GISANS to Study Wet, Soft Matter Interfaces

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Varying either the wavelength or the angle of incidence allows the grazing incidence scattering from different typical depths below an interface to be investigated. Neutron scattering is of particular interest because the incident beam can pass through long paths in several solid materials and the contrast of light elements, particularly when exploiting isotopic contrast with hydrogen and deuterium allows identification of structures in complex multicomponent systems. These studies of 'buried' interfaces are important for studies of processes that occur between two bulk phases of materials. In practice, many studies of these interfaces with neutrons are more correctly described as near-surface small-angle scattering rather than grazing incidence small-angle scattering as the incident angle is typically well-beyond the critical angle and penetration of the beam extends to some micrometres. In many colloidal systems this range of depth sensitivity is very interesting as it matches other length scales within samples. This talk will present two studies that highlight these features and identify crucial distinctions to corresponding X-ray experiments.

The arrangement of colloidal particles in a dispersion near charged interfaces is of considerable practical and fundamental importance. The density of particles can modify rheology and might give rise to apparent slip layers. The extent of lateral order important when using particles to template interfacial structures. A number of experiments have been made with polystyrene particles near sapphire and silica surfaces [1]. Strong Bragg diffraction can be seen in grazing incidence scattering. The intensity of the observed Bragg peaks can be compared with models calculated for structures with particles at different distances, z_0 from the surface, see Figure 1. Although the system investigated did not allow resolution of separations of 10's of nanometres. The comparison with scattering from the bulk phase indicated clearly that oriented layers exist to a distance of some μm but not 0.5 mm. The results can be compared with data from quartz crystal microbalance with dissipation [2].

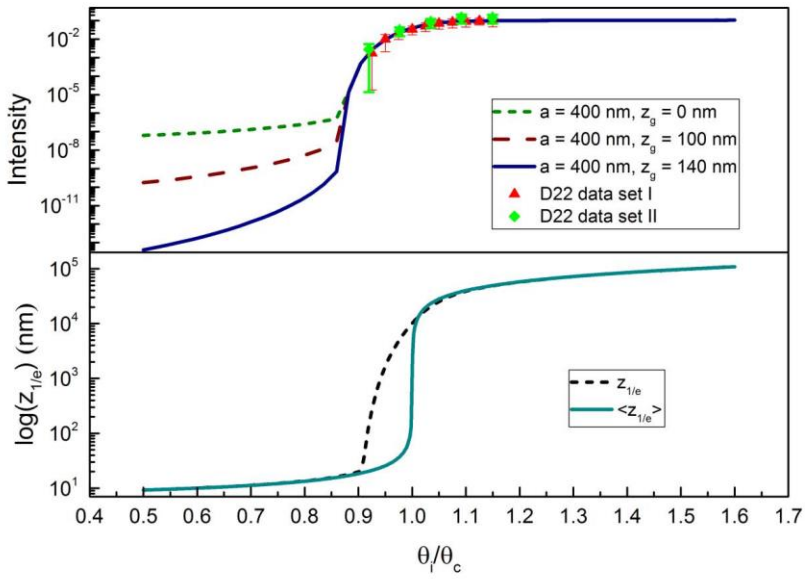

Figure 1: Lower: mean penetration depth of neutrons in a GISANS experiment as a function of angle with the effects of angular divergence and wavelength spread shown as a dashed line in comparison to that for an instrument with perfect resolution. Upper: comparison of measured GISANS peak intensities with models using the estimated penetration depth and instrument resolution. Data measured on D22 at ILL, Grenoble.

In another experiment, reflectivity and scattering has been used to determine the extent of lamellar order for a surfactant near interfaces with different roughness. Example data is shown in Figure 2.

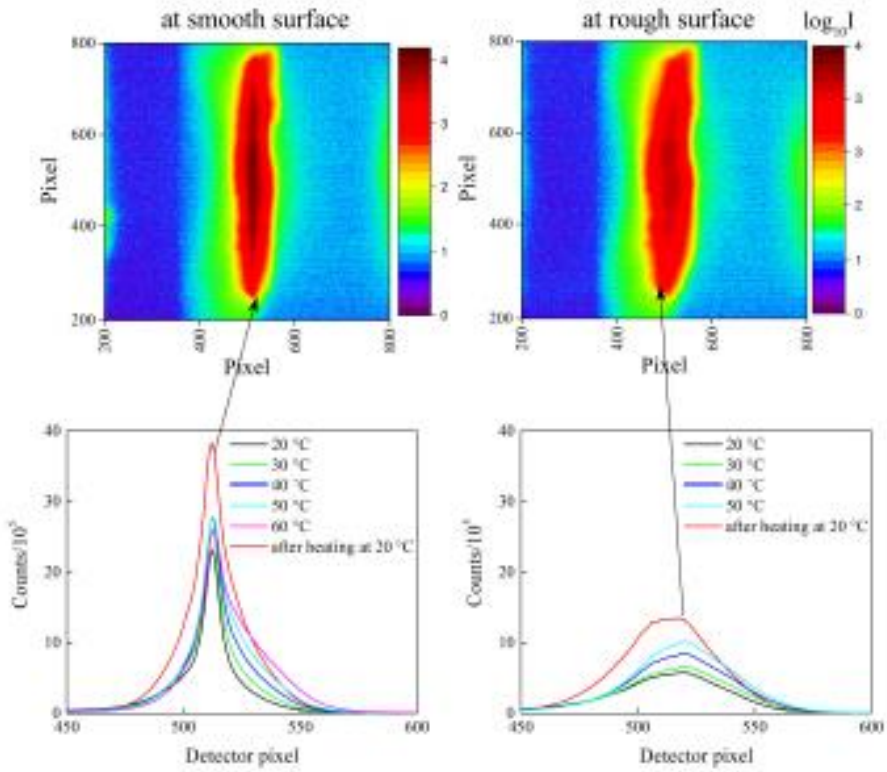

Figure 2: First order Bragg peak from 55% Brij L4 in D_2O at the specular reflection after heating the sample (top) and the vertical sum over the pixels on the detector at different temperatures (bottom). Data measured at Maria, MLZ [3].

The reduced intensity and increased width of samples near the rough surface is apparent. In these measurements, the width of the diffraction peak from the lamellar structure provides information about the extent of the order away from the solid interface. Further results of measurements made as the sample is rotated, rocking curves, allow the orientational alignment to be determined and information about the extent of order in different directions.

These results illustrate the potential of grazing incidence scattering of neutrons to provide important information about the structures in proximity to buried interfaces that are not accessible to other measurement techniques.

References

[1] S. Nouhi, M. S. Hellsing, V. Kapaklis, A. R. Rennie *J. Appl. Cryst.* **50**, 1066-1074, (2017).

[2] M. S. Hellsing, A.R. Rennie, M. Rodal, F. Höök *Langmuir*, **35**, 222-228, (2019)

[3] S. Nouhi, A. Koutsioubas, V. Kapaklis, A.R. Rennie *Manuscript in preparation.*