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Optical field enhancement factor of Silicon and indium phosphide nano-cavities

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ABSTRACT: Nano cavities based on silicon and indium phosphide materials have been compared in this study, considering field intensity enhancement factor. The results of FDTD based simulations declare that the Si nano-cavity improves confined optical field about 7.7 times higher than the InP based nano-cavity. The introduced dielectric nano-cavities support resonance wavelength at about λ=1.55 μm.

Keywords: *Enhancement factor, FDTD, Nano cavity, Photonic crystal.*

INTRODUCTION

The importance of designing all optical systems requires applying basic structures. The optical nano cavities, specially the photonic crystal based nano cavities help to reach this goal in study and practice. Dielectric nano cavities play important role in different fields of optics and photonics and have been utilized in various forms in diverse optical integrated circuits and systems [1-4].

In recent decades, the researchers have designed (simulation and construction) different types of optical cavities to improve their optical properties applicable in wide range of applications [5-6]. One of the most important devices can be designed by introducing PC nano cavities are optical sources and lasers. In this study we compare the efficiency of silicon based and Indium phosphide based nano cavities considering optical field intensity enhancement factor. Mesh grids have been carefully selected in order to cover nanometer size spaces.

RESULTS AND DISCUSION

Photonic crystal nano-cavities based on silicon material and Indium phosphide material have been designed and simulated utilizing finite difference time domain (FDTD) based simulation method. In addition to owning different dielectric substrate, the structural parameters of nano cavities i.e., the radius of the air holes and the center to center distances between air holes (lattice constant) in core and cladding sections are also differ-

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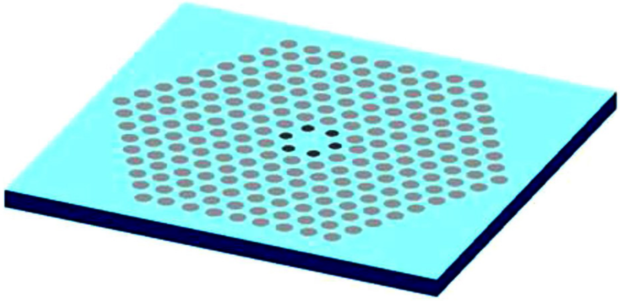

Fig. 1. Schematic of the structure of nano cavities.

ent. Fig. 1 shows the structure of studied resonator nano-cavities. The resonators are formed in H-type photonic crystals.

The geometrical parameters of the Si-based PC nano cavity are as follows: Core air hole radius = 75 nm, cladding air hole radius = 144 nm, core lattice constant = 426 nm, cladding lattice constant = 440 nm. These parameters are defined for InP-based nano cavity as follow: Core air hole radius = 100 nm, cladding air hole radius = 100 nm, core lattice constant = 550 nm, cladding lattice constant = 440 nm. To calculate the enhancement factor of the nano cavities, the structures are simulated utilizing 3D-FDTD based numerical calculations applying proper boundary condition of perfectly matched layer (PML). The input source is electrical dipole that is polarized in x-polarization and is applied to the structures located within the structures.

Benefitting 3D monitors placing on the surface part of the nano cavities, we obtain the improved optical fields produced by the cavities. Si nano cavity improves optical field about 2.3×103 times regarding the exciting field and InP nano cavity enhances the input field about 300 times. The field profiles are illustrated in Fig. 2. Clearly, Si-based PC nano cavity amplifies light stronger than the InP-based one by the factor of about 7.7.

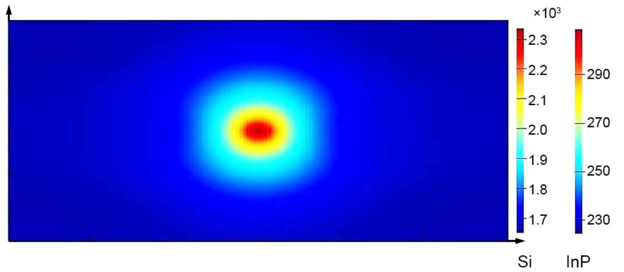

Fig. 2. Enhanced optical field profiles of Si and InP nano cavities

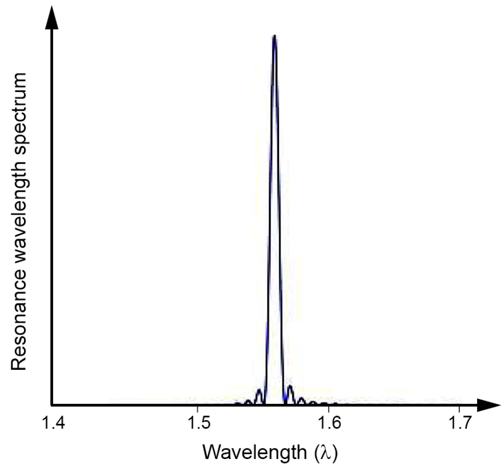

Fig. 3. Resonance wavelength spectrum of Si nano cavity

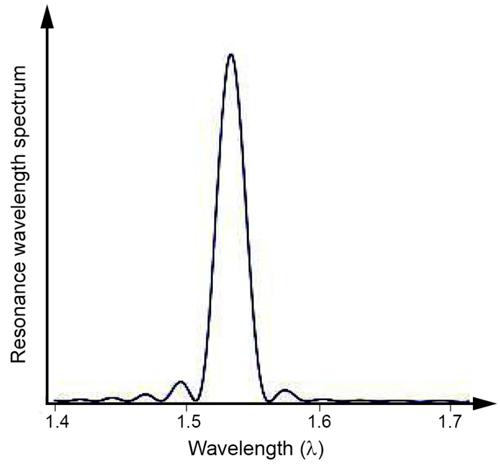

Fig. 4. Resonance wavelength spectrum of InP nano cavity

Since, the performance of the structures are comparable when the devices resonate at the same resonance wavelengths, we plot resonance spectrum of the cavities illustrated in Figs. 3 and 4. Introduced nano cavities enhance the incident optical field at the resonance wavelength of about λ = 1.55 µm, more precisely, λSi = 1558 nm and λInP = 1533 nm.

CONCLUSIONS

The optical filed intensity improvement factor was studied in this paper. For introduced nano cavities of Si and InP, simulation results demonstrate that the Si-based nano cavity amplifies more the incident light. Respecting this fact it is very important to select the suitable nano cavity for different types of applications and systems.

REFERENCES

[1] Kohei, A., Makoto, O. and Minoru, O. (2017). Ultrahigh-Q Photonic Crystal Nanocavities Fabricated by CMOS Process Technologies. Optics Express, 25(15), 18165–18174.

[2] Takashi, A. and Susumu, N. (2018). Optimization of Photonic Crystal Nanocavities Based on Deep Learning. Optics Express, 26(25), 32704-32717.

[3] Takashi, A., Bang, S. and Susumu, N. (2006). Analysis of the Experimental Q factor (1 million) of Photonic Crystal Nanocavities. Optics Express, 14(5), 1996-2202.

[4] Yasutomo, O., Feng, L., Ryota, K., Katsuyuki, W., Katsunori, W., Yasuhiko, A. and Satoshi, I. (2018). Photonic Crystal Nanocavity Based on a Topological Corner State. Optica, 6(6), 786-789.

[5] Ebadi, N., Yadipour, R. and Baghban, H. (2017). High Intensity Gap Light Coupling of Nanoantenna to High Purcell Factor Photonic Crystal Nanocavity. J. Optoelectronics and Advanced Materials, 19(7), 454-459.

[6] Ebadi, N., Yadipour, R. and Baghban, H. (2018). Ultrahuge Light Intensity in the Gap Region of a Bowtie Nanoantenna Coupled to Low-Mode-Volume Photonic Crystal Nanocavity. Current Optics and Photonics, 2(1), 85-89.

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