Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Grating Based Photonic Crystal Optical Sensor for Underwater Application

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Photonic crystal based sensor is highly sensitive because of its periodic nano structure properties affecting the motion of photon in the path of small defect. Grating based photonic crystal sensor is one dimensional photonic crystal. In the proposed work one dimensional photonic crystal based sensing structure is proposed. Sensing structure is based on concept of grating with different dielectric constant layer deposited in one direction of photonic crystal sensing layer. In the proposed work two configuration of photonic crystal is considered i.e. rod in air configuration and holes in slab configuration. Structure is developed in FDTD tool. Investigation has been conducted for different temperature of underwater with varying salinity percentage. Sensitivity and Quality factor of sensing layer has been evaluated for different sensing cases. Proposed sensor having tremendous application in sea water analysis.

Keywords: R Fiber Bragg Grating, Photonic Crystal, Temperature sensors, Underwater.

1. Introduction

Light has found applications in data transmission, such as optical fibers and waveguides and in optoelectronics. It consists of a series of electromagnetic waves, with particle behavior. Photonics involves the proper use of light as a tool for the benefit of humans. It is derived from the root word "photon", which connotes the tiniest entity of light analogous to an electron in electricity. Photonics have a broad range of scientific and technological applications that are practically limitless and include medical diagnostics, organic synthesis, communications and information technology, advanced manufacturing, defense, health, medicine, and energy. Photonic crystals (PCs) of periodic structures are a new class of artificial materials that allow one to manipulate the flow of light. These photonic crystals lead to the formation of Photonic band gaps (PBGs), in which propagation of electromagnetic waves of certain wavelengths is prohibited in them in their transmission spectra. Photonic crystals are macroscopic media which arranged periodically with different are in the range of the incident light. In such structures the permittivity is a periodic function in space. In this case, the dielectric permittivity function repeats itself in one dimension the structure repeats itself in one dimension the structures called one dimensional photonic crystal, if repeats itself in 2D or 3D the structure called 2D or 3D PC. One-dimension photonic crystals have been widely used in silicon photonics due to its simple structure and multiple working regimes: diffraction, Bragg reflection, and subwavelength lithography, many 1D photonic crystal-assisted silicon integrated devices have been proposed and demonstrated to further increase integration density and improve device performance. Over the past decades, various functional PhC devices that are crucial for constructing versatile nano-photonic chips and replacing electronic integrated circuits had been proposed and demonstrated. Among the numerous functions, optical sensing via PhC waveguides and cavities is interesting and practical to our daily lives. This is typically achieved by measuring and analyzing the change of tailored optical fields within well-designed PhC nanostructures caused by perturbations of interest.

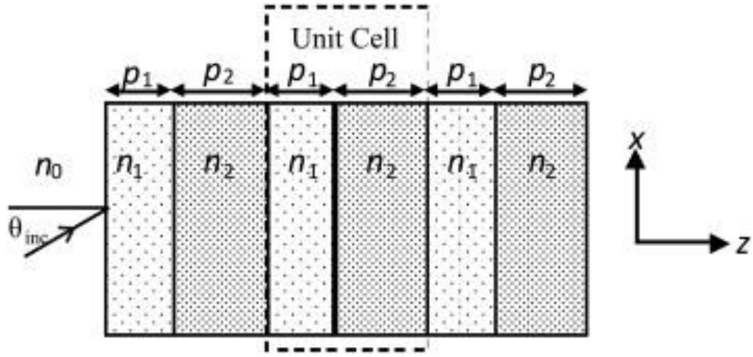

Figure 1. One dimensional photonic crystal

2. Methodology and Principle of operation

One dimensional photonic crystal is designed opens source software with FDTD tool called MEEP. With lattice dimension of 1 micrometer and radius of rods and holes are 0.18 micrometer is maintained. Gaussian light wave is enabled to pass in the one-dimension defect created with code. One dimensional photonic crystal is fibre bragg grating. Its works of on the basis of FDTD wave propagation process. As the refractive index of medium changes monitor will bring out the wavelength shift there by acts as sensor.

3. Results and Discussion

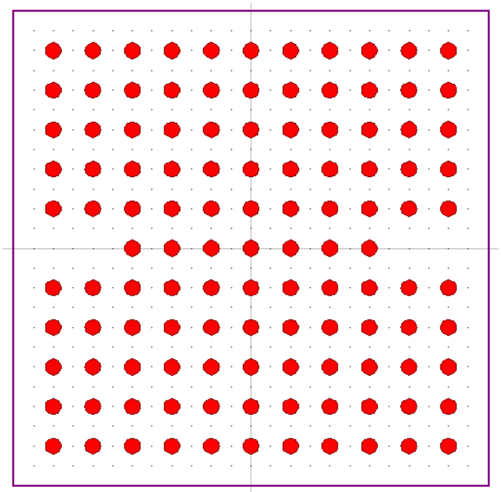

Figure 1: Rod in Air Configuration

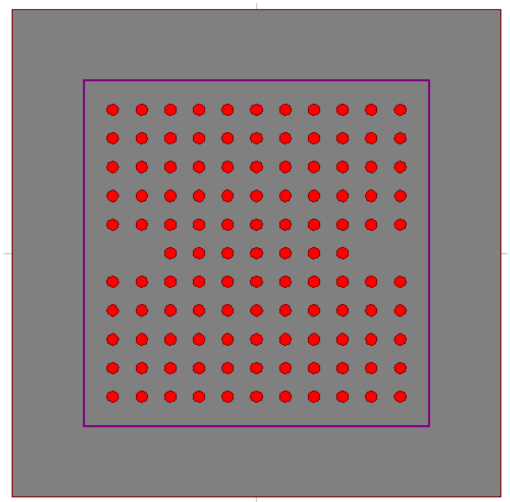

Figure 2: Holes in slab configuration

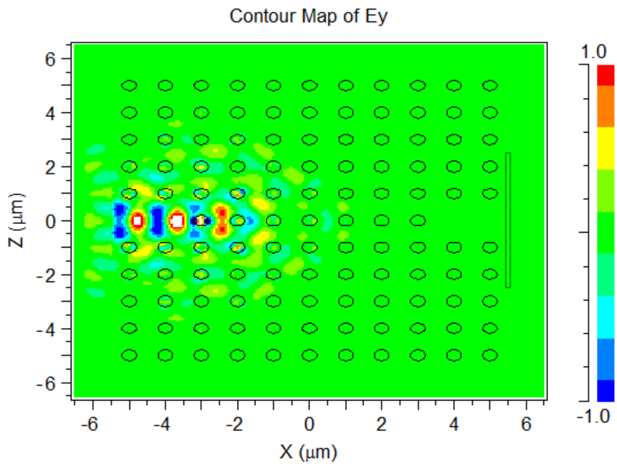

Figure 3. Light propagation in photonic crystal

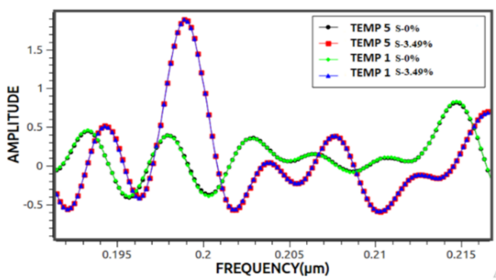

Figure 4. Holes in Slab with respect to variation of temperature

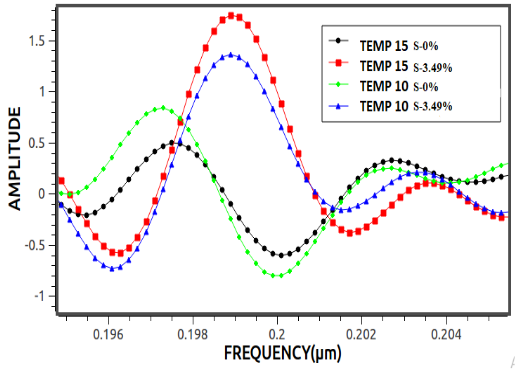

Figure 5. Holes in Slab with respect to variation of temperature

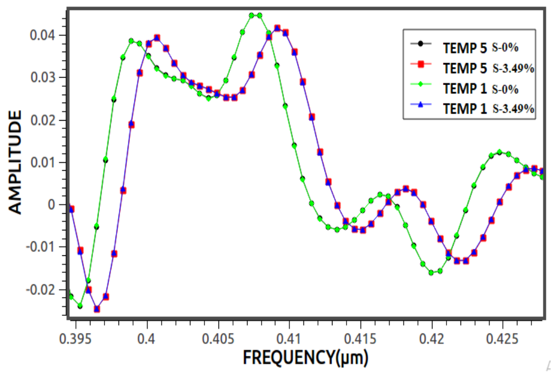

Figure 6. Rod in air configuration with respect to variation of temperature

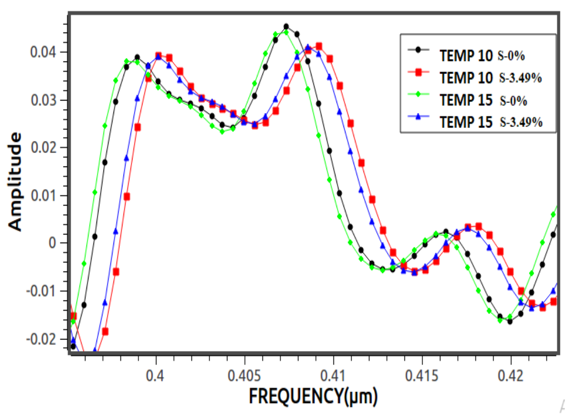

Figure 7. Rod in air configuration with respect to variation of temperature

Figure 1 to Figure 3 shows photonic crystal rod in air and holes in slab configuration with light propagation in photonic crystal configuration. Figure 4 to Figure 7 shows shift in wavelength for change in temperature and salinity percentage For each change in salinity and change in temperature will brings out the change in refractive index of the medium. Since there is change in refractive index of medium will brings out the wavelength shift. Simulation is carried for both rod in air configuration and holes in slab configuration. Quality factor and sensitivity of grating based one dimensional photonic crystal is analysed. It has been found from the result that quality factor obtained in rod in air configuration was higher about 3434 compare to quality factor obtained 2342 for holes in slab configuration, since it decides the confinement of light throughout the slab and air in photonic crystal configurations. Sensitivity of 4.65nm/RIU is obtained for rod in air configuration.

4. Conclusion

Sensor is proposed and designed based one dimensional photonic crystal i.e on the principle of fibre bragg grating for salinity and temperature measurement of underwater. Shift in wavelength is obtained for each change in temperature and water salinity. High q factor of 3434 is obtained for rod in air configuration and sensitivity obtained was 4.65nm/RIU. Proposed sensor having tremendous application in underwater monitoring.

Acknowledgement

Author wish to thank all researcher and staff for guiding in the development of this research paper with good technical input and suggestions.

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