Journal of Sensors
Volume 2009 (2009), Article ID 524237, 20 pages
doi:10.1155/2009/524237

Review Article

Microstructured and Photonic Bandgap Fibers for Applications in the Resonant Bio- and Chemical Sensors

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Received 3 March 2009; Accepted 2 June 2009

Academic Editor: Christos Riziotis

Abstract

We review application of microstructured and photonic bandgap fibers for designing resonant optical sensors of changes in the value of analyte refractive index. This research subject has recently invoked much attention due to development of novel fiber types, as well as due to development of techniques for the activation of fiber microstructure with functional materials. Particularly, we consider two sensors types. The first sensor type employs hollow core photonic bandgap fibers where core guided mode is confined in the analyte filled core through resonant effect in the surrounding periodic reflector. The second sensor type employs metalized microstructured or photonic bandgap waveguides and fibers, where core guided mode is phase matched with a plasmon propagating at the fiber/analyte interface. In resonant sensors one typically employs fibers with strongly nonuniform spectral transmission characteristics that are sensitive to changes in the real part of the analyte refractive index. Moreover, if narrow absorption lines are present in the analyte transmission spectrum, due to Kramers-Kronig relation this will also result in strong variation in the real part of the refractive index in the vicinity of an absorption line. Therefore, resonant sensors allow detection of minute changes both in the real part of the analyte refractive index ($10^{-6}-10^{-4}$ RIU), as well as in the imaginary part of the analyte refractive index in the vicinity of absorption lines. In the following we detail various resonant sensor implementations, modes of operation, as well as analysis of sensitivities for some of the common transduction mechanisms for bio- and chemical sensing applications. Sensor designs considered in this review span spectral operation regions from the visible to terahertz.