Flow-Through Multi-Hole Capillaries for Optofluidic Bio-Chemical Sensing

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Motivation
- We develop novel flow-through multi-hole microstructured fibers/capillaries for sensitive bio-chemical detections with inherent micro-/nanofluidic channels. Compared to the widely-studied photonic crystal fibers (PCFs), the capillaries provides many unique characteristics, and will allow us to carry out versatile and critical applications.

Objectives
- Build a capillary pulling system and fabricate multi-hole capillaries
- Construct an optofluidic Fabry-Pérot cavity biosensor
- Develop an optofluidic 3-D surface-enhanced Raman scattering (SERS) platform for ultrasensitive analyte detection

Capillary Fabrication

Capillary Pulling System

Optofluidic Fabry-Pérot Cavity Biosensor

Operating Principle

Resonance conditions of the Fabry-Pérot cavity:

\[ 2nL = m\lambda \]

\[ 2(nL + 2N \cdot \Delta n \cdot t) = m(\lambda + \Delta \lambda) \]

\[ \frac{\Delta \lambda}{\Delta t} = \frac{2N}{nL} \times \frac{\Delta n}{V} \]

Sensitivity is greatly increased with thousands of micro-/nanosized holes

Optical Sensing System

Fabry-Pérot Resonance Modes

Rapid Analyte Delivery & Sensitive Biomolecular Detection

Optofluidic 3-D SERS Platform

Detection Configurations

SEM Images of Capillary Immobilized with Gold Nanoparticles

Ultrasensitive Molecule Detection (Transverse)

Longitudinal vs. transverse

Raman Intensity (counts)

Raman Intensity (a.u.)

Enhancement factor: > 3 X10^4

Detection limit: < 100 fm

More than 5.5 times higher intensity achieved in longitudinal

Summary

We have successfully fabricated flow-through multi-hole capillaries and developed their applications in optofluidic Fabry-Pérot cavity biosensor and 3-D SERS platform for rapid and ultrasensitive bio-chemical detections.