Imaging ellipsometry

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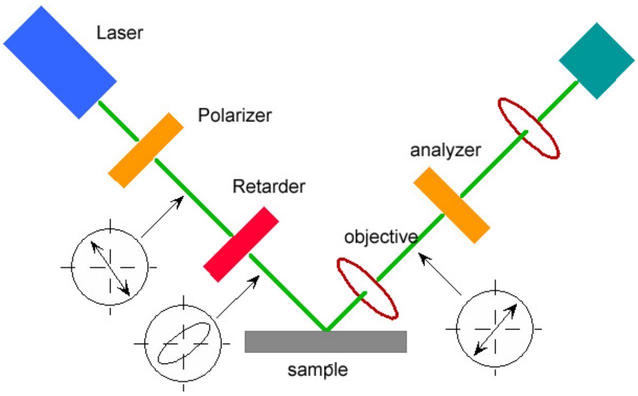
Ellipsometry is a very sensitive measurement technique that uses polarized light to characterize thin films, surfaces, and material microstructure.

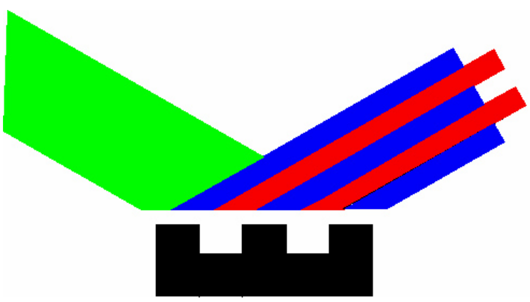
An ellipsometric experiment measures changes in the state of polarization which occur upon reflection on a film covered support. The measurement yields two quantities, Ψ and Δ, which are related to the ratio of the complex reflectivity coefficients for s and p polarization by the basic equation of ellipsometry:

$$\tan \Psi e^{i\Delta} = \frac{r_p}{r_s} \tag{1}$$

The principle of an ellipsometer is sketched in the following figure. Polarizer and retarder are used to produce elliptically polarized light. The state of polarisation is changed upon reflection and the resulting linear polarized light is then cancelled by the analyzer. The null setting of the optical components gives the ellipsometric angles.



The reflected light can be completely cancelled if the sample is uniform. This is not the case if the sample possesses inhomogeneity on a micrometer scale. In this case the lateral inhomogeneity is transfered in the state of polarization as sketched in the following figure:



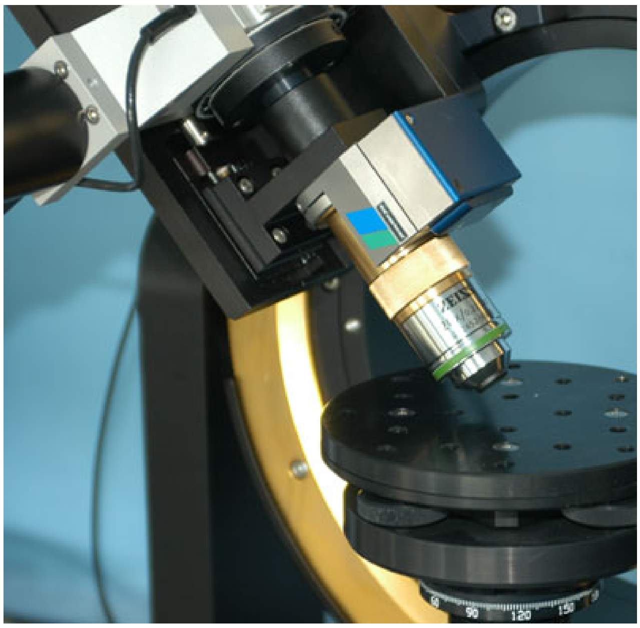
Each region of the surface corresponds to a different Δ and Ψ. A microscopic image of the surface can be formed with the aid of a proper imaging optics. The lateral resolution is determined by the numerical aperture of the microscope objective $\approx 2\mu$m and the vertical resolution is in the sub-nm range due to the ellipsometric contrast.

The measurements are non-destructive and many sample work, even liquid-liquid interfaces are accessible. Imaging ellipsometry can be used for an assessment of two dimensional morphologies and surface pattern. It combines the high vertical resolution of conventional ellipsometry which is in the sub-nm rang with a lateral resolution in the Micrometer range. Hence structures within a monolayer can be visualized.

Typical application

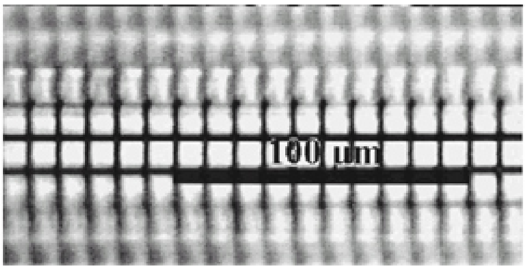
- Assessment of two dimensional morphologies
- Microcontact printing.
- Investigation of two dimensional surface pattern

Multiskop - Imaging ellipsometry



Piezo scanner for obtaining overall sharp images

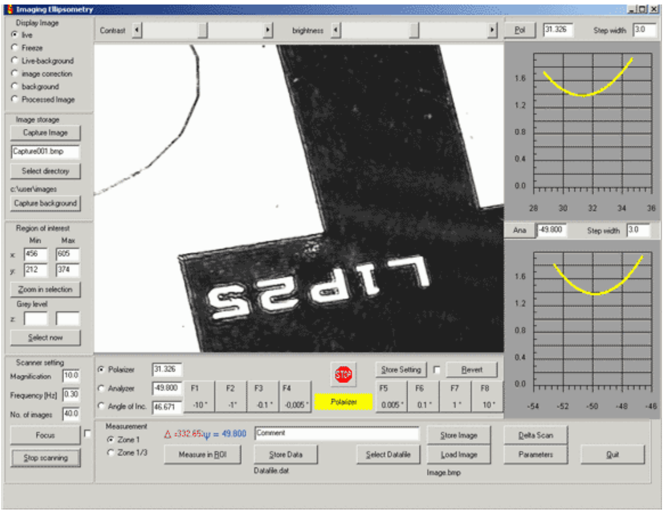
Imaging under an oblique angle faces several problems. The most striking one is that only a narrow stripe is in focus and the image is blurred towards the edges. The region which is in focus depends on the numerical aperture of the objective and the angle of incidence. The limitations are in particular pronounced at high magnifications as demonstrated in the following image:



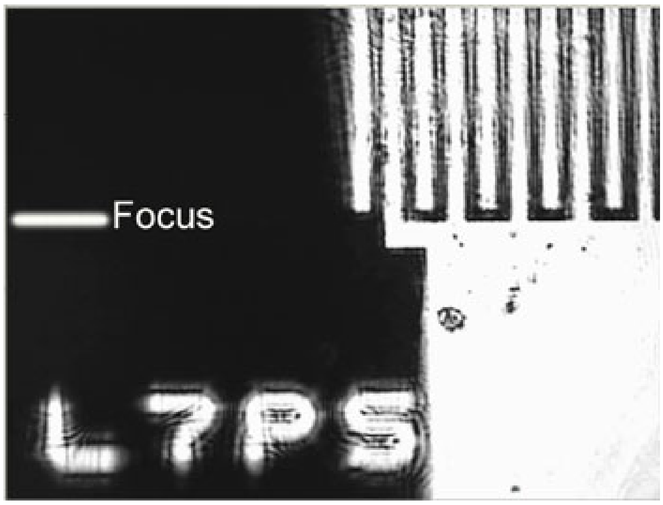
Surface pattern observed with a 20x objective

A straightforward solution consists in a scanning procedure. The microscope objective is mounted in a piezo translation stage which is fully controlled by the ADDA-converter of the Multiskop. The objective performs a continuous movement. A streaming video sequence is recorded which is then used to construct an overall sharp image.

The scanning procedure is fully automated, the software offers many features such as background subtraction or measurements in a region of interest.



An excellent performance is obtained if forty images are used for the final image construction as illustrated by the following surface pattern. The upper image has been measured before scanning (please observe the blurred letters), the lower image side is the very same surface after scanning.



Surface pattern before scanning

Surface pattern after scanning

Only a couple of steps are required to switch between imaging and non-imaging mode. The photodiode is replaced by a sensitive CCD camera and the iris is replaced by the microscope objective and scanner.

The lateral resolution in ellipsometric images is given by the numerical aperture of the objective. We offer a choice of different objectives, they have been selected to combine a large working distance with a high numerical aperture.

magnification	working distance	numerical aperture
5x	34 mm	0.14
10x	33.5 mm	0.28
20x	20.0 mm	0.42