Squeezed hollow core photonic Bragg fiber for surface sensing applications

Jingwen Li, Hang Qu, Maksim Skorobogatiy
Dept. Engineering physics
Ecole polytechnique de Montreal
Montreal, Canada
maksim.skorobogatiy@polymtl.ca

***Abstract*—We propose to use squeezed hollow-core photonic Bragg fiber for surface sensing applications. We demonstrate theoretically and confirm experimentally that squeezing a section of the Bragg fiber core increases overlap between the optical fields of the core-guided modes and the modes bound to the sensing layer, thus significantly enhancing their interaction via anticrossing phenomenon, which, in turn, enhances surface sensitivity of the fiber sensor. As a practical demonstration, we apply our sensor for *in situ* monitoring of the dissolution dynamics of a sub-micron-thick polyvinyl butyral (PVB) film coated on the surface of the Bragg fiber core. The proposed fiber sensor can be used for real time detection of binding and affinity, study of kinetics for a wide range of chemical and biological samples. (*Abstract*)**

Keywords—Bragg fiber; surface sensing; photonics *(key words)*

I. Introduction

Photonic crystal fibers, in particular Bragg fibers, have enormous potential for chemical and biological sensing applications, owing to a number of unique advantages such as high sensitivity, fast response, small volume requirement of samples, ease of fabrication, and potential for detection of specifity. In this work, we propose and demonstrate a hollow-core Bragg fiber for surface sensing applications.

II. Squeezed Hollow Core Bragg Fibers for Surface Sensing Application

The Bragg fiber used in our sensor features a large hollow core (D~600μm) surrounded by a period sequence of high and low refractive index layers, namely polystyrene (PS)/poly-methacrylate (PMMA) Bragg reflector. The cross section of the Bragg fiber with a PVB layer is shown in Fig. 1. The thickness of the PVB layer is estimated to be ~500nm.

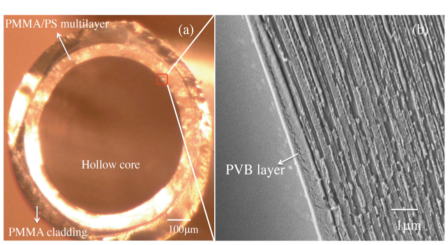

Fig. 1. Cross section of the fiber under microscope (a) and SEM (b).

As a demonstration, we use the sensor to monitor the dissolution dynamic of a PVB film (thickness: ~500nm) coated on the fiber inner surface. Alcohol is used to dissolve the PVB film. As shown in Fig. 2, with the dissolution of the PVB layer, a blue shift is observed with the decrease of PVB layer thickness. A surface sensitivity of ~0.05nm/nm is obtained.

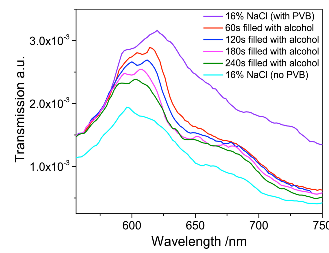

Fig. 2. Transmission spectra of the fiber during the dissolution of the PVB film.

In order to enhance the surface sensitivity, we propose squeezing a section of the Bragg fiber, which effectively enhances the modal overlap with the analyte layer [1]. We choose the same Bragg fiber, as well as the same recipe for the PVB film deposition. We then characterize the surface sensitivity using the same method presented before. As shown in Fig. 3, the surface sensitivities of the squeezed fiber are enhanced by ~35% and ~30% when the fiber is filled with distilled water and 16% NaCl solution, compared to that of a non-squeezed fiber. The mechanism of sensitivity enhancement is due to increased overlap between the core modes and the PVB film when the fiber is squeezed.

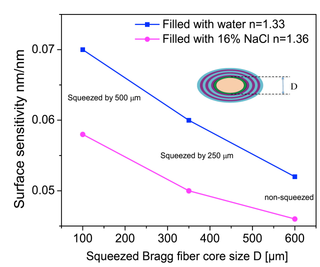

Fig. 3. Surface sensitivities of the sensor at various degrees of squeezing.

References

[1] J. Li, H. Qu, M. Skorobogatiy, “Squeezed hollow core photonic Bragg fiber for surface sensing applicagions,” Opt. Express, vol. 24, pp. 15687-15701, 2016.