A selectively coated photonic crystal fiber based surface plasmon resonance sensor

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Abstract

We propose a novel design for a photonic crystal fiber based surface plasmonic resonance sensor. The sensor consists of selectively metal-coated air holes containing analyte channels, which enhance the phase matching between the plasmonic mode and the core-guided mode. Good refractive index sensitivity as high as 5500 nm/RIU (refractive index unit) can be achieved in the proposed structure. Compared with the entirely coated structure, the selectively coated sensor design demonstrates narrower resonance spectral width. Moreover, the greater resonance depth can improve the sensing performance in terms of signal to noise ratio (SNR). The improvements in spectral width and SNR can both contribute to a better detection limit for this refractive index sensor.

Keywords: photonic crystal fiber, surface plasmon, refractive index sensor

(Some figures in this article are in colour only in the electronic version)

1. Introduction

While optical fibers present an attractive platform for sensing, the use of conventional fiber requires the removal, physically or chemically, of cladding in order to achieve close proximity of the measurand to the fiber core, thereby compromising device reliability. In recent years, the boosting development of a new type of photonic crystal fiber (PCF) with an array of air holes along the propagation direction has attracted immense research interest worldwide [1]. There is a growing interest in exploring PCFs for use as advanced sensor devices by infiltrating the air hole with different materials [2], such as gas, liquid and polymers. The degree of freedom in the waveguide design is greatly enhanced compared with that for conventional fibers for specific applications [3]. Surface plasmon resonance (SPR), characterized by its high sensitivity to variations in the refractive index of the surrounding dielectric, has been implemented in numerous sensing structures, from the classical prism configuration [4] to waveguide based structures, from planar metallic layers [5] to metallic coating around fibers [6].

The combination of photonics and plasmonics is an emerging research area that will benefit from improvements in coating technology and also attract growing interest in the PCF community. Kuhlmeier et al [7] have provided a theoretical model for metal-coated PCFs and showed that they exhibit plasmonic resonances. Recently, Hautakorpi et al [8] proposed a three-hole PCF based SPR sensor. These structures offered higher integrity by ingeniously combining analyte, surface plasmons and optical fiber. Hassani and Skorobogatyi [9, 10] analyzed in detail design principles for two different PCF structures with metallic coating for biosensing applications.