Optofluidic Integrated Bragg Grating Chemical Sensor: Utilising a Sodium-selective Receptor Surface to Enhance Detection

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Planar waveguides can be written with a UV-laser into photosensitised silica to produce a wide range of optical devices. Careful modulation of two interfering beams allows Bragg gratings to be directly written into the channel. These Bragg gratings are inherently sensitive to temperature and strain, however etching away the surface exposes the mode within the grating to its surroundings. The corresponding observed shift in Bragg wavelength can be used to detect changes in this environment [1]. It has been previously reported [2] that the sensitivity of such a refractometer can be enhanced by over an order of magnitude through use of a high-index overlayer of tantalum pentoxide. This enhanced sensor has shown the potential to detect a single molecular monolayer upon the sensor surface [2]. This sensitivity was confirmed through the successful attachment and detection of a single molecular monolayer of a fluorescein-based organic dye to the sensor surface [3].

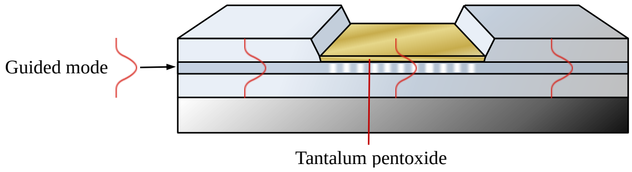
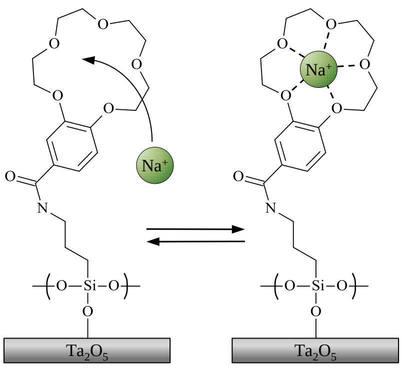


Fig. 1 A schematic of a tantalum pentoxide coated integrated Bragg grating sensor, showing the etched sensor region.

Incorporation of such a sensitive refractometer into a microfluidic flow cell allows for continual monitoring of the refractive index of the fluid passing over it. This system has been shown [4] to be able to determine the composition of known mixtures with high precision, with it demonstrated that the composition of a methanol-water binary mixture can be determined down to 0.3 %. However such refractive index sensors cannot distinguish between different analytes within a mixture. This limitation can be overcome through the functionalisation of the sensor surface with a receptor that will preferentially bind the desired analyte from a mixture, enhancing the refractive index response. This principal is demonstrated in Figure 2, where a simple benzo-15-crown-5 modified surface enhances the refractive index response to a series of sodium chloride solutions in methanol, compared to the equivalent lithium, potassium or rubidium systems:



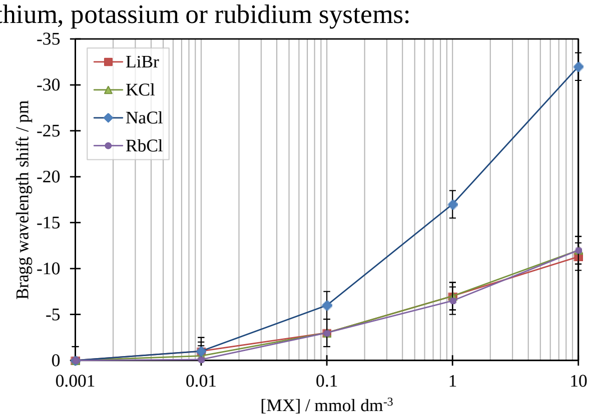


Fig. 2 A schematic of a benzo-15-crown-5 functionalised surface (left) and the Bragg response of the functionalised sensor to varying concentration of lithium, sodium, potassium and rubidium cations in methanol (right).

A second-generation sensor is proposed that aims to enhance both the selectivity and sensitivity of the crown ether system. This sensor uses a calix(4)crown-based ionophore, a receptor that offers a greater affinity for sodium over the simple crown ether receptor. When combined with a switchable dye, this chromoionophore will selectively amplify the refractive index change upon binding sodium over other cations.

We shall present the latest developments towards a highly sensitive and selective sodium sensor using a calix(4)crown-based chromoionophore receptor surface.

References

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