Using High Pressure Chemical Vapor Deposition to Make Multimaterial Optical Fibers

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Abstract

Ever since its advent optical fibers have revolutionized the communication technology but apart from communication they are being used in a variety of other areas such as medical technology, sensing, laser sources in the form of fiber lasers, amplifiers, cutting and drilling, defense applications etc. Optical fibers are manufactured by drawing techniques which have largely limited the materials that can be incorporated in them. High pressure chemical vapor deposition (HPCVD) has emerged as an important technique to deposit various materials inside pre-drawn hollow optical fibers. Using this technique semiconductor optical fibers which guide light by total internal reflection and Bragg fibers which guide light by photonic bandgap formation have been fabricated.

COMSOL Multiphysics® software version 5.0 has been used to design these fibers and subsequently based on those designs the fibers have been fabricated. Semiconductor step index fibers consisting of silicon or germanium core silica cladding have been simulated using COMSOL software as shown in Figure 1. The simulation helps in understanding the light transmission and mode propagation in these fibers including obtaining design parameters required to fabricate single mode semiconductor fibers. Bragg fiber consists of a hollow core bound by concentric alternating layers of high and low refractive index materials which gives rise to a photonic bandgap that confines light in the hollow core that is transmitted with low loss. Such intricate structure makes it difficult to be fabricated by traditional drawing techniques and hence there are very few examples of such fiber. Using HPCVD technique Bragg fibers have been designed by using silicon and silica as the high and low index layers. The transmission properties of these fibers depend on the wavelength of light, thickness of the layers and the number of layers.

The COMSOL software has been used to do finite element modeling on these fibers which helps in optimizing the thicknesses of these layers and their impact on the transmission properties at different wavelengths. Figure 2 shows the light guidance at 1550 nm using the Bragg fiber. Based on the design obtained from these simulations, the Bragg fibers have been fabricated (Figure 3) which have potential applications for low optical loss delivery of high power light for surgeries, sensing, ultrafast physics etc.

Reference

1. P.J.A. Sazio , et. al. "Microstructured optical fibers as high-pressure microfluidic reactors," Science 311, 1583-1586 (2006)

2. S. Chaudhuri, et. al. “Hollow core silicon-silica Bragg fiber,” Conference on Lasers & Electro-optics (CLEO), Stu1N.5 (2015)

Figures used in the abstract

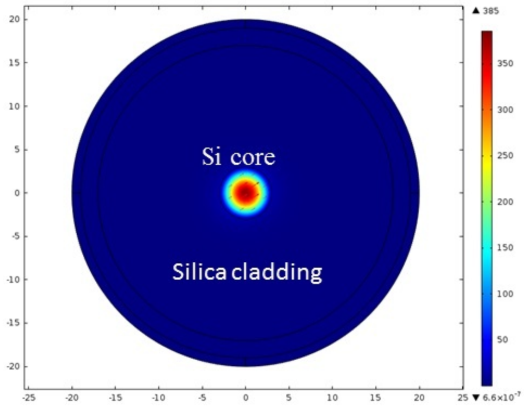

Figure 1: Simulated mode of a silicon core optical fiber at 1550 nm.

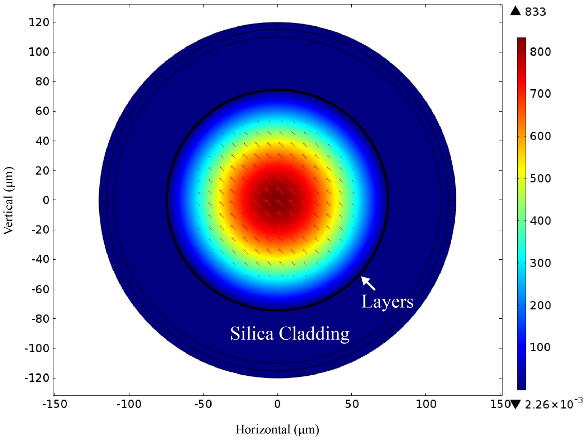

Figure 2: Simulated mode of a Bragg fiber at 1550 nm.

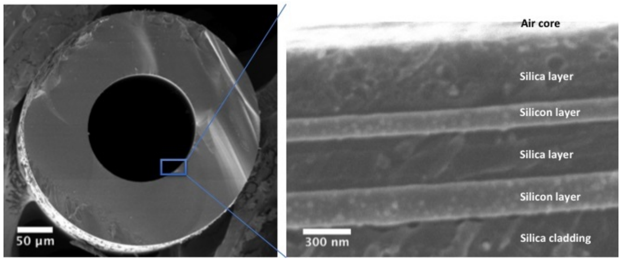

Figure 3: Scanning electron microscope image of a Bragg fiber fabricated by HPCVD.