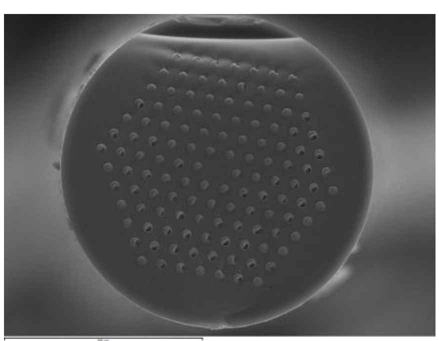
Thermo-optic Effect in Hybrid Polymer/Silica Photonic Crystal Fibers

Photonic crystal fibers, also known as microstructured or holey fibers, have recently generated great interest in the scientific community due to the new ways provided to control and guide light, not obtainable with conventional optical fibers. Proposed for the first time in 1996 from Philip Russell, photonic crystal fibers have driven an exciting and irrepressible research activity all over the world, starting in the telecommunication field and then touching metrology, spectroscopy, microscopy, astronomy, micromachining, biology and sensing. Most photonic crystal fiber has been fabricated in silica glass (other glasses and materials have also been used to obtain particular optical properties such as high optical non-linearity).

On the other hand, poly-dimethylsiloxane (PDMS) is a polymeric silicone material widely used in the area of photonics, particularly in opto/microfluidics, having unique optical properties such as transparency for a wide range of wavelength, high elasto-optic and thermo-optic coefficients, biocompatibility are some of its features. PDMS combined with its low cost and ease fabrication procedure is considered as a potential active material for tunable devices and sensing applications. Therefore, in this work, we demonstrate for the first time the combination of the aforomentioned polymeric material with a commercially available photonic crystal fiber, with aim to develop a tunable fiber device, sensitive to external pertubations such as temperature.

In the beggining, we investigated numerically with the help of Prof. K. Vlachos (Department of Computer Engineering and Informatics of University of Patras) the basic guiding properties of the hybrid PDMS/silica structure using Finite Time Difference Domain (FDTD) method. We observed that under a constant bend of the fiber, the bend-induced power loss could be recovered by simply increasing the temperature. The reason is that the high thermo-optic coefficient (i.e. change of refractive index of polymer/°C) of PDMS can act in a way to partially reconstruct the fundamental guiding mode highly attenuated by bending losses. This of course resulted to increment of the total transmitted power of the fiber. Consequently the next step was to proceed to experimental inverstigation of the proposed structured where all initial theoretical results verified. In our paper, we present experimentally a 6% recovery of the power suffering from bending attenuation for a range of temperatures up to 75°C.

We believe that the presented hybrid PDMS/silica fiber has the potential to be used for macro-bend sensing, whereas the feature of power recovery with temperature, further enhances the ability of the fiber to act as temperature-tuned device over a wide range of wavelengths. All the experiments performed in TPCI, NHRF where part of the modeling and numerical calculations in University of Patras.



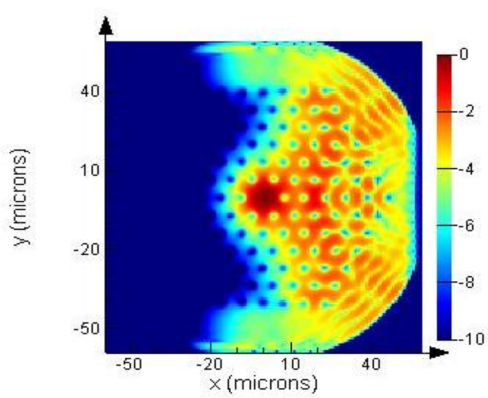


Fig.1 Hybrid PDMS/silica photonic crystal fiber (left). Hybrid Photonic crystal fiber suffering from bending attenuation: Electric field distribution of the fundamental mode (right).

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