Nano-scale intra-cavity defects in photonic crystal microcavity filter for enhancing transmission

A. S. Jugessur

University of Iowa Microfabrication Facility
Optical Science and Technology Center, University of Iowa 52242 USA
aju-jugessur@uiowa.edu

Abstract: One- or two-dimensional photonic crystal (PhC) microcavity filters have been widely investigated for over a decade. The functionality of these devices can be tailored to suit any specific application such as an optical filter, sensor or optical data storage. However, the coupling of light into these miniature devices results in optical losses. In this work, 60-90 nm sized features within the microcavity of the PhC microcavity filters are fabricated on GaAs/AlGaAs epitaxial substrate using Electron Beam Lithography and Reactive Ion Etching. An increase in optical transmission by a factor of 2.5 is obtained by the addition of the nano-scale defects.

There have been numerous reports[1-3] on one- (1-D) or two-dimensional (2-D) photonic crystal (PhC) microcavity filters over the last several years. The functionality of these devices can be tailored to suit any specific application such as optical filters[2,4], sensors[5,6] and optical memory[7]. In particular, 1-D PhC microcavity filters are promising candidates for a wide range of applications. Nevertheless, the coupling of light into these miniature devices still poses a technical challenge, especially, when light transits the waveguide region to the photonic crystal structures and vice versa. Large reflection, coupling and scattering losses are common at these transition zones. Appropriate features need to be added in those regions in order to provide a gradual modal conversion. In previous reports, by the same author, a mode-matching technique has been demonstrated in 1-D PhC microcavity filters[4] outside the cavity region. In this work, nano-scale defects are designed and added within the cavity that demonstrates an enhancement in optical transmission. Unlike previous reports[4], the added features do not have the same periodicity as the PhC holes in the mirror section. The size and period of the mode-matching holes have been designed and optimized to obtain a higher transmission at the selected second resonance peak. The computation spectrum of the 1D PhC filter without intra-cavity defects is shown in Figure 1. Figure 2 shows a schematic of the device design with the intra-cavity holes. Figure 3 shows the fabricated device using Electron Beam Lithography and Reactive ion etching, where a proximity correction tool has been used for the exposure of the structure. The addition of nano-scale defects such as holes within the cavity region results in an optical transmission enhancement by a factor of 2.5, as demonstrated in the experimental spectrum in Figure 4.

[1] R. M. De La Rue and C. Seassal, Laser Photonics, **Rev. 6 No. 4**, 564-587 (2012)
[2] A. S. Jugessur, P. Pottier and R. M. De La Rue, Optics Express, **12**, 1304-1312 (2004)
[3] P. B. Deotare, L. C. Kogos, I. Bulu and M. Loncar, IEEE Journ. Of Selected Topics in Quantum Electronics, **19**, 3600210 (2013)
[4] A. S. Jugessur, P. Pottier and R. M. De La Rue, Electronics Letters, **39**, 367-369 (2003)

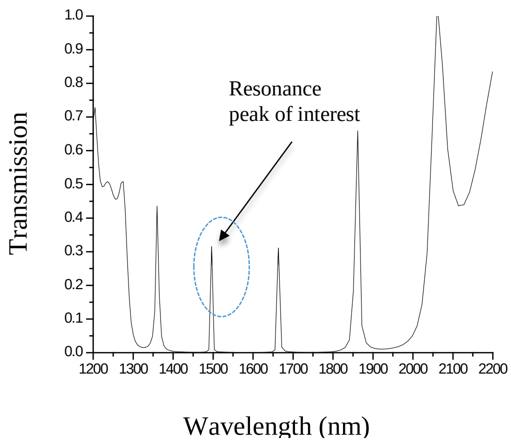

Figure 1. Computed wavelength (2-D FDTD) spectrum of the 1-D PhC microcavity filter without nano-scale defects within the cavity.

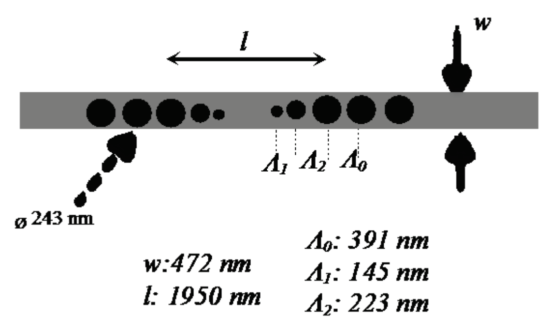

Figure 2. Schematic of the 1-D PhC microcavity filter with nano-scale defects within the cavity.

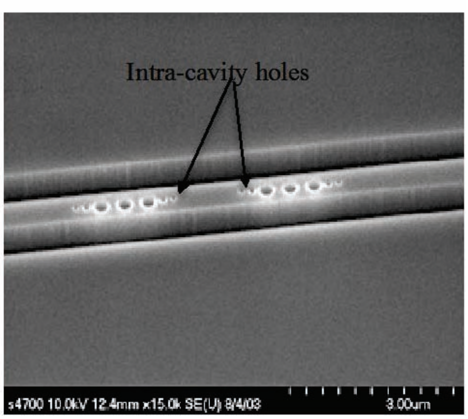

Figure 3. A scanning electron micrograph of the fabricated 1-D PhC microcavity filter with nano-scale defects within the cavity and outside the cavity region.

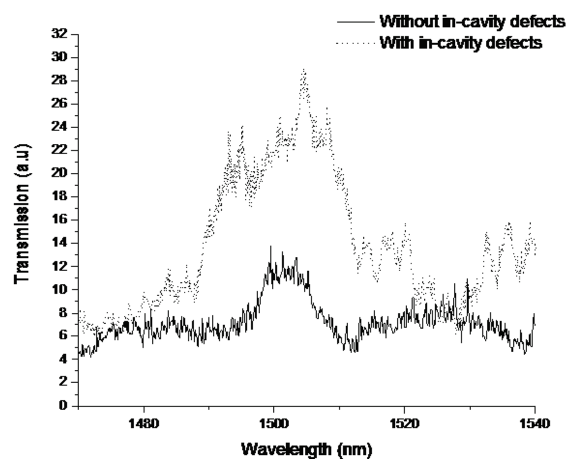

Figure 4. Experimental wavelength spectrum of the 1-D PhC microcavity filter with and without nano-scale defects within cavity.