IR - Synchrotron Ellipsometry for the Characterisation of nanostructured organic and biomolecular films: DNA Bases and Polymer Brushes

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Nanostructured and biomolecular films were characterized by IR ellipsometry [1-4] and complementary methods (VUV ellipsometry, XRD and AFM). For the laterally resolved ellipsometric measurements the recently upgraded IR synchrotron mapping ellipsometer at the IRIS beamline was used and it could be shown that the molecular structure of nanopatterned organic films can be derived from the measurements. Organic films are of technological interest for development of electronic, optical and sensoring devices. For the design of such organic devices it is often important to know the structural and optical properties of organic films and how they are bonded to the substrate. Optical methods are well suited for the contactless and non-invasive characterization. Infrared and VUV optical properties of thin films are correlated to vibrational and electronic excitations, respectively. Therefore the corresponding spectra are well suited for structural analysis, while the application of VIS ellipsometry for this purpose is often limited by the similarity of refractive indices for many organic materials. Ellipsometric results for two thin organic films on silicon, a DNA base and a polymer brush gradient film are discussed in the following.

Guanine film on silicon

In cooperation with Chemnitz University of Technology different films of DNA bases were studied and it could be shown that the average molecular orientation and the anisotropic optical constants can be determined from synchrotron ellipsometric spectra. Fig.1 shows measured and calculated ellipsometric spectra for a 84 nm thick guanine film together with schematic drawings for the molecular orientations used for the calculation. The shape of molecular bands, which are assigned to characteristic molecular vibrations, is characteristic for the average molecular orientation. From simulations within optical models the thickness and the molecular orientations can be derived [1-4]. However, even from the raw data qualitative assertions concerning the molecular orientation can be drawn from the observed spectral line shapes.

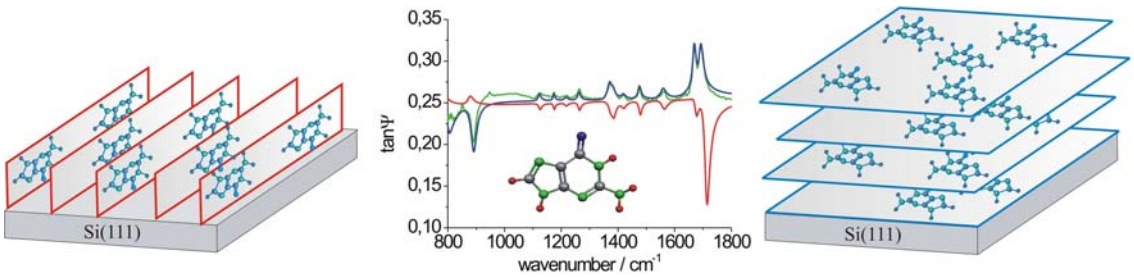

Fig.1: Thin guanine film on silicon: Measured tan Ψ spectrum is shown in comparison with calculated spectra for two different molecular orientations. In the shown spectra dip-up features indicate predominant in-plane orientation of the corresponding transition dipole moments, dip-down features indicate substantial out-of plane components. A single tan Ψ spectrum was measured within less than 25 s (including the time needed for rotation of polarizers). The structure of the guanine molecule is shown as inset.

Polymer brush film on silicon

During the 2nd semester of 2006 the existing IR ellipsometric set up was modified to allow micro-focus mapping experiments for scanning areas up to 50 x 50 mm. The upgrading of the ellipsometer was successfully tested with the investigation of mixed polymer brush gradient films. These ultra thin stimuli responsive films are studied in collaboration with IPF Dresden with the aim to analyze the dependence of their functionality on the brush composition. As a proof of principle 1D polymer gradient brushes of PS/PBA and PS/P2VP were mapped (see figure 2).

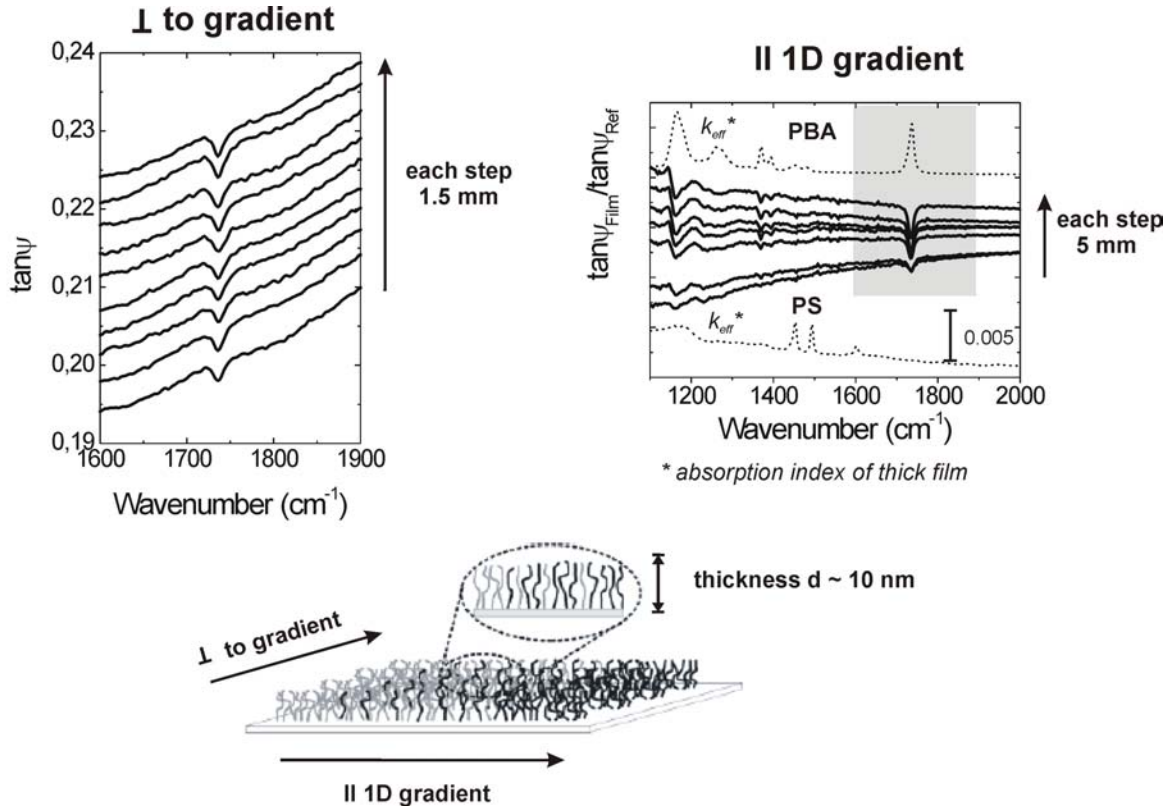

Fig. 2: Schematic of the geometry of a polymer brush gradient film and maps perpendicular to the gradient (top left) and along the gradient (top right) of a PS /PBA brush on silicon. The laterally varying composition of the brushes can easily be followed by the IR ellipsometric parameter tan Ψ.

In conclusion the presented results show that mapping ellipsometric measurements for structural analysis of nanostructured thin organic films are now possible within suitable time scales (a single spot with a size of 400 x 400 μm^2 can be investigated in 25 seconds). Based on these results further mapping experiments for analysis of biodiagnostic arrays and stimuli-responsive polymer brush gradients are scheduled in 2006. For example the binding of biomolecules to a specific linker will be investigated. Support by the EU through SSA DASIM (ctr. Nr. 00055326) and through the EFRE program (ProFIT grant, contract nr. 10125494) is gratefully acknowledged.

*[1] K. Hinrichs, M. Gensch, N. Esser, Applied Spectroscopy **59** (2005) 272A*
*[2] K. Hinrichs, S. D. Silaghi, C. Cobet, N. Esser and D. R. T. Zahn, phys. stat. sol. b **242** (2005) 2681*
*[3] L. Ionov, A. Sidorenko, K.-J. Eichhorn, S. Minko, K. Hinrichs, Langmuir **21** (2005) 8711.*
[4] M. Gensch, E.H. Korte, N. Esser, U. Schade and K. Hinrichs, Infrared Phys. Technol. (2006) in print.