

Guided Resonance in 2D Photonic Crystal with Lower Refractive Index Contrast

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Guided resonance (GR) in photonic crystal (PhC)s[1] is very attractive for advanced vertical cavity surface emitting lasers (VCSELs), for instance, with hybrid cavity of a PhC structure with a DBR mirror[2]. In this type of lasers, an air bridge structure is generally used because high reflection GR in a simple PhC requires a high index contrast. In addition, broadening of GR reflection band is also required for practical use. But, it has so far been difficult to obtain high and broad reflection GR in low refractive index contrast ($\Delta n < 10\%$) systems.

To overcome this issue, we successfully designed the novel 2D PhCs satisfying the following two conditions: retaining the high effective index for the resonant mode in the PhC and decreasing the photon lifetime in it, which are not compatible in general.

The simplest one of our approaches is reducing the hole depth d while increasing the hole radius in the PhC layer to obtain high and broad reflection GR. As an example, we calculated the hole depth dependence of the transmission spectra in the 2D square lattice PhC by using the transfer matrix method (Fig.1). We assumed the relative index difference of $\Delta n = 9.3\%$ between the PhC layer and the lower layer, and the hole radius $0.4a$ (a : lattice constant). Though there is no reflection peak in the spectrum for $d = t$ (t : PhC layer thickness), by decreasing the hole depth d the strong GR is obtained for $d \leq 0.7t$. Moreover, by changing hole profiles we also confirmed that the resonance width can be broadened by a factor of ~ 2 .

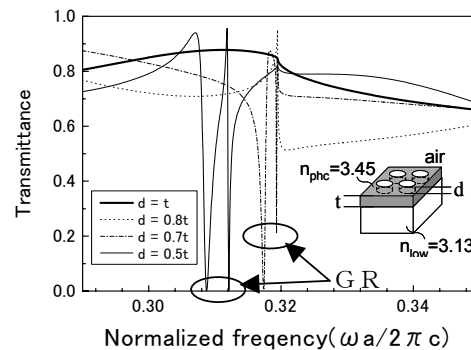


Fig.1 PhC structure and its calculated transmission spectra for different hole depths d . The strong GR occurs under $d \leq 0.7t$ (t : PhC layer thickness).

Experimentally, we fabricated the PhCs with GaAs/AlGaAs compounds ($\Delta n \sim 8\%$). Their GR behaviors were in good agreement with our calculation results.

In conclusion, we have shown that it is possible to obtain the GRs with both high and broad reflection in low refractive index contrast ($\Delta n < 10\%$) systems.

[1] S. Fan, J. D. Joannopoulos, Phys. Rev. B **65**, 235112 (2002)

[2] Y. Z. Michael, C. Y. Huang, C. J. Chang-Hasnain, IEEE/20th-ISLC 107 (2006)