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Metal films tapered fibers to enhance environmental sensing capabilities

Tapered Optical Fibers to Enhance Environmental Sensing Capabilities

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Abstract

Using a tunable laser we analyze the optical signal transmission through a bi-tapered fiber sensor. With the fiber sensor we can detect aqueous refractive index changes around a bitapered fiber. We have also developed a phase-based signal processing technique to improve the sensitivity of the measurements to smaller changes of the refractive index near the surface.

Introduction

The application of optical fibers in sensing systems is a signature development in manipulation of light based on different physical phenomena in fibers. Many fiber sensors base their operation on the interaction of the guided mode with the surrounding environment, one of the most developed techniques is sensor applications with tapered fibers. In a sensor based in tapered fiber, the light that's enter to the fiber from one of the end passed through the untapered region, it has a higher order mode that interact with the fundamental mode in the taper region and coupled together. At the other end of the fiber the coupled mode generate interference due to the differences in the effective indices between the glass and the surrounding medium.

Objective

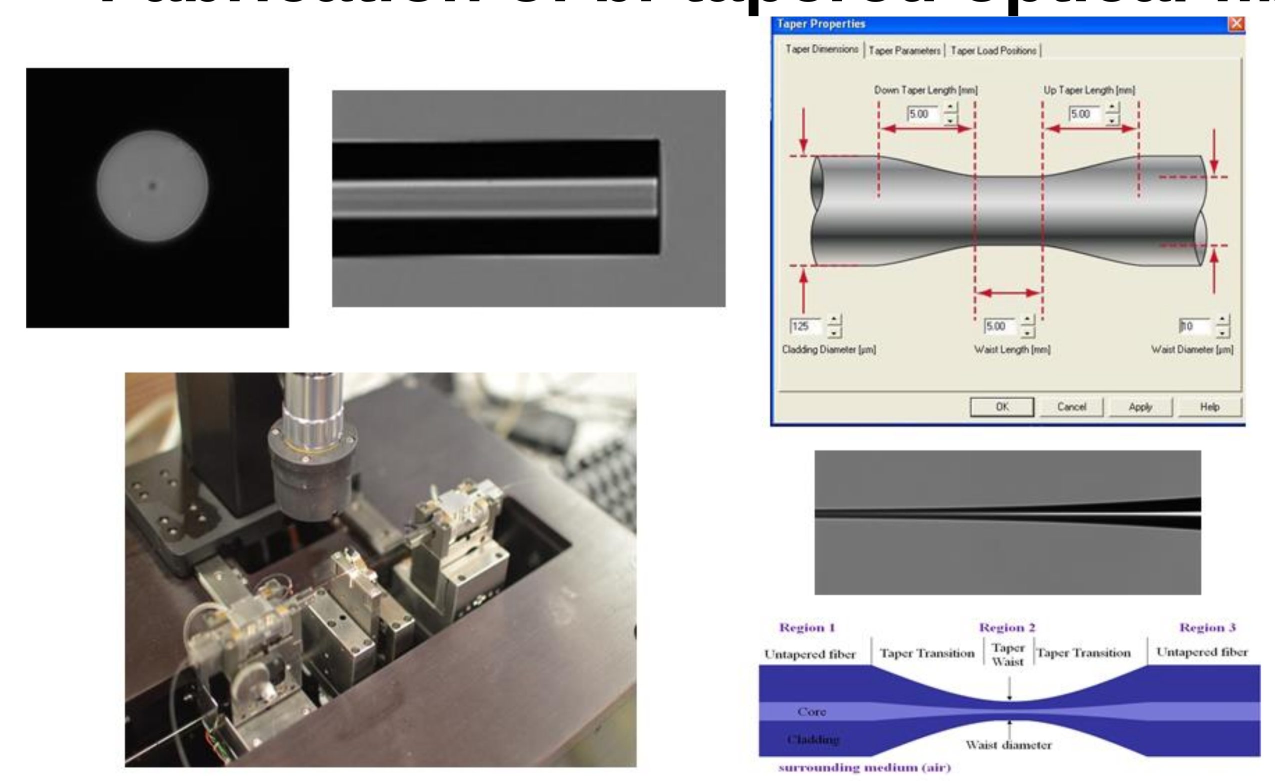
Design a high sensitivity bi-tapered optical fiber sensors to detect refractive index changes in solutions of water-glycerol mixture with different weight concentration.

Methodology

➢ Experiment

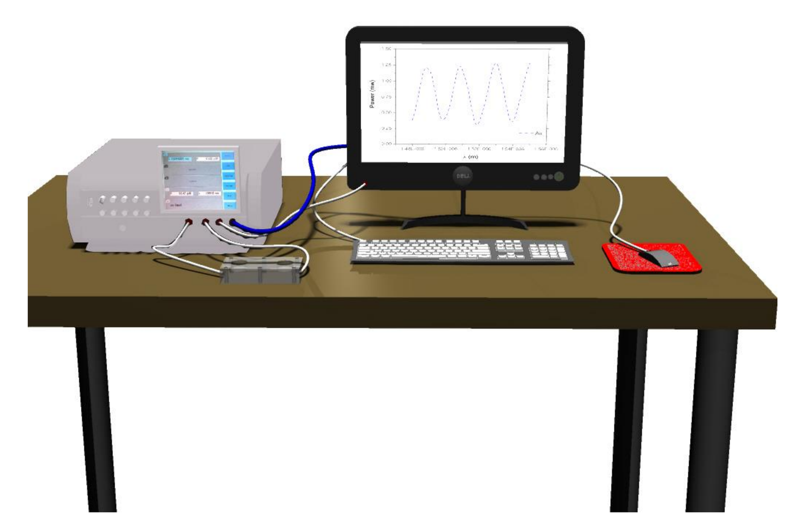
The bi-tapered fiber often begins with a standard, single mode optical fiber; the diameter is reduce gradually in a specific region by heating and stretching the fiber forming a waist that maintains its cross-sectional profile over a specified length. The bi-tapered fiber is fabricated using a Vytran splicer GPX-3000 system. It allows us to control the parameters of the taper such as the taper rate, shape and length and the fiber waist diameter and length. Generally, the diameter of the waist for a taper fiber is chosen between 15 to 2 µm.

Fabrication of bi-tapered optical fiber



The Vytran GPX-3000 has a high precision for the fabrication of taper device. The system has two holding blocks where each end of the fiber is firmly attached. There is a filament in the center of the system that locally heats the fiber and the entire system is computer controlled

Experimental setup



At the up-taper end of the fiber the fiber modes generate interference due to the phase differences between the individual modes

$$I_T = I_{co} + I_{cl} + 2\sqrt{I_{co} \cdot I_{cl}} \cdot \cos\phi$$

The phase ϕ expresses the interference of fiber modes as a function of wavelength .

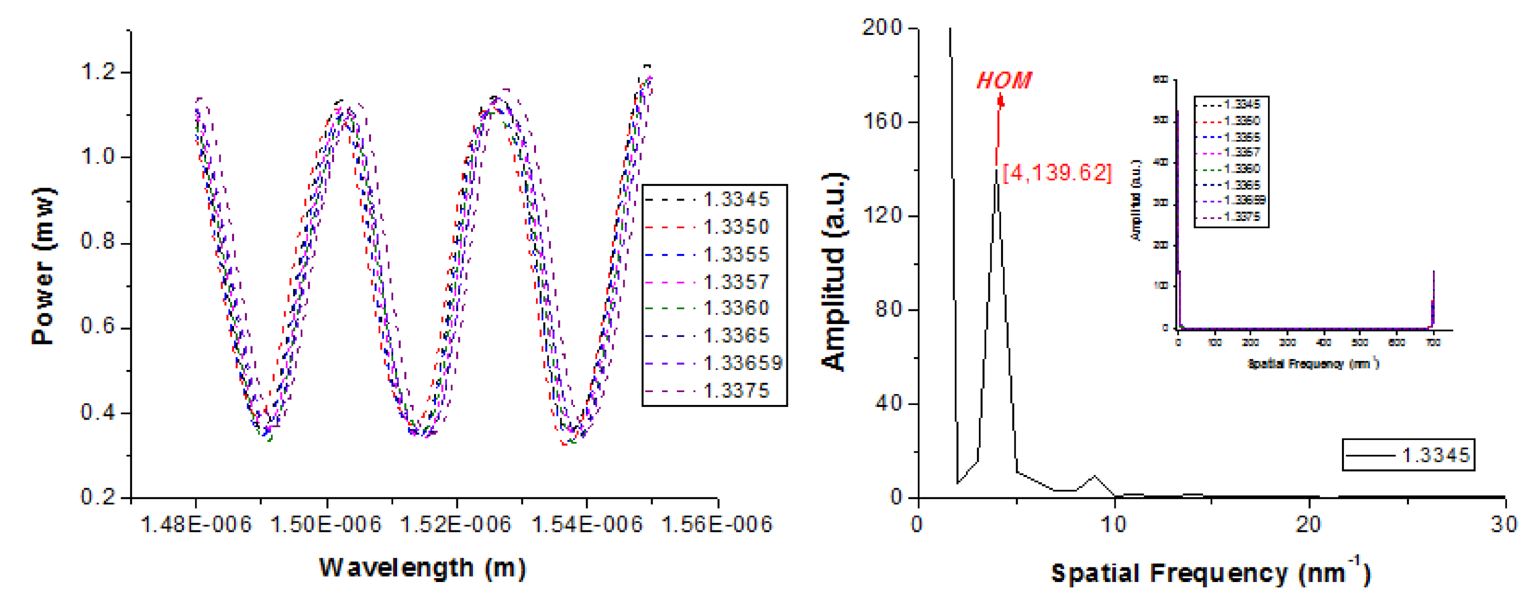
Preparation of Solutions

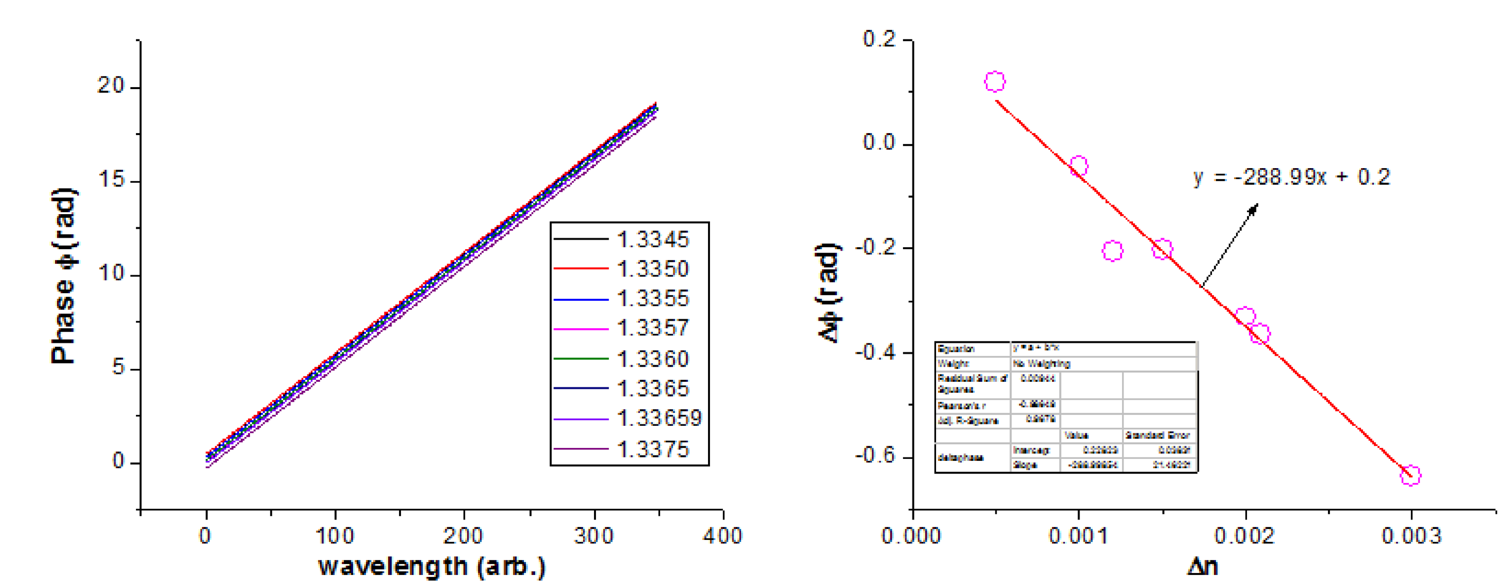
Concentration (%)	n
1.00	1.3345
1.25	1.3350
1.50	1.3355
1.75	1.3357
2.00	1.3360
2.25	1.3365
2.50	1.33659
2.75	1.3375

Eight solutions of water-glycerol mixture with different weight concentration that correspond to different refractive indices a room temperature were made. The concentrations of the solutions start from 1% to 2.75%

Results

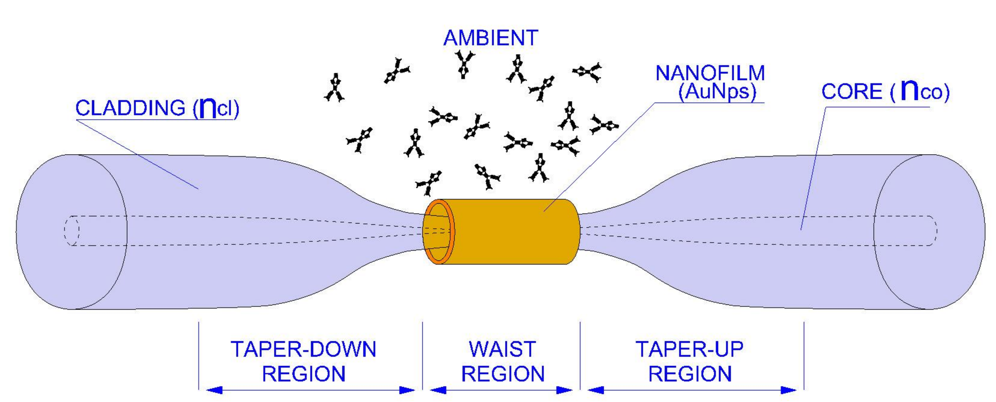
$L = 5\ mm\ ;\ d = 10\ \mu m$





Future Work

➢Design a new generation of high sensitivity bi-tapered optical fiber sensors by adding a thin metal film on the surface to detect trace amounts of selected biomolecules in aqueous solutions or in vapors.



References

➢D. G. Duff and A. Baker, "A New Hydrosol of Gold Clusters. 1. Formation and Particle Size Variation," Langmuir **9**, 2301 (1993).

➢S. J. Oldenburg, R. D. Averitt, S. L. Westcott, and N. J. Halas, "Nanoengineering of Optical Resonances," Chem. Phys. Lett. **288**, 243-247 (1998).

➢D. Jauregui-Vazquez et al., "Bitapered Fiber Sensor: Signal Analysis," Sensors and Actuators B **218**, 105–110 (2015).