2.6 Langmuir Films

2.6.1 X-Ray 2D-Powder Diffraction Methods for Films at Liquid Surfaces

K. Kjær and W.G. Bouwman, *Department of Solid State Physics, Risø National Laboratory, Denmark*

Langmuir films (mono- or multilayers of – usually – amphiphilic molecules on the surface of liquids) have been studied by X-ray Grazing-Incidence Diffraction at the undulator beam line BW1 in HASYLAB at DESY, Hamburg. The samples are nearly always '2D powders', *i.e.*, rotating the sample container around a vertical axis has no effect on the scattering pattern observed. Thus, the experimental variables are the vertical incidence and exit angles $\alpha_i(\simeq 0)$, α_f, and the horizontal scattering angle $2\theta_{\rm hor}$. Experimentally, 3-dimensional diffraction data (I *vs.* $(2\theta_{\rm hor}, \alpha_f)$) are collected with the program TASCOM running in the BW1 μVAX. A vertical linear PSD resolves α_f while $2\theta_{\rm hor}$ is resolved by scanning a Soller collimator consisting of many vertical, parallel plates. Software has been written in the language IDL for visualising the data on-line during scans and for doing the first data analysis on-line. This runs on a Pentium PC which is linked to the BW1 μVAX by the PCSA network protocol. New mirrors installed by HASYLAB in Nov. 1994 give an additional $\times 4$ gain in useful flux for liquid surface studies, chiefly because of improved horizontal focussing. Most systems form thin films that are horizontal over many mm^2 and many of them are 2D-'*crystalline*' powders. Hence, as function of horizontal scattering vector $q_{xy} \simeq (2\pi/\lambda)(1+\cos^2\alpha_f - 2\cos\alpha_f\cos 2\theta_{\rm hor})^{\frac{1}{2}} \sim (4\pi/\lambda)\sin(2\theta_{\rm hor}/2)$, narrow peaks of constant q_{xy} (Bragg rods) are observed – their q_{xy}-width Δ_I limited by resolution and by lateral positional coherence length in the film. As function of the vertical component $q_z \simeq (2\pi/\lambda)\sin\alpha_f$, (*i.e.* along the Bragg rod) one observes broader maxima of q_z-width $\Delta_{II} \sim 2\pi/L$, L being the thickness of the film. Recently, however, we have found that some multilayer films (*e.g.*, C_{24}-alkane films, *cf.* Fig. 1 and a separate report in this volume) additionally exhibit a third type of broadening in the (q_{xy}, q_z)-plane: along lines of constant $q_{tot} = (q_{xy}^2 + q_z^2)^{\frac{1}{2}}$ (the *Scherrer rings*), indicating a *mosaic* distribution of 2D-crystallites. For small misorientation u, the broadening becomes $\vec{\Delta}_{III} = \mathrm{FWHM}u \cdot (G_z, -G_{xy})$. Thus, for $G_z \neq 0$, $\vec{\Delta}_{III}$ can easily be separated from Δ_I and Δ_{II}, *cf.* Fig. 1a, but for $G_z \sim 0$, $\vec{\Delta}_{III}$ resembles Δ_{II}. The cause of the mosaicity is under investigation.

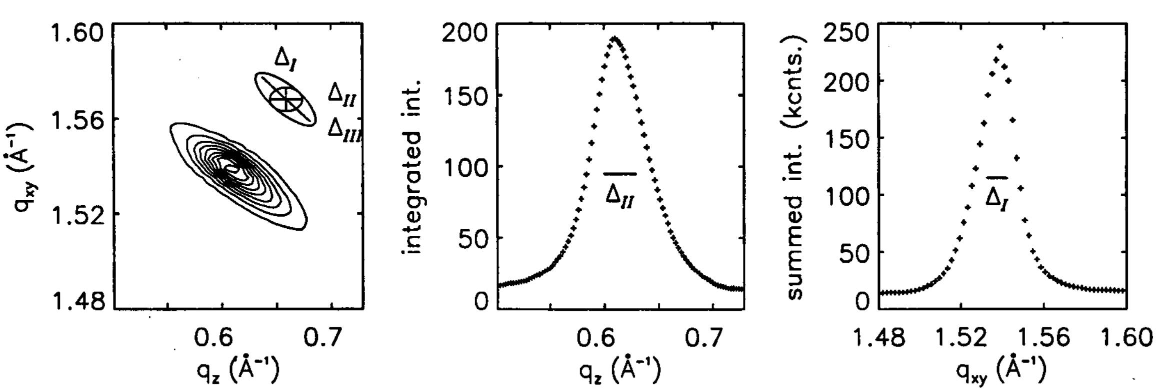

Fig. 1. Data for multilayers of $C_{24}H_{50}$. a) From analysis of the contour plot we find that FWHMu = 1.6°, Δ_1 is determined by the resolution, and Δ_2 corresponds to a film thickness of 180Å, corresponding to 6 layers. The projections b) and c) are broader than Δ_2, resp. Δ_1, due to the mosaicity contribution $\vec{\Delta}_{III}$.

Annual Progress Report of the Department of Solid State Physics for 1994.
Risø National Laboratory, Roskilde, Denmark (1995). ISBN 87-550-2026-7.