

# Modes splitting phenomenon in dual row defects nanophotonic waveguide

E. H. Khoo<sup>1</sup>, A. Q. Liu<sup>1†</sup>, J. Li<sup>2</sup> and D. Pinjala<sup>2</sup>

<sup>1</sup>School of Electrical and Electronic Engineering,  
Nanyang Technological University, Nanyang Avenue, Singapore 639798  
<sup>2</sup>Institute of Microelectronics

Singapore 11, Science Park Road, Science Park II, Singapore 117685

<sup>†</sup>Corresponding author: eaqliu@ntu.edu.sg, Tel: (65) 6790-4336 Fax: (65) 6792-0415

Degenerated modes exist when there are more than one possible mode field distributions for a particular frequency. A good example is the present of dipole field distribution<sup>1</sup> for photonic crystal (PC) cavity. The surface of PC structure also allows the formation of degenerated mode by considering the case of two semi-infinite lattices as shown in Fig. 1. The dual surface allows present of two doubly degenerated modes. Fig. 2 shows the field patterns for the modes, showing the odd and even symmetries. At far distance from, the mode fields on both perturbed PC surface do not interact and there are two clear possible field patterns, forming doubly degenerated mode in the bandgap. But at sub-wavelength proximity of the surface field results in strong optical near field interaction, causing the doubly degenerated modes to split as shown in Fig. 3. Thus phenomenon is analogous to the case of energy level splitting in atomic configuration due to the influent of external field<sup>2</sup>. The splitting of modes results in red-blue shift of the mode frequency in the bandgap shown in Fig. 4. Potential applications of this phenomenon include band pass filter, mode-frequency convertor as well as nonlinear PC properties investigation.

[1] P. R. Villeneuve et al, "Microcavities In Photonic crystals: Mode Symmetry, Tunability and Coupling Efficiency," *PRB*, **54**, 7837 (1996).

[2] U. Reossler, "Solid State Theory: an introduction," Springer (2004)

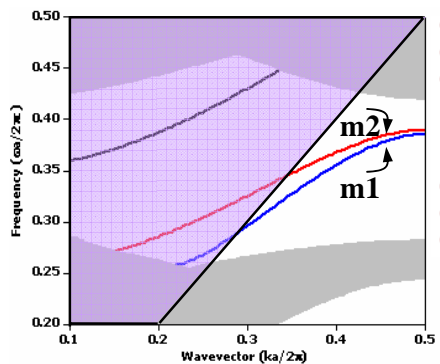


Fig. 1: Schematic layout of the dual side PC surface and band structure

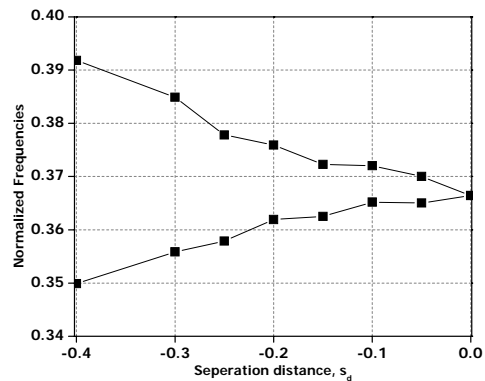


Fig. 3: Graph showing the mode splitting as the distance between surfaces reduce

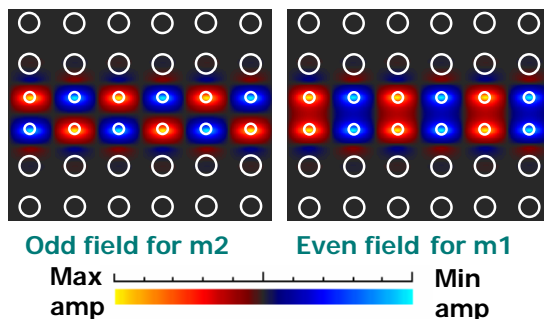
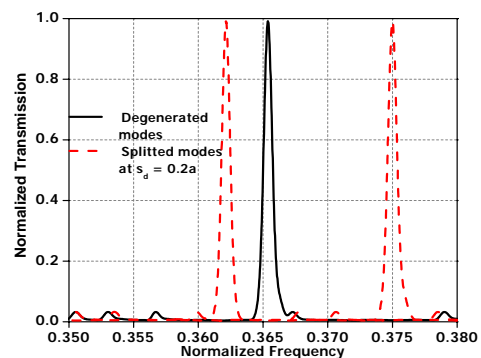


Fig. 2: Field distribution of the doubly degenerated modes



Transmission spectrum showing the frequency conversion