On-chip optical sensor platform

Integrated and chip-based sensing, or 'lab on a chip', is a rapidly growing field that offers potential applications in healthcare, security, and the environmental sciences. At the heart of the field is the ability to detect and identify minute quantities of chemicals, particles or microbial organisms using compact systems with dimensions of centimetres or less.

In Oxford we are developing flexible chip-based sensors based on optical microcavities. By confining light to volumes of order 1 μm^3, about a cubic wavelength, tiny quantities of target species cause measurable modifications to the intracavity medium that can be observed using a range of straightforward optical techniques. The cavities can be fabricated into large arrays for parallel sensing, and are compatible with microfluidic systems for controlled analyte delivery.

Our novel approach to cavity-enhanced sensing involves a stable Fabry Perot style resonator in which light is trapped between a planar and a concave mirror (Figure 1). Analyte is passed between the mirrors so that it interacts directly with the cavity mode for maximum sensitivity. By perfecting the fabrication process we can make highly resonant modes cavity modes (Q~10^4 and higher) that react measurably to the smallest change within the cavity volume.

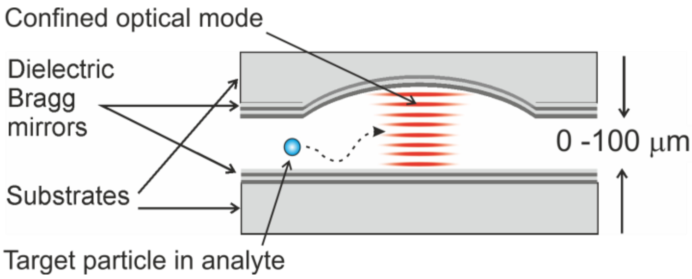

Fig 1. Open resonator geometry provides high sensitivity and spectroscopic tunability

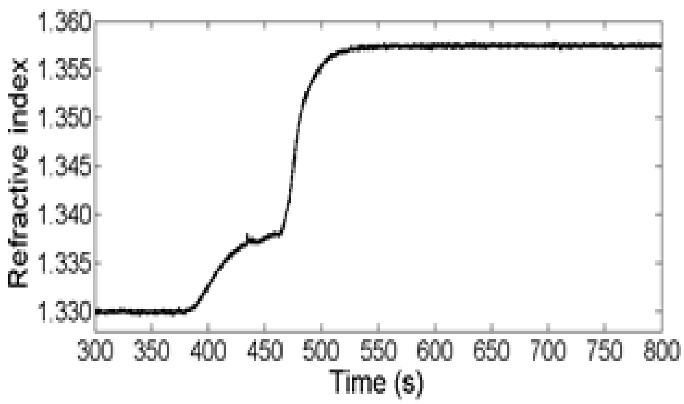

Fig. 2 Refractive index change due to injection of glucose solution. Sensitivity of 3.5 × 10^{-4} RIU has been demonstrated.

We have demonstrated the sensing of glucose in aqueous solution by measuring the change in the refractive index via a shift in the mode resonance (Figure 2). The total volume of fluid in the active region of the sensor at any instant in time is of order 30 femtolitres. The device is currently capable of measuring changes in refractive index units (RIU) down to about 3×10^{-4}. With future generations we anticipate that 10^{-6} will be possible, competitive with the most advanced interferometric methods.

A similar approach allows detection of individual particulates passing through the sensor. Figure 3 shows fluctuations observed in the resonant wavelengths when a polymer sphere of 200 nm diameter diffuses through the sensor. The five different time-traces shown in the figure are measured simultaneously and can be combined to track the position of the sphere as it diffuses, thus allowing calculation of the size of the particle. We estimate that particles as small as 20 nm may be measured, making the sensor suitable for detecting a wide range of water-borne or airborne viruses, particulates, and aerosols.

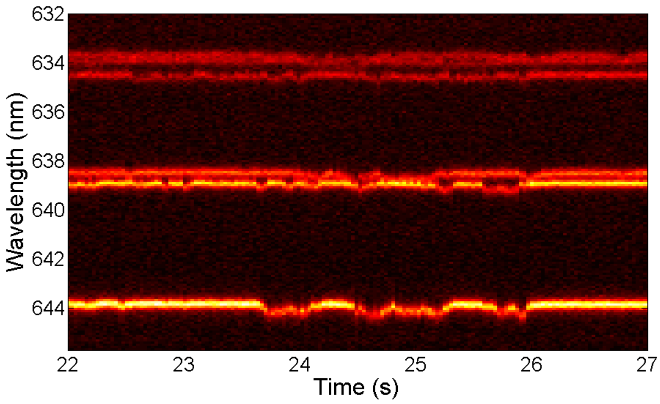

Fig 3. Trace showing a 200 nm polymer sphere diffusing in water through a cavity. The different signals provide positional information that can be used to measure the size of the particle.

Other techniques for which the cavities could be used include fluorescence, optical absorption, and Raman scattering, all in principle reaching single molecule sensitivity. The cavities are fully tuneable so that in-situ spectroscopy can be performed to identify target species.

We have patent protection for the cavity-enhanced sensing platform and are currently looking for companies to help us develop commercial products, either standalone sensors or accessories to other microscopy and spectroscopy instruments. We are also working on tuneable lasers and tuneable optical filters based on the same microcavity technology, and which are inter-compatible with the sensor platform described here. For more information on any of these programmes or to register your interest please contact us using the address below.

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