Recent Progress in Soft Interface Characterization by Quantum Beam and What We Expect for J-PARC

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Polymer surface and interfaces contribute to numerous technical applications. Block copolymer, nanotextured polymer thin films, and polymer brushes can be tailored for various functional applications. However, it is necessary to obtain precise structural information at the surface and interfaces in order to design high performance thin films.

Grazing incidence wide angle X-ray diffraction (GIWAXD)/ small angle X-ray scattering (GISAXS), SAXS, SR-infrared spectroscopy, Soft X-ray XPS are powerful nondestructive analytical tools for characterization of surface and buried interface in organic thin films on various substrates. GIWAXD refers to an X-ray diffraction method based on the grazing incident geometry is perfectly suited for the investigation of the molecular aggregation structure and crystalline state of surfaces and thin films. GISAXS is also powerful tool to observe nano-scale structures of block copolymer thin films, which are strongly affected by surface and interface, and in some cases they are different from those in bulk samples. Several examples such as surface crystallization of fluoropolymers, surface microphase-separated structure of block copolymers will be discussed at the symposium.

Neutron reflectivity (NR) measurement is one of the most powerful tools to characterize buried interfacial structures. The authors have installed a horizontal-type time-of-flight neutron reflectometer SOFIA at J-PARC. The performance of NR was confirmed by measuring NR of deuterated polystyrene (d-PS) thin films on a silicon wafer and multilayers of cadmium stearate prepared by the Langmuir-Blodgett method. NR at the deuterium oxide (D_2O)/silicon disk showed specular reflection down to 10^{-6}–10^{-7} and q up to 2.0 nm^{-1}, which improved the precise structure analysis of swollen polyelectrolyte brush at the D_2O interface. Also time-resolved in-situ NR measurements were carried out to observe interfacial mixing of d-PS on the PS brush surface during 398 K annealing, demonstrating that nonequilibrium behavior at the interfaces can be analyzed on the order of minutes.