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# Improving sensitivities and detection limits of fluorescence-based microcavity refractometric sensors

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Refractometric sensors can be used to detect small changes in refractive index (RI) of an analyte fluid. In microfluidics, they can be used to measure temperature or chemical changes in a miniscule analyte volume. Refractometric sensors can be extended into the biosensing domain via chemical functionalization of the sensor surface. My project goal is to find ways to improve the sensitivities and detection limits of the fluorescence-based microcavity refractive index sensors.

In a spherical or cylindrical dielectric with a circular cross section, light can propagate around the circumference by total internal reflection, forming the so-called whispering gallery mode (WGM) resonances. I work primarily with optical fiber (d = 125 $\mu$m ) and quartz micro-capillary (d = 50 $\mu$m ) sensors that demonstrate WGM resonances. These structures are coated with a thin film (up to 1 $\mu$m) consisting of a silica matrix embedded with silicon quantum dots. Under blue laser light, these have a broad red fluorescence which overlaps with the WGM spectrum of the sensor. Since the film has a higher RI than the glass fiber or capillary, fluorescent WGMs are mostly confined within the film but their profiles extend slightly into the inner (capillary) or outer (optical fiber) medium. Spectra of the quantum dot fluorescence then feature regular sharp peaks associated with the cylindrical dielectric fiber or capillary resonances in that particular medium. By continuously collecting fluorescence WGM spectra and monitoring the peak positions, I can make sensorgrams (change in RI over time) as the sensor is exposed to different fluids.

These devices have sensitivities of tens of nanometers per RIU (refractive index unit) and modest detection limits on the order of $10^{-4}$ RIU. I will show how to obtain a threefold improvement to our signal-to-noise ratio and thus our experimental detection limit by controlling for environmental factors and by using data processing methods. I'll also discuss two additional fabrication methods which may increase the sensitivities and thereby further decrease the detection limits of these devices.

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