Enhancement and reproducibility of high quality factor, one-dimensional photonic crystal/photonic wire (1D PhC/PhW) microcavities

ABSTRACT

Background: The production of compact and multi-functional photonic devices has become a topic of major research activity in recent years. Devices have emerged that can be used for functional requirements in high speed optical data processing, filtering, nonlinear optical functions such as all-optical switching - and many other applications. The combination of photonic crystal (PhC) structures consisting of a single row of holes embedded in a narrow photonic wire (PhW) waveguide realised in high index-contrast materials is a possible contender for provision of a range of compact devices on a single chip. This trend has been motivated by the availability of a silicon technology that can support monolithic integration to form fully functional devices on CMOS chips. Results: We have successfully demonstrated experimentally an enhancement of the quality factor of a one-dimensional (1D) photonic crystal/photonic wire (PhC/PhW) microcavity that can exhibit resonance quality factor (Q-factor) values as high as 800,000 - together with a low modal volume of approximately 0.5 $(\lambda/n)^3$. These results are based on the use of a mode matching approach previously used for device design - through the engineering of tapered hole sections within and outside the cavity - and were achieved without removing the silica cladding layer below the silicon waveguide core. The simulation results obtained in this case also agree with the experimental results obtained. Conclusions: In this work we have demonstrated that the mode matching, as light enters the photonic crystal structure, can be further enhanced through the use of careful fine tuning of the third hole, t_3 of the tapered hole region outside the cavity. The Q-factor value obtained was approximately four times greater than that achieved in our previous work on a similar structure.

Keyword: Photonic crystal; Nanophotonic; Integrated optics