ICANS-XV
15th Meeting of the International Collaboration on Advanced
Neutron Sources
November 6-9, 2000
Tsukuba, Japan

11.3 Status Report on Reflectometer Group in Japanese Joint Project

M. Takeda[1*], H. Matsuoka[2], K. Soyama[3] and N. Torikai[4]

[1]Graduate School of Science, Tohoku University, Sendai 980-8578, Japan
[2]Department of Polymer Chemistry, Kyoto University, Kyoto 606-8501, Japan
[3]Japan Atomic Energy Research Institute, Tokai 319-1195, Japan
[4]High Energy Accelerator Organization, Tsukuba 305-0801, Japan
*E-mail:takeda@iiyo.phys.tohoku.ac.jp

Abstract

Present status of reflectometer group in JAERI-KEK joint project is reported. We are now considering two conventional reflectometers. One is a vertical reflectometer for magnetic thin films and multilayers, another is a horizontal reflectometer for soft matter and free surface. In addition, capabilities of quasi and inelastic neutron reflectometer and the grazing angle reflectometer are also discussed.

1. Introduction

The importance of neutron reflectometer has been now widely recognized not only in the field of scientific research but also industrial application. Reflectometer group in Japanese Joint Project (JJP) was organized in order to consider what kind of reflectometers should be installed in JJP. The members were recruited from researchers working in Japan. Now four members are working to design the reflectometers, and using a mailing list[1] we are ready to listen to opinion from non members who have any idea or suggestion for the reflectometers. In this brief report, the reflectometers which are considered in our group are introduced.

[1]Japanese only

2. Reflectometers

2.1 Vertical Reflectometer

We are now considering four types of reflectometers. The first one is a vertical reflectometer on which the sample plane is set to be vertical and the scattering vector in horizontal. This reflectometer is dedicated to investigation of magnetic thin films and multilayers. Therefore polarized neutrons will be intensively used. Neutrons are mostly polarized by polarizing supermirrors, and ^{3}He polarizing filter is another candidate for analyzing the polarization of reflected neutrons.

Table 1 is a list of characteristic parameters of the vertical reflectometer. It utilizes cold neutrons in a wavelength band between 1 and 14 Å from a coupled liquid hydrogen moderator, because the intensities reach maximum at 2 Å as shown in Fig.1. This is one of results of ray tracing simulation of beam intensity at the sample position. In this case we can use $1 \times 10^7[n/50 \times 0.5\text{mm}^2/\text{sec.}]$ neutrons. The distance between moderator and sample, $L1$, and between sample and detector, $L2$, are 10 m and 1 m, respectively. As compared with a horizontal reflectometer, it is easy to go up to the higher Q by changing incident angles. The covered Q range is from 0.005 to 10.8 Å^{-1}. If we use a $3Q_c$ polarizing supermirror as a polarizer in transmission geometry, it also works as a frame over-wrapping mirror. In such case the maximum wavelength of polarized neutrons is cut off at 6 Å and consequently the Q range becomes narrower. To eliminate higher energy neutrons, simulations are going to decide which is better, using T0 chopper or curved guide.

Table 1: Instrument parameters of the vertical reflectometer.

moderator	coupled liquid H_2
moderator - sample distance [L1] (m)	10
sample - detector distance [L2] (m)	1
wavelength range (Å)	1.0 - 14.4(unpolarized)
	1.0 - 6.0 (polarized)
incident angle (deg.)	0.3 - 60
Q range (Å^{-1})	0.005 - 10.8 (upolarized)
	0.011 - 10.8(polarized)

2.2 Horizontal Reflectometer

The second one is a reflectometer for the investigation of free surface or liquid/gas, liquid/solid interface and so on. This is a horizontal reflectometer on which the sample plane is in horizontal plane and the scattering vector is vertical. In this type of reflectometer the incident angle is not easy to be changed than the vertical reflectometer. Thus the incident angle is one of important parameters which defines the total performance of the reflectometer. The idea of changing the incident angle in the horizontal reflectometer is schematically shown in Fig.2. The beam is extracted downwards by 3.9 deg. at the first section of 5.0 m long. After this section the beam is bent once more by successive 6 supermirrors of $3Q_c$. In the last section 4 different configured supermirrors are set in an elevator. The topmost, the second and the third supermirrors make the beam bent

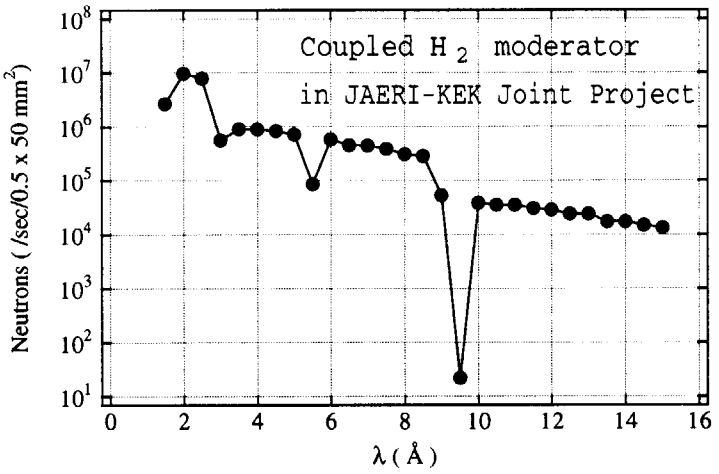

Figure 1: The expected beam intensity at sample position estimated by ray tracing simulation.

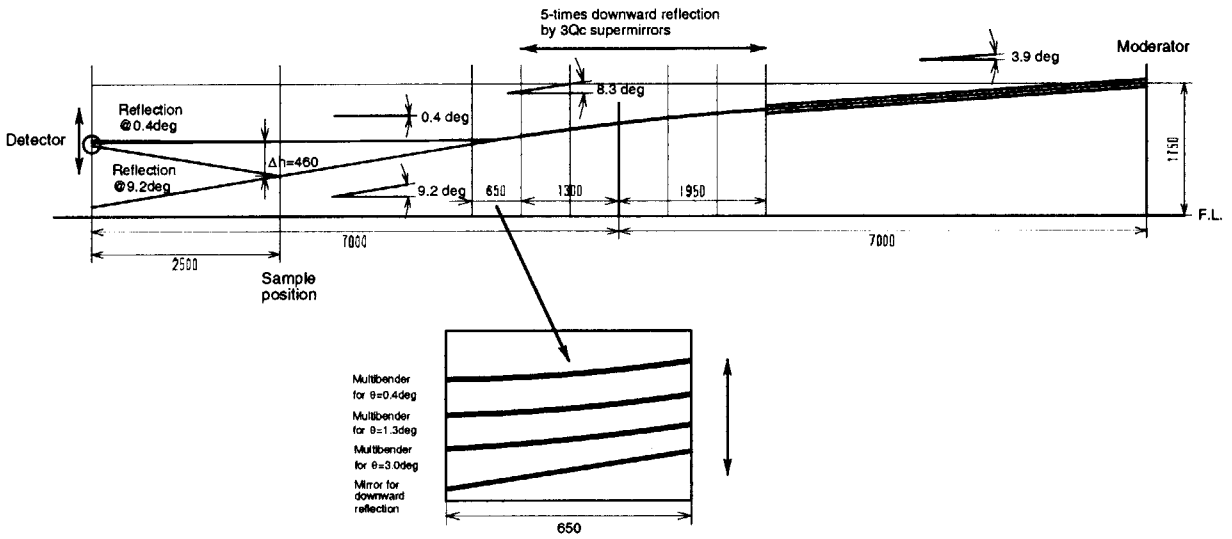

Figure 2: The beam line design for horizontal neutron reflectometer.

upward, and by using of these supermirror smaller incident angles of 0.4, 1.4 and 3.0 deg. are available. The bottom supermirrors make incident angle to be 9.2 deg. The temporary parameters of this reflectometer are listed in Table2. The supermirror bender and the parameters in Table 2 make it possible to measure reflectivity between 0.08 $Å^{-1}$ and 1 $Å^{-1}$.

A simulation of neutron reflectivity of a kind of lipid membrane on heavy water and null scattering water indicates that the reflectivity of 1×10^{-10} is necessary to be measured. However, incoherent background from hydrogenous materials is likely to cover the signals we really want to know. Such spin incoherent background can be removed by using polarized neutrons. Thus we now consider a polarized neutron option in this spectrometer.

Table 2: Instrument parameters of the horizontal reflectometer.

moderator	coupled liquid H_2
moderator - sample distance [L1] (m)	14
sample - detector distance [L2] (m)	2.5
wavelength range (Å)	1.0 - 11
incident angle (deg.)	0.4, 1.3, 3.0, 9.2
Q range ($Å^{-1}$)	0.008 - 1

2.3 Grazing Angle Reflectometer

In addition to specular neutron reflectivity, we are very interested in off specular neutron reflection which contains information about in-plane structure of surface and interface. Thus two reflectometers intend to have a off specular detector bank composed of a two-dimensional position sensitive detector. They may also cover a neutron grazing angle reflection measurements. However, we continue to examine necessity of installation of an spectrometer for exclusive grazing angle reflection measurements.

2.4 NSE Reflectometer

The last one is classified into a new instrument which is expected to explore new field of science. It is a quasi elastic of inelastic neutron reflectometer for investigation surface or interface dynamics in soft matter and biological materials. In such materials dynamics of surface and interface are strongly connected with its function. Therefore it is sometimes very useful to know the motion of surface or interface like adsorbed polymer chain. At present we have no concrete idea of this instrument. We are groping the way how to realize such instrument. The most promising candidate is a hybrid of reflectometer and NSE. There is few words about this instruments for the time being. But we really hope to realize this NSE reflectometer.

3. Summary

Reflectometer group in JJP is now discussing what kinds of reflectometers are suitable for the intense neutron source which is coming up to Japan. We have mainly considered four reflectometers. Two of them are conventional reflectometers, and the rest are rather new instruments. However, we are now on the start line. Concrete design and simulation work for each spectrometer have just started.