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Enhanced Surface-to-Bulk Sensitivity Ratio of a Waveguide Grating Biosensor by Angular Interrogation at Short Wavelengths

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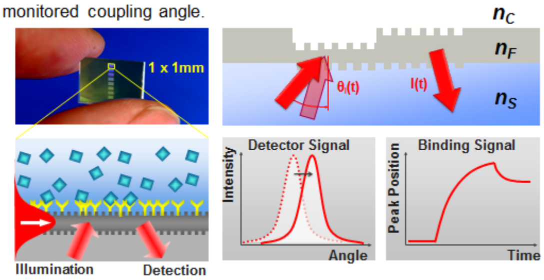
Results in brief

Label-free waveguide grating based biosensors are highly sensitive to effective refractive index changes caused by the adsorption of biomolecules onto the sensor surface and/or due to refractive index changes of the bulk solution[1]. As these changes can only be sensed within the penetration depth of the evanescent field of the propagating mode, the so-called surface-to-bulk sensitivity ratio can be optimized by changing the wavelength of the interrogating light source. Since short wavelengths lead to a shallower penetration into the bulk solution but higher field densities in close proximity to the sensor, events of molecular binding to the surface can be measured with enhanced sensitivity, whereas adverse refractive index changes of the bulk solution are suppressed[2,3]. And the higher refractive index contrast at shorter wavelengths leads to an increased sensitivity. Besides numerical simulations and comparative measurements at different interrogation wavelengths ranging from the near-ultraviolet to the infrared, an integrated angle interrogated micro-electro-mechanical sensor system working at shorter wavelengths and higher repetition rates than common commercial systems has been presented.

The presented work is part of the FP7 Project RADAR, funded by the European Commission, Grant Agreement Number 265721, a project which aims to develop a multiplex robust, label-free, remotely controlled, and portable biosensor platform for spot measurements and online monitoring of toxins and pollutants in food production processes and in the aquatic environment.

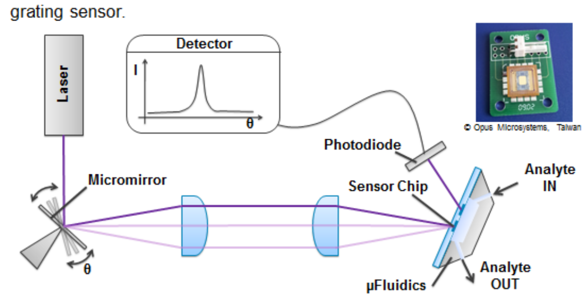
Sensing Principle

The adsorption of target molecules onto the Ta_2O_5 waveguide grating as well as the variation of the cover refractive index n_C cause a change of the effective refractive index and therefore a shift of the monitored coupling angle.



Reader System Schematics

MEMS scanning mirror for fast angular interrogation of the waveguide grating sensor.



The optical reader development is part of the European FP7 Project RADAR. Grant Agreement Number: 265721

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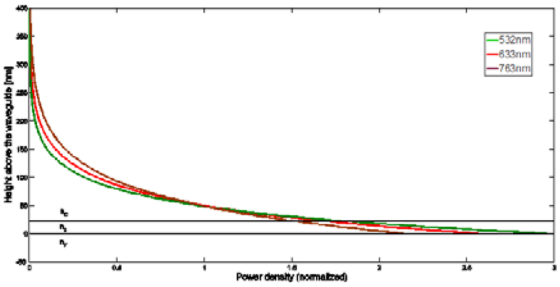
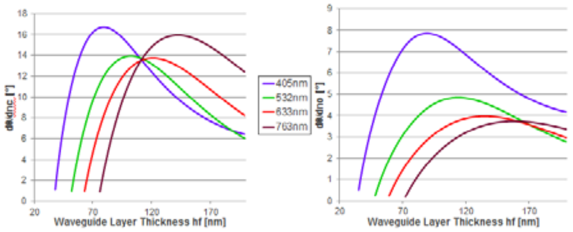
Evanescent field for different wavelengths

Simulated power density distribution of the evanescent sensing fields for different wavelengths. Short wavelengths exhibit a higher surface to bulk power density ratio compared to longer wavelengths with a bigger penetration depth.



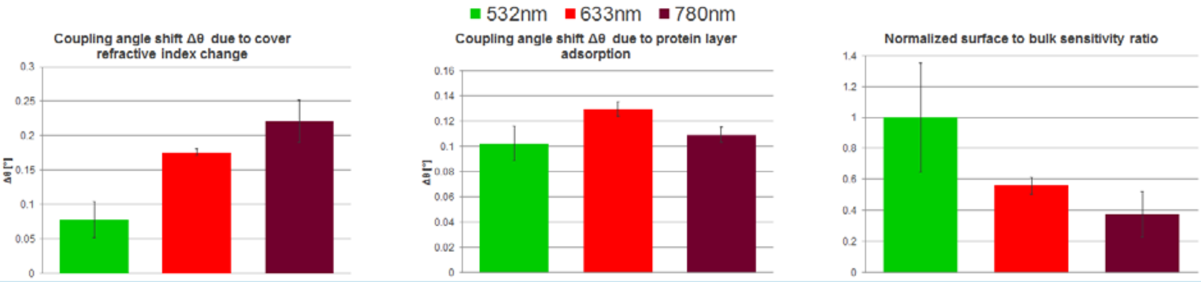
Simulated Sensor Sensitivities

Calculated sensor sensitivities for different interrogation wavelengths upon refractive index changes of the bulk cover medium (left) and within the sensing layer (right) with a thickness of 20nm, simulating the adsorbance of molecules to the surface. The simulations suggest that the sensitivity regarding bulk refractive index changes stays approximately constant for different wavelengths considered, while short wavelengths are favoured for the detection of adsorbed species.



Measurements / Results

To investigate the abovementioned simulations, the coupling angle shift Δθ upon the change of the cover refractive index (H20 → 10%wt Glycerol in H2O) and upon the adsorption of a protein layer (10% serum in PBS) for a waveguide grating coupler (hf = 150nm) has been measured for three different wavelengths. In agreement with the simulations, the measured shift induced by the cover refractive index change decreased for shorter wavelengths, whereas the shift due to the adsorption of a protein layer is similar for all investigated wavelengths at the given waveguide layer thickness. Thus, short wavelengths exhibit a increased surface-to-bulk sensitivity ratio and therefore a potentially higher signal-to-noise ratio.



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http://www.fp7-radar.eu/

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