Microscopic Characterization of Nanofilms and 2D Materials by Imaging Ellipsometry and Brewster Angle Microscopy – an Overview

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The clue of ellipsometry is to measure the change in polarization of light, reflected at an interface of interest to obtain the optical thickness and complex refractive index of layers that are much thinner than the wavelength of the observing light. Imaging ellipsometry combines ellipsometry and microscopy to quantify the optical thickness in the microscopic scale, but also to increase the nanofilm/substrate contrast.

Imaging ellipsometry can be considered a further development of Brewster angle microscopy – a technique that is state of the art in imaging domains of monolayers on water surfaces, especially in Langmuir- and Langmuir Blodgett experiments. In the case of Brewster angle microscopy, the contrast between the water and the monolayer is maximized by illumination with linear polarized light at the Brewster angle of water. Currently this technique is of increasing interest for example to study the interaction between biological molecules in model membranes and interaction partners from the sub phase.

A number of applications of imaging ellipsometry are also related to model membranes like supported lipid bilayers. Research is focused on their phase transition characteristics and the bio molecular interaction analysis of incorporated biomolecules performed at the solid/liquid interface. According to the general approach of the technique, applications are in the fields of biophysics, surface chemistry, semiconductors, organic photovoltaic, 2D-materials, photonics and many more. More in detail, imaging ellipsometry has been used to characterize patterned self-assembling monolayers. It is possible to distinguish between areas of different chain lengths, changes in the c-terminated end groups and packing density. Polymer coatings, especially with PEG and hydro gels have been characterized in 2D arrays for biochip applications at changing temperature and as a basic coating on micro cantilevers.

The enhancement to spectroscopic imaging ellipsometry enlarges the field of application in different dimensions. The first is that samples with a larger variety of thicknesses can be characterized with a lower ambiguity than in single wave experiments. The second is that spectroscopic ellipsometry gives detailed information about the dispersion of the optical properties of nanofilms, tiny samples and bulk materials. Spectroscopic imaging ellipsometry offers unique opportunities to perform ellipsometric measurements at micro crystallites of 2D materials. A third advantage is that a wavelength can be chosen where the substrate is nontransparent. A typical example of this approach is the characterization of micromechanical cantilevers made out of Si: With red light the typical issues of transparent substrates have to be taken into account, with blue light the measurements are straightforward. In combination with knife edge illumination, it allows also an easy characterization of coatings on thin transparent substrates. The advantage in comparison to scanning techniques is the opportunity of directly imaging fluidic interfaces, like the air/water or liquid/liquid.

The presentation will give an introduction to the technique and will show an overview of typical applications. The characterization of 2D materials like graphene, MoS2 and hex BN will be the main emphasis of the talk.