Mueller ellipsometry: Basic Principles, Instrumentation and Applications

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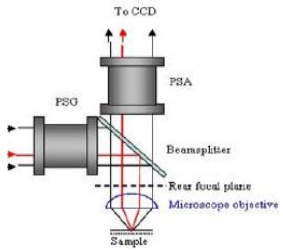
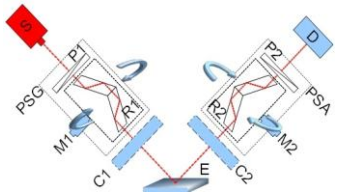
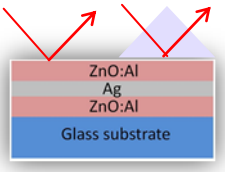
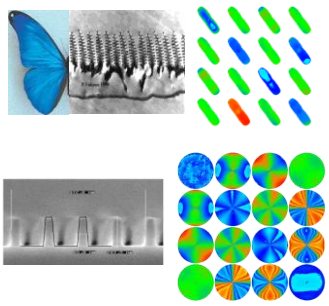
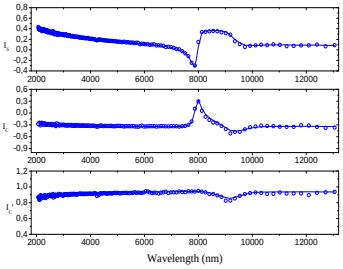
The use of light in science and industry as tool for characterization and analysis has several advantages such as the non-invasiveness, and the easiness of manipulation. All optical characterization techniques have in common the measurement of the intensity of light, but some of them, such classical ellipsometry and Mueller ellipsometry, go a step further and take profit of polarization as an additional source of information. Classical ellipsometry cannot provide reliable measurements when depolarization is present, i.e. for partially polarized light. Depolarization can be originated in samples by multiple reasons, such as lack of homogeneity, incoherent scattering or lack of coherency of light, among others. To treat correctly partially polarized light, there exists a more general approach than standard ellipsometry, termed Mueller ellipsometry. The goal of this presentation is to give an overall vision of Mueller ellipsometry. The first part will be an introduction to the Jones and Mueller mathematical formalisms used to describe the polarization of light. A second part will be devoted to experimental aspects of Mueller ellipsometry showing some of the most advanced implementations, in particular, spectroscopic Mueller ellipsometers working from the visible, to the mid-infrared range, and polarimetric microscopes working in both imaging and reciprocal modes. The third and last part will be dedicated to show some applications of Mueller ellipsometry and data modeling for metrology of complex nanostructures (metamaterials and nanogratings for microelectronics), plasmonics (SPR ellipsometry), and life sciences (biosensors and "optical biopsy" for early cancer detection).

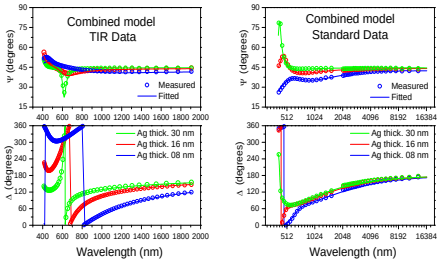












Schematic representation of the angle-resolved Mueller ellipsometer (top).

Angle-resolved image of a butterfly wing. Angle-resolved Mueller matrix of a 1D diffraction grating.

Schematic representation of the broadband spectroscopic Mueller polarimeter.

Experimental and best-fitted data in the spectral range from 2 to 13µm corresponding to a thermal SiO_2 thin film grown on a Silicon wafer.

Optical configuration to perform measurements in standard configuration and in total reflection (TIR) mode. A metallic thin film stacked between dielectric films allow to excite a surface plasmon (SPR) wave when measured in TIR mode.
Experimental and best-fitted data in TIR (left) and a standard (right) configurations corresponding to stacks with a metallic film of different thickness.