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Depth-sensitive GISAXS analysis of a polymer flim on a Si substrate

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Introduction

Grazing-incidence small-angle scattering in relatively hard SX region (1.7-3 keV) is a new experimental field of interest from a viewpoint that resonant X-ray scattering experiments on several key elements are available at the energy. Another possible application on the use of soft X-ray in the crystal monochromator rigion is that, it has a moderate penetration depth convenient for depth sensitive measurements. In the present proposal, we have been working on evaluating multilayer effect in the SX-GISAXS analysis. This report concerns how the surface, or the region very close to the surface can be evaluated by controlling penetration depth at the photon energy close to the K absorption edge of Si.

Experimental

The GISAXS measurements at the Si K absorption edge were carried out at beam-line 11B, with a GISAXS vacuum chamber evacuated by a turbo molecular pump. The experimental details are given in [1]. The energy was chosen by a InSb double crystal monochromater. It turned out that there are weak third-order harmonics in the incident beam, which can be identified by transmission SAXS of standard samples, but should be negligibly small for GISAXS mode.

For the GISAXS measurements with hard X-ray to evaluate average structure over the whole film, GISAXS measurements at 8.2 keV have been made at BL15A. The intensity was recorded either by IICCD or Pilatus.

The sample used here is a triblock coplymer film, SEBS-8, deposited on a Si substrate.

Results and Discussions

From the refractive indices calculated from the crutical angle of the sample at Cu Ka1 radiation and the composition of the film. The penetration depth calculated from the refractive indices is shown in Fig.1 as a function of the angle of incidence. When copared with the depth calculated for hard X-ray, it is clearly shown that the depth for SX region is much smaller , with much larger critical angle. It suggests that the penetration depth is more easily controlled at the SX region, and the footprint area of the incident beam is smaller owing to the larger critical angle. Form this viewpoint, it is worthwhile examining feasibility of depth-resolved GISAXS with a use of soft X-rays. Figure 2 compares two GISAXS profiles taken at 1.77 keV at the incident angle of 0.6 degree and 0.8 degree, respectively. The profiles clearly show depth-limited elongation of the Bragg spot of micro-phase separated lattice structure whose change agreed with an expectation obtained from a kinematical simulation.

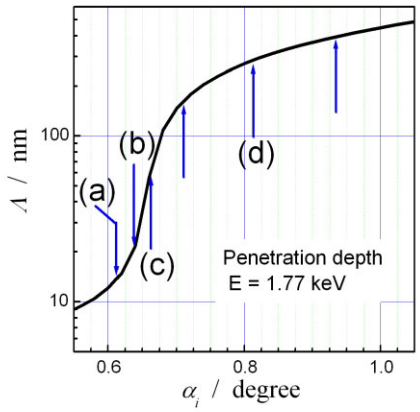

Fig.1 Penetration depth calculated for the present film.

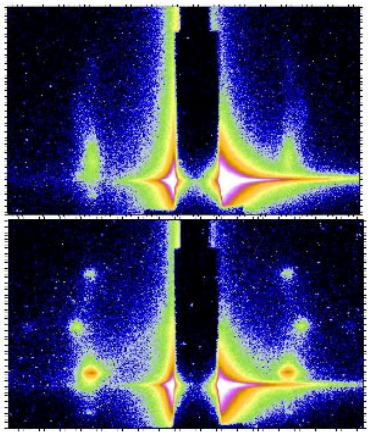

Fig.2. GISAXS patterns at 1.77keV with 0.6(above) and 0.8 degrees of incident angles.

References

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