ROBL-CRG	**Experiment title:** **Study of structural properties of sputter-deposited and selfassembled multilayer waveguides**	**Experiment number**: 20_02_029
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Report:

We report a x-ray diffraction experiment of multilamellar membranes incorporated into a resonant beam coupler or x-ray waveguide structure. In the device, the lipid bilayers are confined to one side by the silicon substrate and to the other side by an evaporated thin metal cap layer. By shining a highly brilliant x-ray beam onto the system, we could excite resonantly enhanced, precisely defined and clearly distinguishable standing wave field distributions (modes). The in-plane structure of the acyl chain ordering was then be studied by grazing incidence diffraction under simultaneously exited modes. A significant gain in signal-to-noise ratio as well as an additional spacial resolution can be obtained in such a setup . The technique can be generalized to various kinds of organic thin film samples, ranging from synthetic polymers to two-dimensional protein crystals, and can be used to study macromolecular and supramolecular structure, and in future possibly also dynamics. In the present experiment we have validating earlier measurements by our group carried out at the D4 bending magnet of HASYLAB, and, in addition, have shown for the first time, that the incorporated lipid membranes can undergo a phase transition from the liquid crystalline gel phase to the so-called liquid L_a -phase. The brilliance of an ESRF bending magnet is ideally suited to map out the short range structural correlations in the plane of the membrane (acyl chains), even at small scattering volumes corresponding to about 10 bilayers. The experiment was carried out at an x-ray energy of 13 keV. The grazing incidence diffraction scans performed under simultaneous excitation of the waveguide modes demanding high angular precicion could easily be implemented on the Huber 6-circle diffractometer. A resonant enhanced standing electromagnetic field is generated between two parallel surfaces with an comparably large critical angle α_c separated by a medium that is suitable thick and x-ray transparent (low density organic films) [1-5]. Fig. 1 shows the reflectivity of a hybrid organic-inorganic waveguide consisting of a stack of about ten phospholipid bilayers prepared by a new spin-coating method on silicon substrate and cap-

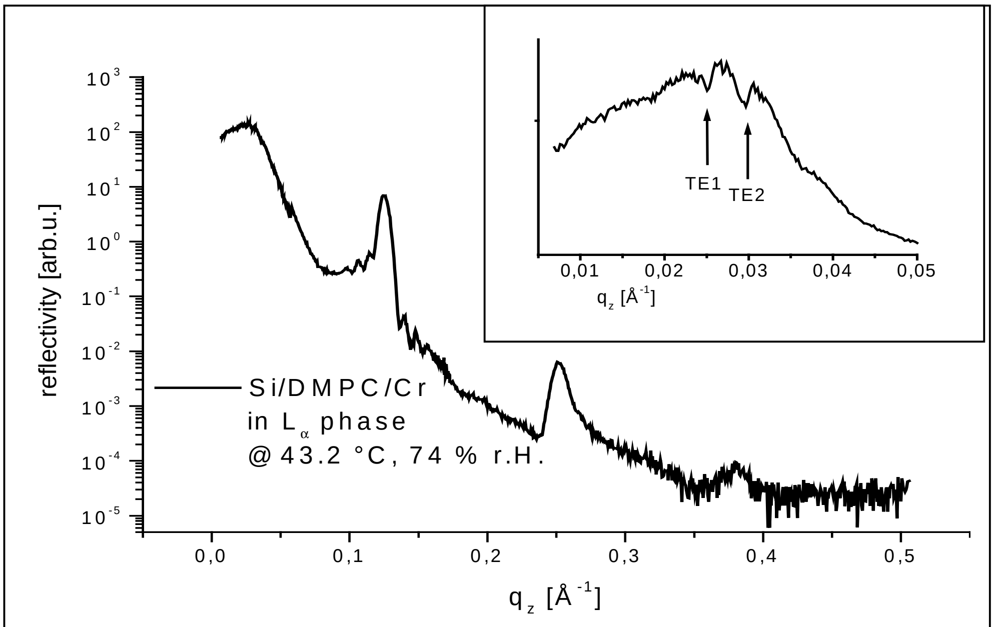
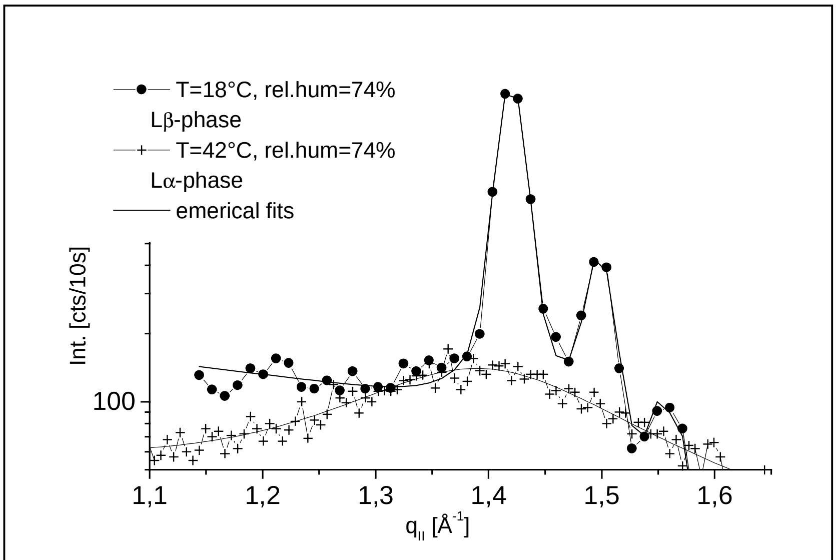


Fig.1: Reflectivity of a Si/DMPC/Cr waveguide, with the lipid bilayers kept in the liquid phase.

ped by an evaporated Cr cap. Note that the lipid bilayers are in the liquid phase. Several different standing electromagnetic field-distributions (modes) are resonantly excited by shining a parallel beam onto the waveguide under grazing incidence at a set of discrete angles α_i slighly bigger than the critical angle of the spacer layer, as evidenced by the corresponding cups in the reflectivity profile (inset).

To gain an understanding of the mode excitation, we have calculated the internal (and external) standing electromagnetic field as a function of the structural and geometric parameters (layer-thick-ness, composition and density, interface roughness, angles of incidence, x-ray energy) by a transfer matrix algorithm similar to the one used in the case of optical waveguides. Equivalently, one can use the well known Parratt-formalism for such calculations. The measured reflectivity profiles an the GID scans with the peaks reflecting the acyl chain packing are currently analyzed. At this point we can safely claim that interes-ting projects on organic-inorganic waveguide hybrids will be possible in future. The setup may present an opportunity to study thin organic films in resonantly enhanced films with unprecedented signal to noise ratios.



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