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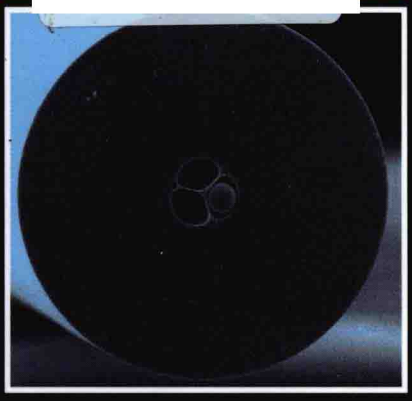

Optofluidics, Sensors and Actuators in Microstructured Optical Fibers

Edited by Stavros Pissadakis and Stefano Selleri

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Preface

The invention of the Photonic Crystal Fiber (PCF) was a cornerstone demonstration, inaugurating the field of Microstructured Optical Fibers (MOFs), where light confinement into the fiber core was departed from the traditional total internal reflection mechanism. The guiding mode confinement within a microstructured optical fiber core by employing mechanisms such as the modified total internal reflection, the antiresonant guidance, or the photonic band gap localization imparted new optical characteristics to those new fibers not being available before. Since then, several research groups spanning all over the world have directed their experimental and theoretical efforts into this rapidly growing field, illustrating new light confinement and propagation effects and exotic device designs. In addition, the hollow structure of MOFs naturally pushed the integration of fluidic functionalities into the fiber itself. Thus, numerous scientific and technical challenges have emerged since the early days of the establishment of the microstructured optical fibers field, indicatively related to the tailoring of the optical mode guiding characteristics, to the implementation of standard processing procedures (tapering, splicing, grating recording, etc.) into the MOF fashion, and to the investigation and potential exploitation of fluidic actuation into the MOFs/PCFs capillaries. During the last twenty years the field of PCFs and MOFs has been massively grown, new fiber types have been presented, and disruptive photonic devices have been demonstrated, while the new insights into the field are constantly augmented. Moreover, the technology of PCFs and MOFs has been commercialized through the deployment of broadband super-continuum sources and the development of high efficient and power fiber lasers. In parallel, the research carried out within the field of PCFs and MOFs has been largely interconnected with other photonic fields, such as those of Optofluidics, Imaging, Metrology, and Optical Sensing as well as with other nonphotonic fields such as those of Biology, Nanomaterials, and Chemistry, leading to the development of device designs with novel functionalities and/or improved performance. The last statement that there are constantly new advancements into the field of MOFs/PCFs, while attracting significant attention from both the academic and industrial photonic communities.

The book *Optofluidics, Sensors and Actuators in Microstructured Optical Fibres* reviews and updates recent advances in the vibrant field of PCF and MOF devices, focusing on fabrication methods and materials as well as related applications. The progress undergone within the field during the last few years spans beyond the pure photonic aspect, wherein new materials and processing/infiltration methods prompt the implementation of the "Lab-in-a-Fiber" protocol, where the guiding modes localized

with PCFs and MOFs are used for probing (or even inducing/catalyzing) biological, chemical, or physical actuations occurring within the MOFs/PCFs capillaries, opening new horizons for them into high socioeconomical impact application fields. In this volume there are 10 chapters authored by high caliber research groups working in the field of PCFs and MOFs photonic devices, covering the thematic aspects discussed above, while being analyzed as follows.

In Chapter 1 K. Kalli and coauthors present a mathematical model for the flow along a microchannel also accounting for heat transfer and provide numerical results for given flow and heat configurations along single or multiple microchannel fibers.

In Chapter 2 A. Argyros and coauthors explore fabrication approaches and fiber drawing methods as potential techniques for metamaterial fabrication. Specific types of drawn metamaterial with designed electric and magnetic responses are discussed in more detail with a further emphasis on hyperlenses that beat the diffraction limit.

In Chapter 3 E. Kriezis and coauthors investigate the natural possibility for infiltrating fiber capillaries with fluid materials, like liquid crystals, in order to introduce a means for dynamic control by electro-optical addressing, in the context of switching applications. In particular they present design and performance of three switching elements, namely a single-polarization switch, a complete polarization controller, and a dual-core polarization splitter.

In Chapter 4 M. Pisco and coauthors present interesting results on the layering of carbon nanotubes into the capillaries of MOFs, their corresponding waveguiding behavior, and finally their chemosensing response to organic substances and solvents.

In Chapter 5 I. Konidakis reviews recent investigations on the infiltration of silica glass PCFs with high refractive index soft glasses for developing photonic band gap guidance fibers and studying light propagation, plasmonic absorption, and glass transition effects in those.

In Chapter 6 H. Thienpont and coauthors deal with optical fiber sensors based on fiber Bragg gratings that have evolved into one of the most mature fiber sensor technologies, combining all the advantages of optical fiber sensors with excellent resistance to fatigue at high loads, thus being the most successful approach for structural health monitoring applications.

In Chapter 7 T. Wolinski and coauthors demonstrate features of photonic liquid crystal fibers used for dynamically controlled and tunable electromagnetic field sensors. Considering the fiber as a matrix of parallel waveguide channels, when optical nonlinearity is taken into account, spatial light localization and delocalization can be obtained, paving the way not only for all-optical sensing but also for switching.

In Chapter 8 G. Rajan and G.D. Peng present an overview of the recent progress in the development of polymer optical fiber Bragg grating sensors, including polymer microstructured FBGs, polymer microfiber Bragg gratings, and grating arrays. They discuss some of the recent developments in this area, such as accelerometers, fast-response humidity sensors, force, and pressure measurements.

In Chapter 9 A. Cucinotta and A. Candiani explore a novel DNA photonic-sensing approach based on peptide nucleic acids functionalized microstructured fibers. By employing Bragg gratings, the signal is monitored in reflection mode, allowing the

use of the fiber itself as a probe. The detection of DNA chains of great relevance for the medical and food industries is reported.

In Chapter 10 Hang Qu and coauthors demonstrate new designs for photonic band gap and Bragg fibers for liquid refractometry, analyze the protocols of detection, and utilize those specialty fibers for analytes sensing.

From the above presentation of the content of the chapters the academic audience of this volume can be easily drawn. This audience is thematically diverse, covering scientists from optics and photonics, optical fiber sensors, materials science, biosensing, and instrumentation; also, scientists from the industrial sector (mainly the optical fiber sensor sector) may find hybrid PCF and MOF components and fabrication methods presented herein useful for their devices under development. In addition, this book can be equally valuable for young postdoctoral researchers and doctorate and Msc students for obtaining a niche update on related technologies developed in PCFs and MOFs and being familiarized with infiltration techniques and sensing protocols.

Both editors would like to acknowledge Elsevier Publishing services for their help in organizing and editing this book, and especially Laura Pugh, Anneka Hess, Josh Bennett, Adam Hooper, and Poulouse Joseph for their continuous help. Also, a warm acknowledgment is directed to our scientific colleagues who work immensely hard at producing the high quality scientific results as presented in this book. Finally, Stavros and Stefano would like to deeply thank all of the authors who contributed their high impact scientific work into this new volume, rendering a final result of the highest quality possible.

Stavros Pissadakis and Stefano Selleri