Indium Arsenide-Based High-Sensitivity Pressure Sensor with a 2D Photonic Crystal Waveguide Coupled to Two Microcavities

Tarek ZOUACHE*, Abdesselam HOCINI

LAAS Laboratory, Dept. Electronic. M'sila University, M'Sila, Algeria

*Corresponding author's e-mail: tarek.zouache@univ-msila.dz

ABSTRACT

In this work, a hydrostatic pressure sensor based on two microcavities coupled to a photonic crystals waveguide is presented. The pressure sensing part is formed by a double asymmetrical microcavities made in the slab of the sensor, with the aim of creating a sharp resonant output spectral response. These defects introduce a pressure detection mechanism based on the change of the Indium arsenide semiconductor (InAs) slab refractive index when an applied pressure on his active surface changes and this refractive index change leads a shift of the response resonant wavelength. The proposed structure provides very distinguishing resonance peaks with good quality factor of 210^3 for the considered pressure range, and a pressure sensitivity reaching 26.1 nm/GPa. In addition, our proposed design ensures an impeccable linear relationship between the resonance wavelength and the corresponding applied pressure, which offer a highly selective pressure detection.

Keywords: Indium Arsenide Photonic crystal, pressure sensor, pressure sensitivity.

1 Introduction

The stacking of layers of different dielectric materials while respecting a certain spatial periodicity (generally denoted **a**) of their thicknesses gives rise to very interesting structures called photonic crystals. These structures give rise to a photonic gap (PBG) with a width depending on several parameters, among others, the materials relative permitivity, and also, their geometric parameters [1]. It has demonstrated that these structures offer a good platform for the realization of pressure sensors through the exploitation of the property that the refractive index (RI) of the slab material changes when hydrostatic pressure is applied to its active surface [2], [3]. The optical properties of the sensor are studied using both the two numerical methods: the finite-difference time-domain (FDTD) algorithm and the plane wave expansion (PWE).

2 Methodology

The behaviour of the refractive index of InAs as a function of pressure is given in the references [4]. From these references and by performing a first order polynomial interpolation of the data from, we obtained the following relation (1).

$$n = -0.062 \times P + 3.858 \qquad (1)$$

The sensitivity to pressure Sp (nm/GPa) is a very important factor to be considered because it can indicate the quality of any sensor designed. From the field literature, SP calculated using the relation (2) [5]

$$S_P = \frac{\Delta\lambda}{\Delta n} \times \frac{\Delta n}{\Delta P} \quad \text{(nm/GPa)} \qquad (2)$$

Where, $S_{RI} = \frac{\Delta\lambda}{\Delta n}$ (nm /RIU) is the refractive index sensitivity.

DOI: 10.21467/abstracts.163 ISBN: 978-81-965621-5-1 (eBook)

3 Results and Discussion

Our proposed structure is given in the Figure (1). The radius of the defective holes Rc is taken equal to 0.4r. The response of the sensor excited by different pressures is shown in Figure (2).

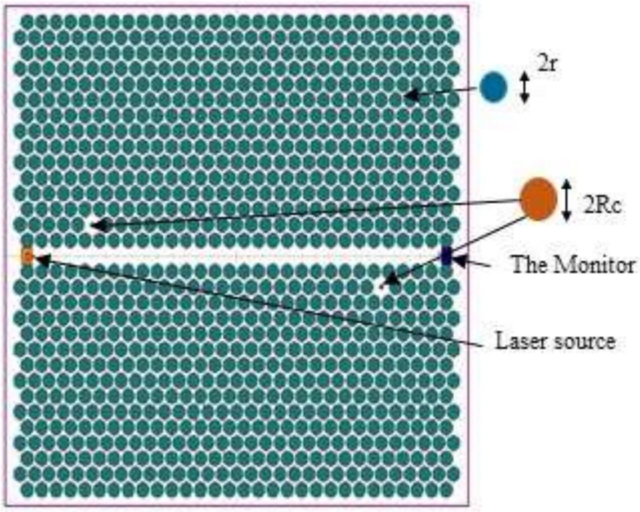

Figure 1: *Structure of Phc pressure sensor with holes radius r and points defects radius Rc*

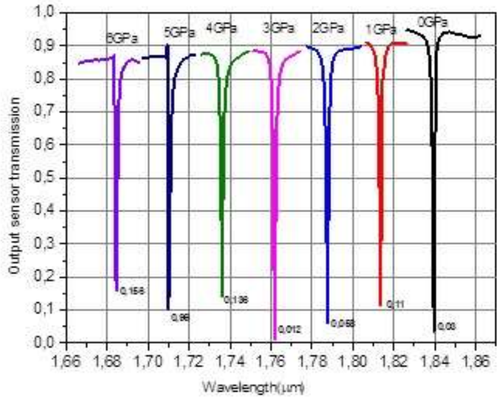

Figure 2: *Sensor response for various pressures P*

The sensitivities achieved by our proposed design are 421 nm/URI for refractive index changes and 26.1 nm/GPa for pressure. Also, these values remain high and almost constant for the pressure range between 0 and 6GPa. For the Quality factor, this latter reached very competitive values of 2015 near to 1GPa and remains up to 1600 for all the pressures considered, which represents very good results for all our measurements.

4 Conclusion

In this work, the proposed structure reaches a refractive index and a pressure sensitivity of 421 nm/URI 26.1nm/GPa near 5GPa respectively and a quality factor Q reaching 2015 near 1GPa and stay up to 1600 for the other pressure.

5 Competing Interests

The authors declared that no conflict of interest exists in this work.

How to Cite

T. ZOUACHE and A. HOCINI, "Indium Arsenide-Based High-Sensitivity Pressure Sensor with a 2D Photonic Crystal Waveguide Coupled to Two Microcavities", *AIJR Abstracts*, pp. 57–58, Feb. 2024.

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ISBN: 978-81-965621-5-1

Series: AIJR Abstracts

DOI: 10.21467/abstracts.163