Optical Biosensing Based on Photonic Crystal Surface Waves

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INTRODUCTION: We present a new optical biosensing technique based on registration of bounded optical surface waves (SWs) propagating along an external interface of a one-dimensional photonic crystal (1D PC). Unique tunable properties of 1D PCs permit the design of a 1D PC structure with one of surface modes abutting on the angle of the total internal reflection (TIR). This mode, in which the exited angle is infinitesimally close to the angle of TIR from the external medium, has a very large penetration depth in this medium (e.g., water) and may be used as a reference of bulk RI fluctuations. This permits us to segregate the volume and the surface signals from the analyte and increase the sensitivity of the PC SW biosensor.

METHODS: For biosensing in a liquid, both *s*- and *p*-polarized PC surface waves (PC SWs) may be employed on a dielectric surface. The liquid RI may be determined by measuring the critical angle for *p*-polarization of the laser beam, while the *s*-polarization is used for the excitation of the adlayer-thickness-sensitive PC SW.

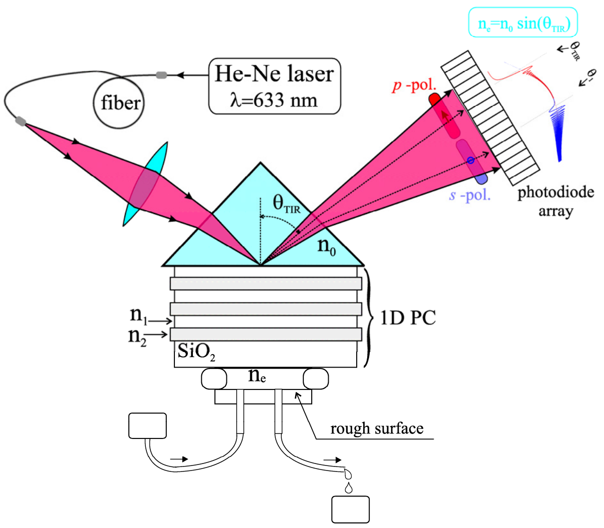

Fig. 1: A sketch of the biosensor. The typical reflection profiles are shown near the photodiode array.

The absence of metal damping (in contrast to the SPR technique) leads to increasing of the propagation length of the *s*-polarized SW that enhances the sensitivity of this wave to the adlayer deposition. A high sensitivity of the RI detection in the presented technique arises from the fact that the sharpness of the reflection near the critical angle (for *p*-polarization) is much higher in this system than both in SPR-based systems and in standard critical-angle Abbe refractometers on uncoated prisms.

RESULTS: To demonstrate of the biosensor sensitivity we present the experimental data of free biotin binding on the streptavidin monolayer.

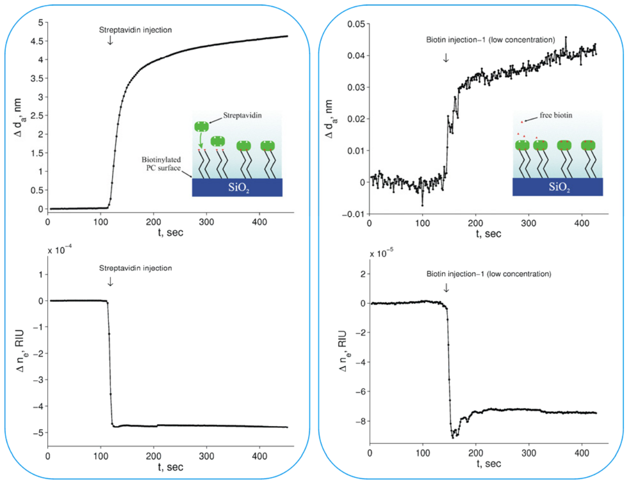

Fig. 1: Immobilization of streptavidin on a biotinylated surface (top left) with subsequent binding of free biotin to this streptavidin monolayer (top right). Corresponding changes of RI of the buffer during these injections is shown at the bottom. In color inserts the possible corresponding processes are illustrated.

CONCLUSIONS: The exploitation of the 1D PCs as substrates supporting the long-range optical surface wave propagation permits to detect the adsorption of (bio)nanofilms and their thickness variations at the level better than 10^{-3} nanometre, segregate surface and volume events in biosensing and improve the RI sensitivity of the Abbe-like refractometer to the level ~9×10^{-8} RIU.

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