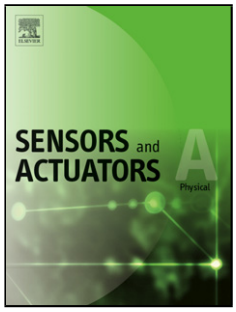

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A Review for Optical Sensors Based on Photonic Crystal Cavities

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Abstract: This review covers photonic crystal cavities (PCCs) and their applications in optical sensors, with a particular focus on the structures of different PCCs. For each kind of optical sensor, the specific measurement principle, structure of PCC, and the corresponding sensing properties are all presented in detail. The summary of the reported works and the corresponding results demonstrate that it is possible to realize miniature and high-sensitive optical sensors due to the ultra-compact size, excellent resonant properties, and flexibility in structural design of PCCs. Finally, the key problems and new directions of PCCs for sensing applications are discussed.

Keywords: Photonic crystal cavity (PCC); optical sensor; high sensitivity; miniature sensor.

1. Introduction

Since E. Yablonovitch and S. John first proposed the concept of photonic crystal (PC) in 1987 [1, 2], PC, which possesses a periodic dielectric structure and the capability of guiding and manipulating light at the scale of optical wavelength, has been studied extensively both in theory and experiment [3, 4]. One of the basic properties of PC is the photonic band gap (PBG), and the propagation of light within the frequency range of PBG will be forbidden [5]. Nevertheless, the periodicity of this dielectric structure will be broken when some defects are introduced in PC, which makes it possible for PC to present strong electromagnetic field confinement, small mode volume, and low extinction loss [6]. On the other hand, by adjusting the structural parameters of PC or infiltrating suitable materials in the air holes of PC, the propagation of light can be modified and engineered at will. Therefore, many PC based devices have been widely used in the applications of light flow control, such as filters [7, 8], electro-optical modulators [9, 10], switches [11, 12], and delay devices [13]. Specially, PC based sensors seem to be much more popular due to their promising characteristics like ultra-compact size, high measurement sensitivity, flexibility in structural design, and more suitable for monolithic integration [14-16]. Besides, the PC based sensors can also inherit the favorable characteristics of optical sensors, such as safety in flammable explosive environment, immunity to electromagnetic interference, long-distance monitoring, and rapid response speed. Therefore, during the last decades, many excellent optical sensors based on PC have been investigated and developed in a large range of sensing applications, such as gas sensors [17-19], liquid sensors [20], temperature sensors [21], stress sensors [22], refractive index (RI) sensors [23, 24], humidity sensors [25-26], and biochemical sensors [16, 27].