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Abstract

Stable Porous Silicon Membranes for Fast Bacterial Detection †

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Abstract: The rapid detection of hazardous bacteria is important for healthcare situations, where such identification can lead to substantial gains for patient treatment and recovery and a reduced usage of broad-spectrum antibiotics. Potential biosensors must be able to provide a fast, sensitive and selective response with as little sample preparation as possible. Indeed, some of these pathogens, such as *Staphylococcus aureus*, can be yet harmful at very low concentrations in the blood stream, e.g., below 10 colony forming units per mL (CFU/mL). These stringent requirements limit the number of candidates, especially for point-of-care applications. Amongst several biosensing techniques, optical sensing using porous silicon (PSi) substrate has been widely suggested in recent years thanks to unique features such as a large surface area, tunable optical characteristics, and above all relatively easy and affordable fabrication techniques. In most configurations, PSi optical biosensors are close-ended porous layers; this limits their sensitivity and responsiveness due to diffusion-limited infiltration of the analytes in the porous layer. Also, PSi is a reactive material, its oxidation in buffer solutions results in time-varying shifts. Despite its attractive properties, several challenges must still be overcome in order to reach practical applications. Our work addresses three main improvement points. The first one is the stability over time in saline solutions helped by atomic layer deposition of metal oxides inside the pores. Besides a better stability, our solution is helping with an increase of the optical signal to noise ratio, thus reducing the limit of detection. The second one is to perform the lysis of the bacteria prior to its exposure to the sensor, such that the selective detection is based upon the percolation of bacterial residues inside the pores rather than the bacteria themselves. The third one is to remove the bulk silicon below a PSi layer to create a membrane, that allows for flow-through of the analytes, thus enhancing the interactions between the lysate and the sensor's surface. This approach allows us to avoid the step of surface functionalization used in classical biosensors. We tested thanks to these improvements the selective detection of *Bacillus cereus* lysate with concentrations between 10^3 and 10^5 CFU/mL. Future works are dedicated to further improvements, including optical signal enhancement techniques and dielectrophoretic assisted percolation in the porous silicon membrane.

Keywords: biosensor; porous silicon; porous silicon membrane; *Staphylococcus aureus*; *Bacillus cereus*; atomic layer deposition; optical biosensor; pathogens

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