MLF Experimental Report

Investigations on the in-plane structure in silver photo-doping into Ge-chalcogenides

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1. Introduction

Ag/ amorphous chalcogenide double-layer films exhibit silver diffusion into amorphous chalcogenide layer by light illumination. In order to clarify the kinetics in the depth direction, we perform neutron reflectivity measurement of the films under light illumination. In 2012A0068, we measured time-resolved neutron reflectivity of Ag/ $Ge_{40}S_{60}$/ Si substrate films and found that there would be an interface layer with less scattering length density, compared to those of the adjacent layers: Ag and $Ge_{40}S_{60}$ layers [1]. Since silver photo-diffusion occurred even after the appearance of the interface layer, the flow of Ag ions is *not* considered to stop at the interface layer. Therefore, the interface layer must *not* be vacant one. The interface layer could indicate the presence of inhomogeneous in-plane structure at the interface, which can produce a loss in the specular scattering. The inhomogeneous structure on the interface layer may be related to the generation of the nucleus of the Ag-reaction channel and the growth of the nucleus. Such in-plane structure will be proved by the observation of off-specular scattering. In the present experiment, we measured off-specular scattering of light-illuminated Ag/ $Ge_{40}S_{60}$/ Si substrate films using the two-dimensional detectors (Multi-Wire Proportional Counter: MWPC), which were recently installed on BL17, to know if our assumption is true.

2. Experiment

In the present experiment, the T0 chopper, which eliminates "burst" neutrons (very fast neutrons penetrating the phase-control choppers) was removed from the beam line because it did not work properly. Such very strong neutron beam can damage the two-dimensional detectors, and we used the detectors only to detect the reflected beam from the sample, and not to detect the direct beam, by limiting the angle-position of the detectors. We also considered the characteristics of the detectors on the linearity in the response. According to the previous study by the beam line group, the detectors near the specular region are affected as if signals spread over the surrounding region. Due to the reason, we also measured the off-specular scattering by putting a mask on the specular region. In order to doubly check the effect of such spatial "leakage" of strong signals on the off-specular scattering data, we also measured off-specular scattering of Ag/ Si substrate as a reference sample, in addition to the light-illuminated Ag/ $Ge_{40}S_{60}$/ Si substrate films.

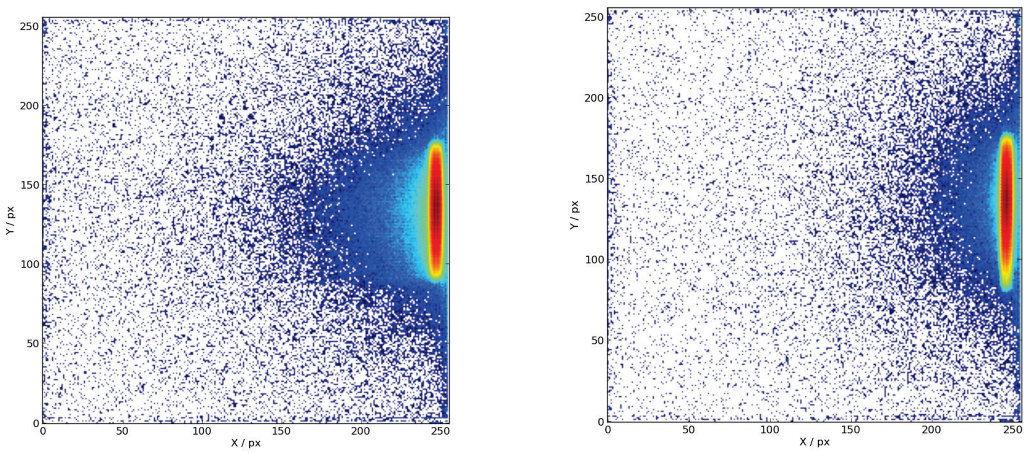
3. Results

Fig. 1 shows the intensity map of the scattered neutrons on the two-dimensional detectors for the light-illuminated Ag 500Å/ $Ge_{40}S_{60}$ 2000Å/ Si substrate (a) and Ag 500Å/ Si substrate (b). The horizontal (x) axis shows the reflected angle, the vertical (y) axis shows the height of the sample. All neutrons with different TOF are counted on the map. The red line on the map is the portion where the specular scattering came. This means that the x-value on the red line indicates the angle of the incident beam. Obviously, the scattered neutrons came on the detectors at different angles from the incident angle, which are shown in blue on the map, and these are the off-specular scattering. The blue area more spreads in (a) than in (b). This means that there is something to produce the off-specular scattering on the light-illuminated Ag 500Å/ $Ge_{40}S_{60}$ 2000Å/ Si substrate film. Fig. 2 is the same intensity map as Fig.1, but it was obtained with a mask of the B4C slit at the specular scattering region. In the map, the effect of the spatial "leakage" of the scattered signals from the strong specular scattering region is eliminated. In the case of Ag 500Å/ Si substrate, the off-specular scattering is very small (Fig. 2(b)). On the other hand, there are considerable off-specular scattering from the Ag 500Å/ $Ge_{40}S_{60}$ 2000Å/ Si substrate, over a wide angle region, as shown in Fig.2 (a).

4. Conclusion

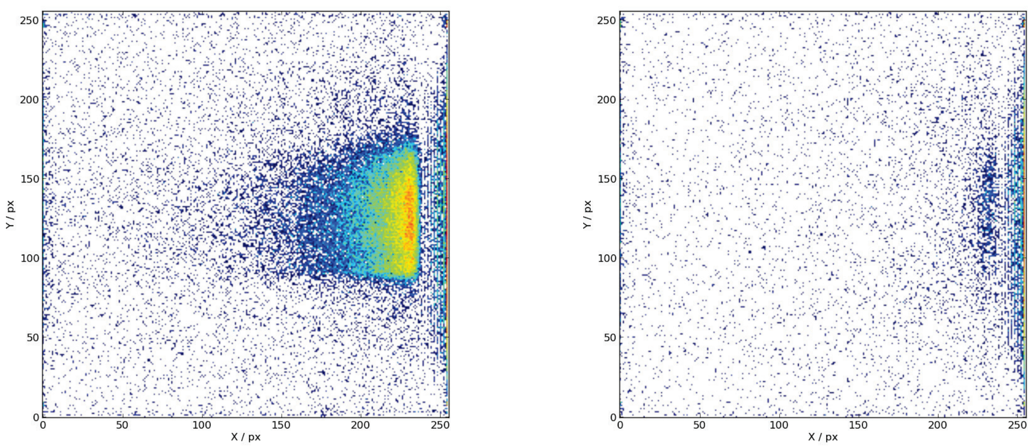
These experimental results qualitatively demonstrate that off-specular scattering is produced by the light-illuminated Ag 500Å/ $Ge_{40}S_{60}$ 2000Å/ Si substrate film. We are now trying to proceed to quantitative analysis to find out what the in-plane structure is.

[1] Y. Sakaguchi, H. Asaoka, and M. Mitkova, *J. Appl. Phys.* **122** (2017) 235105



(a) (b)

Fig.1



(a) (b)

Fig.2