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Protein Biosensing with Fluorescent-Core Microcapillaries

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Whispering gallery modes (WGMs) are the electromagnetic resonances of dielectric spheres, cylinders, or rings. The WGM wavelengths can shift when the resonant field interacts with a local analyte fluid. This work demonstrates a fluorescent core microcapillary that utilizes WGMs for biosensing applications. This device consists of a glass microcapillary with a 50-µm-diameter inner channel. The channel wall is coated with a film composed of fluorescent silicon quantum dots (SiQDs). Because the SiQD film has a higher index of refraction than the glass capillary wall, it can support cylindrical WGMs. The QD fluorescence spectrum thus consists of a set of sharp peaks at the WGM resonance wavelengths. Part of the WGM field extends into the capillary channel where it samples the fluids pumped inside; thus the cavity resonance wavelengths in the QD fluorescence spectrum depend on the channel medium. The sensitivity of the WGM wavelengths varied between 3 and 24 nm per refractive index unit, depending on the SiQD film thickness. Biosensing with this device was then demonstrated using the standard biotin-avidin system. The QD film in the capillary channel was coated with alternating charged polyelectrolyte (PE) layers with exposed amines for attaching biotin. Biotin in turn has a high specific affinity for the neutravidin protein. These biotinylated PE layers were found to capture neutravidin, yielding a detection limit of 6 nM and an equilibrium association constant of 1.1 x 106 M-1 for biotin-neutravidin in this sensor. Several "blank"runs indicate minimal nonspecific binding. Attractive features of this device include a high degree of physical robustness and minimal equipment requirements (e.g., a tuneable laser is not needed to scan the cavity modes). Future work will aim to increase the so-far moderate detection limit, potentially by improving the device sensitivity via finer control over the SiQD film thickness.

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