DEMONSTRATION OF TWO DESIGN TRATEGIES FOR HIGHLY SENSITIVE INTEGRATED PHOTONIC TRANSDUCERS FOR SiO_2:TiO_2 SOL-GEL DERIVED WAVEGUIDE FILMS

Andrzej Kaźmierczak, Ryszard Piramidowicz, Muhammad Ali Butt

Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, Ul. Koszykowa 75, 00-662 Warsaw, Poland
e-mail: Andrzej.Kazmierczak@pw.edu.pl

For two last decades one can observe an intensive development of integrated photonics sensors. These sensors have been investigated in numerous research centers all over the world. This type of sensors is beneficial due to its compactness, high sensitivity, possible operation with minimal volumes of sample and reagents and possibility of constructing multiparameter devices. A typical strategy for developing such sensors is construction of the evanescent wave photonic transducer. The operation of such transducer exploits the fact that the guided mode is not fully confined within the integrated photonic structures basing on semiconductor or insulating waveguide films. Consequently some fraction of the guided mode energy is guided outside the structure and therefore its propagation depends on ambient conditions. When the device is intended for sensing the ambient influence effect is enhanced by using the resonant structure. When properly designed and appropriately functionalized such transducer in order to detect the presence of a given material (e.g. substance or antibody).

One of fundamental requirements to be met by the integrated photonics sensors is simplicity and low cost of their fabrication. This is especially important in the view of typical single-use modus operandi of such sensors. The SiO_2:TiO_2 sol-gel derived waveguide films technology developed by the group of prof. Karasiński from Silesian University of Technology evanescent wave transducer Technology [1]. This technology is developed further in the aiming on the efficient and low-cost fabrication of integrated photonic structures.

In this work we analyze two design strategies for integrated photonic sensors construction for the mentioned technology basing on optical ring resonators (Fig. 1.a) and photonic crystal cavities (Fig. 1.b). In both cases the influence of devices layout and material properties of waveguide film is investigated numerically in order to define most profitable devices configurations.

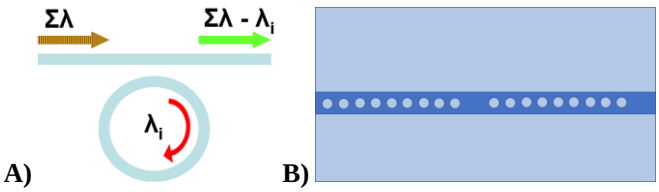

Fig 1.Schematic representation of the ring resonator (a) and photonic crystal (b) sensors.

The optical ring resonator bases on two evanescently coupled waveguides: the closed loop waveguide where the whispering gallery mode is formed and evanescently coupled straight bus waveguide aimed for optical signal introducing into the structure. In this work a set of parameters were investigated in order to find the structure, most sensitive for the ambient refractive index variations. The conducted simulations showed that in the case of ring resonator sensors with the waveguide core refractive index of 1.8, waveguide cross section (width × height) of 800 nm × 200 nm and a ring resonator radius of 12 μm the sensitivity (defined as a quotient between the shift of resonant wavelength and the shift of the ambient refractive index) reached the value of 82 nm/RIU.

The alternative structure of integrated photonic sensor that has been investigated is a photonic crystal cavity. It is formed on the base of simple band-stop photonic filter with some defect (missing hole) in the photonic structure forming the photonic cavity and supporting an optical transmission for a given resonant wavelength within the stop-band. In the case of such transducer the sensitivities ranging from 75 nm/RIU to 175 nm/RIU can be obtained.

[1] Karasiński P., Kaźmierczak A., Zięba M., Tyszkiewicz C., Wojtasik K., …, Highly Sensitive Sensor Structure Based on Sol-Gel Waveguide Films and Grating Couplers, Electronics 10 (2021), 1389

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