Imaging Ellipsometry

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Introduction

Ellipsometry is a powerful non-invasive microscopy technique. It is widely used in characterizing thin films, semiconductor industry and also in biotechnology. Ellipsometry uses the polarization change upon reflection on the sample surface in order to determine the film thickness. This technique is very sensitive, a spectroscopic setup can determine the complex dielectric constants of materials. A more straight forward setup with a single wavelength can already distinguish single atomic layers, provided the sample composition is know. An imaging ellipsometer uses a camera for detection instead of a photodiode or linear ccd. This makes it possible to measure a wide area in one measurement, a regular ellipsometer will need a time consuming scan over the surface or can only measure one spot. The imaging ellipsometer will be used to measure growth in a vacuum environment. For this purpose it is important to measure fast enough in order to record single atomic layer growth over an area slightly larger than the EUV spot size.

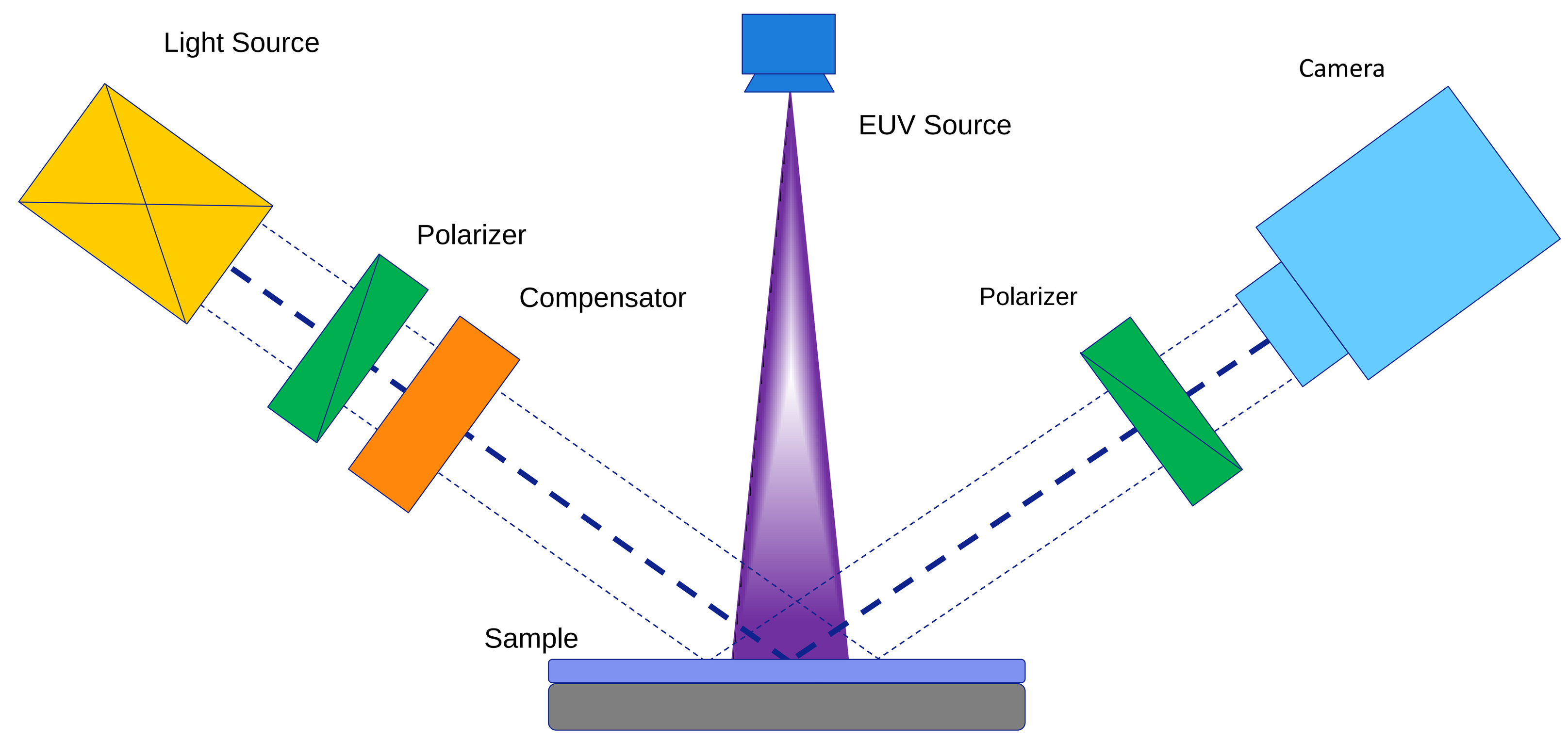

Figure 1: Schematic drawing of an imaging ellipsometer

Experimental setup

An imaging ellipsometer is made from several key elements. The light source produces a parallel beam which is linearly polarized with the first polarizer. The compensator is a rotating quarter-wave plate which modulates the polarization of the light. After reflection a secondary polarizer, the analyzer, creates an projection of the elliptic polarization state on the camera. The intensity is measured and the amplitude of four different Fourier components can be related to the ellipticity parameters ψ and Δ. If this information is combined with a Fresnel reflection model and known optical constants of the substrate, layer thicknesses can be calculated.

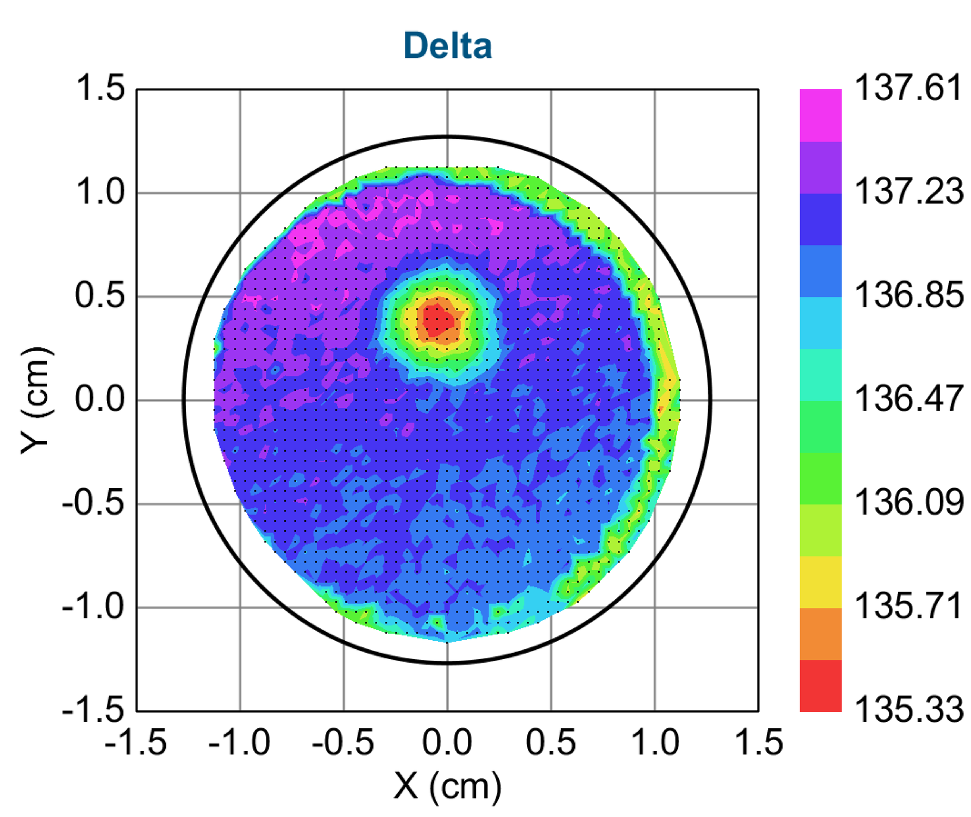

Figure 2: Spectroscopic Ellipsometer measurement. A delta distribution is visible. A scan typically takes 3 hours, while the imaging ellipsometer needs around a minute.

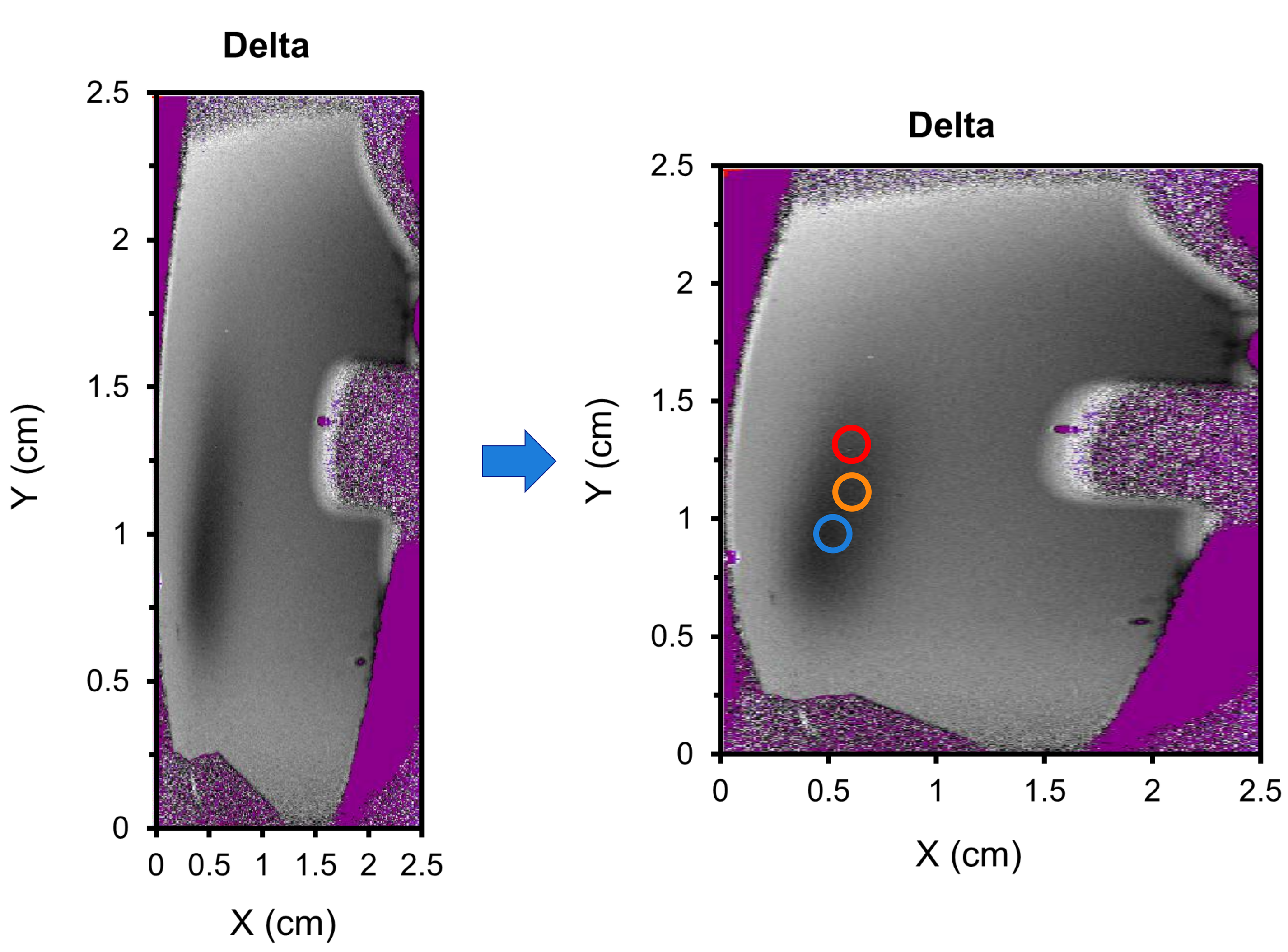

Figure 3: Left: Imaging ellipsometer delta map. Right: Aspect ration corrected image for viewing angle. The different locations for Figure 4 and 5 are indicated by their appropriate color.

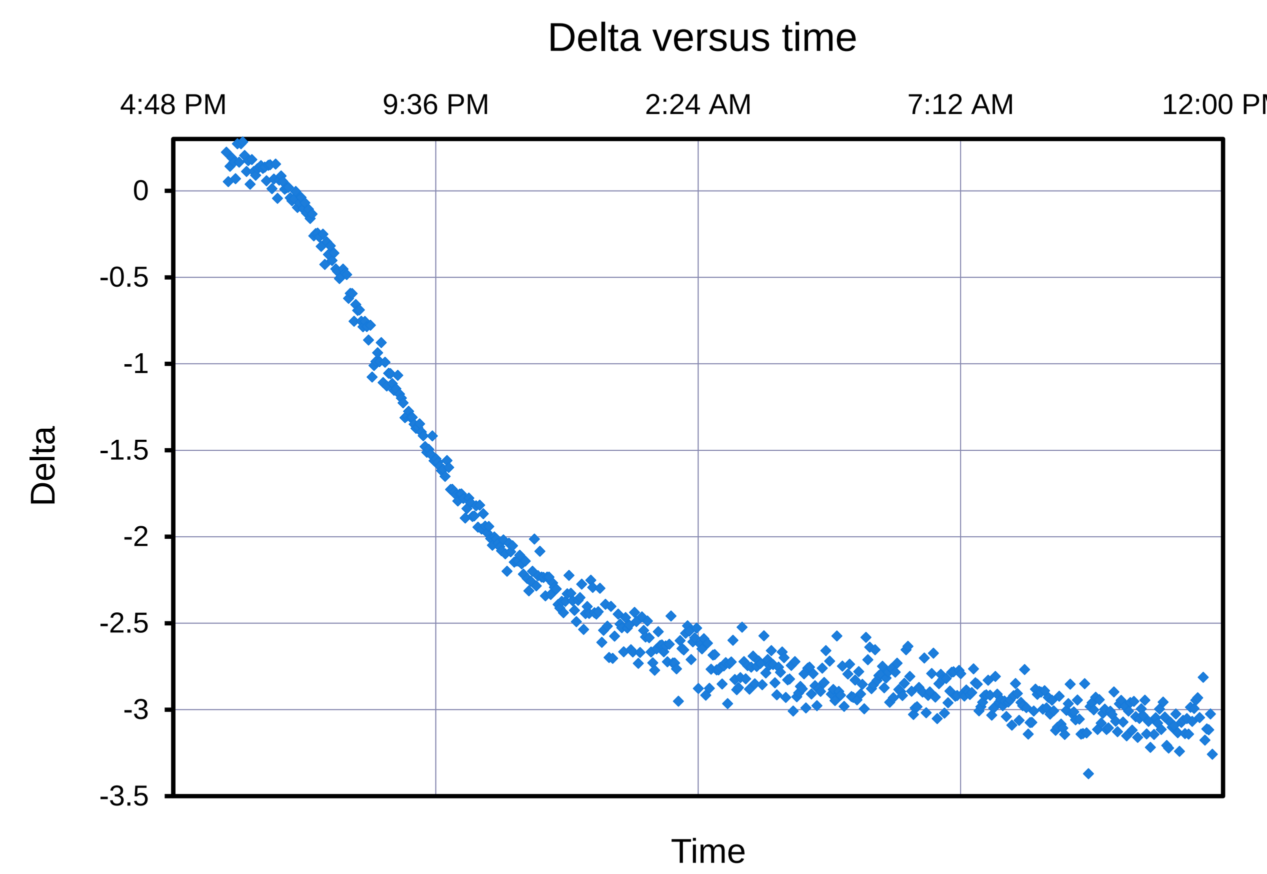

Figure 4: Increasing thickness, decreasing delta, with time.

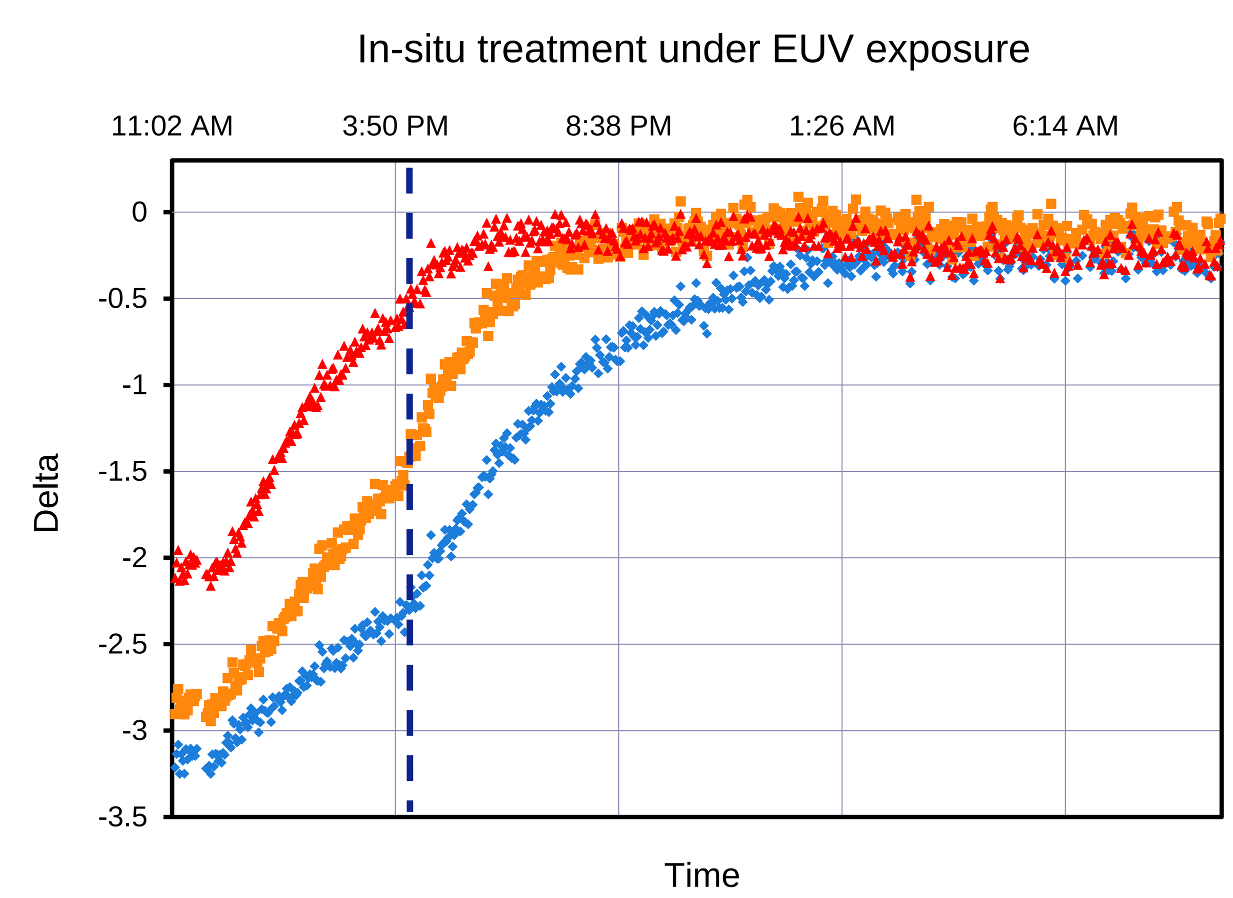

Figure 5: In-situ observation of the removal of material under EUV exposure. At the dashed line, the gas atmosphere was changed and the removal rate increases.

Results and outlook

Results

- Real-time measurement of spatial profiles of overlayers
- Results in agreement with spectroscopic ellipsometer

Outlook

- Develop more advanced multi-wave length imaging ellipsometer
- Higher accuracy and lower uncertainty
- Solve problems with distortion and limited depth of field

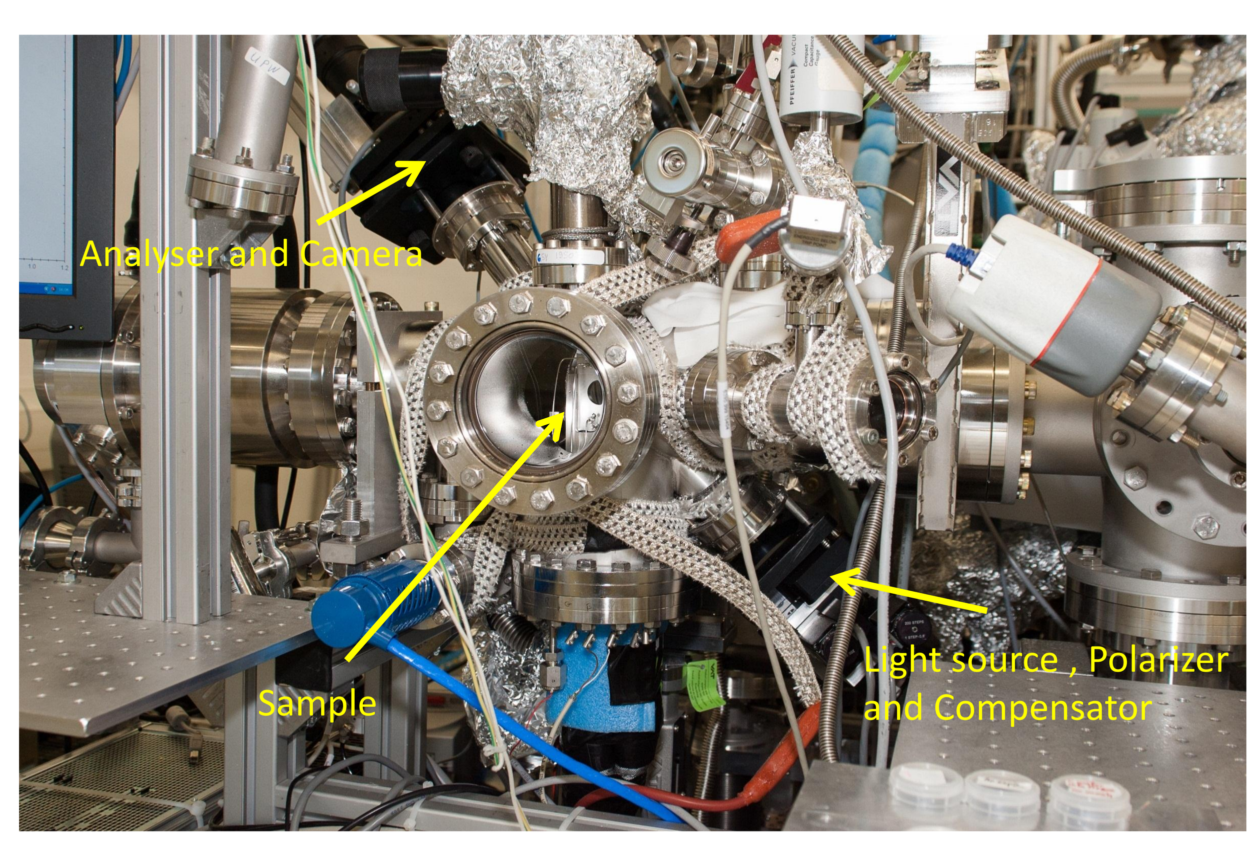

Figure 6: Overview of the current imaging ellipsometer setup with 633 nm light source, the different components are indicated.