# Tapered Optical Fibers for Biosensing Applications

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This study focuses on the design, fabrication and characterization of a tapered optical fiber platform for the label-free detection of biomolecules. Molecular binding to the fiber surface changes the refractive index and thickness of the biolayer, which interacts with propagating light, causing a measureable phase shift in the output.

Single mode optical fibers are designed for low-loss transmission of information over long distances. These fibers are composed of a silica core surrounded by a cladding, the refractive index of which allows for total internal reflection of light through the core. When the beam undergoes total internal reflection, some of it will exist outside of the core. A portion of the electric field permeates through the core/cladding interface and decays as a function of distance from the interface; this phenomenon is known as an evanescent wave. Evanescent light waves are the basis for surface plasmon resonance, a popular biosensing technique. In optical fibers, however, the cladding is much thicker than the distance it takes for the evanescent wave to decay to a negligible value, which is why they are useful for long-distance transmission. This low loss characteristic, however, makes an untapered fiber an ineffective platform for sensing on its outer surface since light propagating through the fiber can only be measured in the core. Tapering of single mode fibers results in a fiber where the field exists outside the tapered region which is where the biomolecular recognition layer is tethered. Binding of analyte to the recognition layer results in a molecular conformational change and is detected as a change in the light propagation pattern.

Single mode fibers were tapered to a 'waist' diameter of approximately 10 microns, and then functionalized with biomolecules for aqueous (antibody) detection of analytes. Optical fibers from Fibertronics Inc. with 9/125μm core/cladding diameter and pigtail connectors were used. The ends of the fibers were cleaved at a 90° angle with the Vytran LDC-200-G optical fiber cleaving system. These cleaved fibers were spliced with the Vytran GPX-3000 graphite filament, fusion fire-polishing system. Once spliced, the GPX-3000 was used to taper the waist region of the fiber to a diameter of approximately 10 microns. Fibers were functionalized with primary antibody (Sigma-Aldrich; goat-anti-rabbit IgG) using standard silane chemistry for covalent linkage of the antibody to the fiber surface. Using a custom flowcell, fibers were exposed to varying concentrations of secondary antibody (rabbit IgG) and resulting light transmission patterns were recorded via spectral sweeps from 1475-1565 nm. Exposure of functionalized fibers to the positive control (rabbit IgG) resulted in a phase shift toward the red while exposure to the negative control (human IgG) resulted in no net phase shift. Our empirical results correspond well with the theoretical characterization of the tapered fiber. We are currently exploring the use of tapered optical fibers for detection of vapor phase analytes. We envision the use of tapered optical fibers in array format for detection of multiple analytes in complex samples for biomedical (blood, saliva, breath), environmental, and homeland security applications.