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Combining GIWAXS, GISAXS and XRR for a structural study of organic thin films

Thin films based on organic materials are at the heart of much of the revolution in modern technology, from advanced electronics, to optics to sensors to biomedical engineering.

Their functional properties rely on the supramolecular assembly at the interface with the substrate surface. Structure and morphology depend on the chemical structure of the molecule/polymer, the deposition method and the nature of the substrate where the thin film grows.

This lecture will introduce surface-sensitive techniques, based on X-ray scattering, to characterize thin films structure and morphology from the first organic layer close to the substrate surface till the top layer.

X-Ray Reflectivity (XRR) allows to detect thickness, roughness and density of each layer composing the film, regardless the crystalline order. From XRR curves the critical angle can be determined, it corresponds to the angle below which all the incidence beam is reflected and it represents the keynote of the surface-sensitive techniques. In Grazing Incidence Wide (Small) Angle X-ray Scattering, GIWAXS (GISAXS) technique, the incident beam is fixed to a value close to the critical angle of the organic film limiting the penetration to few molecular layers. The collected pattern corresponds to the reciprocal space map of the film focused at different length scales: GIWAXS pattern probes molecular length-scales, exploring the crystal structure of the film; GISAXS pattern probes nm length-scales, enabling studies of nanoscale objects deposited on surfaces (e.g. nanoparticles, nano-islands), thin and ultra-thin layers of nanomaterials (e.g. block-copolymers, nano-aggregates due to segregation in heterojunctions), or nano-structured surfaces (e.g. lithographic patterns).