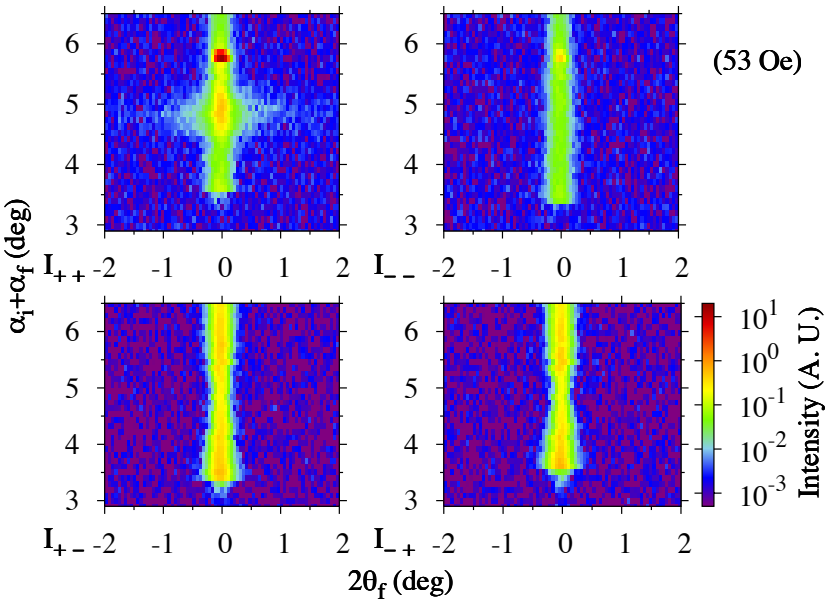

Fig 2: Measured GISAS images for the same sample as Fig. 1.