

Biosensing in the ultraviolet wavelength range by Kretschmann-Raether ellipsometry

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Optical biosensors are sensitive, non-destructive, label-free and capable of quick in-situ characterization. Among the many types of optical sensors those utilizing the surface plasmon resonance (SPR) are one of the most popular. Biological processes are usually accompanied with a change of dielectric function in the layer or at the interface, and they can therefore be followed by in-situ high-sensitivity optical characterization techniques. The SPR method usually utilizes the Kretschmann-Raether configuration, in which there is a metal layer at the interface which is illuminated from the media of the higher refractive index. The features of the plasmons excited in the metal layer can be analyzed by detection at changing angle of incidence, wavelength, or both. SPR sensors usually measure the reflected intensity, but with ellipsometry the difference between the r_p and r_s polarizations can be measured also in term of phase, where r_p and r_s denote the complex reflection coefficients of light polarized parallel and perpendicular to the plane of incidence, respectively.

In this work a Bragg multilayer structure (Fig. 1) was designed utilizing materials of SiO_2 and ZrO_2 that creates an interference feature in the ultraviolet wavelength range. The target wavelength was 270 nm, at which most proteins have an absorption peak. The peak position can be adjusted by the angle of incidence, but also by the layer structure and the thicknesses, which opens an opportunity to use combinatorial [2] in the Kretschmann-Raether configuration. The width of the peak at half maximum is as small as 3 nm. Using one or multiple resonant peaks in the spectrum helps to increase the selectivity of the sensor, although the sharp feature is a challenge in terms of spectral resolution of the monochromator. It might cause depolarization, such as the focusing of the beam. Focusing is on the other hand an enabler for combinatorial applications, in which the lateral resolution can be identified as the resolution of the composition. The peak position can be adapted to specific materials and tasks. Compared with the traditional plasmonics, the position, the width or even the number of peaks can be changed. All these features are important when targeting a good selectivity, besides the sensitivity, which can be achieved even by a purely spectroscopic approach, i.e. without changing the angle or using any moving parts in the configuration. The demonstrated sensitivity was $6.55 \cdot 10^{-6}$ and 10.4 pg/mm^2 for the refractive index and for the surface mass density.

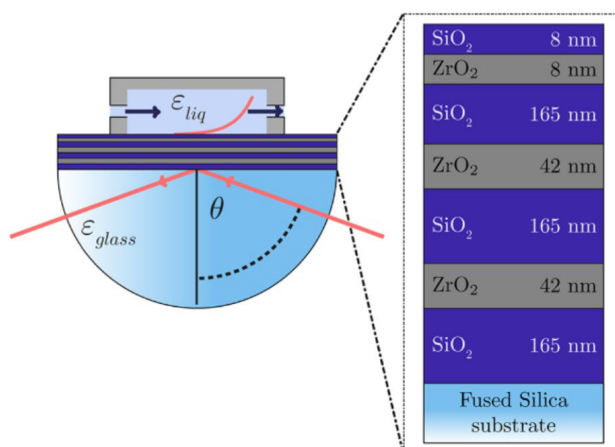


Figure 1: Kretschmann-Raether ellipsometry using multilayer optimized for enhanced sensitivity at the wavelength of 270 nm. Most proteins have an absorption peak at this wavelength.

Keywords: bioellipsometry, biosensing, optical characterization, optical properties of proteins

References

- [1] B. Kalas, K. Ferencz, A. Saftics, Z. Czigany, M. Fried, P. Petrik, Bloch surface waves biosensing in the ultraviolet wavelength range – Bragg structure design for investigating protein adsorption by in situ Kretschmann-Raether ellipsometry, *Applied Surface Science*. 536 (2021) 147869. <https://doi.org/10.1016/j.apsusc.2020.147869>.
- [2] B. Kalas, Z. Zolnai, G. Sáfrán, M. Serényi, E. Agocs, T. Lohner, A. Nemeth, N.Q. Khánh, M. Fried, P. Petrik, Micro-combinatorial sampling of the optical properties of hydrogenated amorphous Si_{1-x}Ge_x for the entire range of compositions towards a database for optoelectronics, *Scientific Reports*. 10 (2020) 19266. <https://doi.org/10.1038/s41598-020-74881-5>.