A highly integrated optical sensor for point of care label free indentification of pathogenic bacteria strains and their antibiotic resistance

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We overview our recent developments in nanophotonic biosensor arrays for the detection of whole bacteria and PCR products. The work is part of the EU InTopSens project, with the aim to demonstrate the feasibility of a rapid diagnostic test for sepsis. This requires detecting the presence and identification of bacteria species from whole blood and their antibiotic resistance profile, which can be accomplished through the detection of the presence of specific DNA strands. Our principal approach is by the simultaneous measurement of bacterial nucleic acid strands on a 64 sensor spot array, to identify the presence of *e-coli*, *streptococcus aureus* or *coagulase negative staphylococci*, as well as the β Lactams and fluroquinolones resistance markers.

Recent publications [1, 2] have demonstrated slot waveguide ring resonator sensors with a detection limit as low as 5×10^{-6} RIU and a sensitivity as high as 240 nm/RIU over a 7K temperature operating window, without need of external temperature control or individual sensor calibration. A detection limit of 1×10^{-7} RIU for TM polarized light has been recently shown [3] for Mach-Zehnder based DNA sensing.

For simplicity of experimental design, photonic sensor development within the project has to date been carried out on immunoassays rather than bacteria and/or nucleic acids. The next steps will be in meeting the challenge of extreme temperature ramping for the sample DNA melting (at 95 ºC) and subsequent hybridization (at 60 ºC). Initial developments in the first sensor 'base technology' for SOI silicon photonic wires began by replacing strip ring resonators [4] with slot-waveguides rings in order to improve sensitivity and the limit of detection for DNA hybridization sensing. Experiments with biotin/avidin showed [5] the resonators to have 298 nm/RIU sensitivity and 4.2×10^{-5} RIU detection limit for changes in the refractive index of the top cladding, a 3.5x increase in sensitivity over the base technology but a poorer detection limit due to bending and surface roughness losses. In an alternative approach to a structure with an improved detection limit Mach-Zehnder Interferometers with folded waveguides have been realized. Developments in the second sensor 'base technology' of SOI silicon photonic crystals have led to a sensitivity of 82.5 nm/RIU for the TE cutoff wavelength which corresponds to a detection limit of 2.2×10^{-4} RIU, an factor of 2.5 improvement compared to that previously seen [6].

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