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エアバンド光共振器を有するシリコンフォトニック結晶バイオセンサ
Silicon photonic crystal biosensors having air-band optical resonators

東大工　°平井格郎 荒木貴裕 蔡靖楠 和田一実 石川靖彦
Univ. of Tokyo　°Kakuro Hirai, Takahiro Araki, Jingnan Cai, Kazumi Wada, Yasuhiko Ishikawa
NTT MI 研　林勝義 堀内勉 岩崎弦 上野祐子 為近恵美
NTT MI Labs　Katsuyoshi Hayashi, Tsutomu Horiuchi, Yuzuru Iwasaki, Yuko Ueno, Emi Tamechika
E-mail: y-ishikawa@material.t.u-tokyo.ac.jp

1. Introduction

Optical biosensors using Si-based near-infrared (NIR) photonic devices, such as photonic crystal (PhC) resonators [1], have been investigated for label-free and low-cost sensing. Analytes are detected as a shift in the resonance wavelength, resulting from the refractive index change due to the adsorption of analytes on the surface. In this study, Si PhCs having air-band optical resonators are proposed to enhance the S value, defined as the amount of shift in the resonance wavelength per refractive index unit (RIU).

2. Si PhC biosensors having air-band optical resonators

In order to enhance the S value, an increased interaction is required between the analytes and the light. Although slot structures are often used [2, 3], a new concept is proposed here to use the so-called air band in PhCs. In PhCs with a photonic bandgap (PBG), the band below PBG is referred to as the dielectric band, where the light is mainly present in the higher index material, while the band above PBG is referred to as the air band, where the light is mainly present in the lower index material. Figure 1 shows a typical dispersion relationship for a one-dimensional (1D) Si PhC. A simple structure was used, consisting of periodic air holes (the period $a = 0.49$ μm and the radius $r = 0.125\ a$) in a Si channel waveguide (the width of 0.40 μm and the thickness of 0.22 μm) on SiO_2. The NIR wavelength region of 1.51 - 1.74 μm (the frequency $f = 0.325 – 0.414\ c/a$) is found to be located in the air band. This structure is selected as a resonant cavity at the center of sensor shown in Fig. 2(a). Such an air-band cavity is in contrast to ordinary PhC resonators, where the cavity is formed by partially omitting the hole(s). 1D PhC mirrors for the resonator can be formed when the period of holes is reduced and/or the size of holes is increased, leading to the increased frequency of light in the PBG region. Figure 2(b) shows a typical calculated result showing the distribution of light field (square electric field) for the structure shown in Fig. 2(a). Using the air-band cavity, the light is found to be located in the air holes of cavity PhC. The S value is also found to be more than 200nm/RIU, which is much larger than ordinary 1D PhC resonators.

3. Summary

Si PhCs having air-band optical resonators were proposed to enhance the S value in the optical sensing. The S value was obtained to be more than 200nm/RIU, being effective for the sensing.

[1] *e.g.,* P. M. Fauchet *et al.*, *Biophotonics* (Springer, Berlin, 2008), Chap.7.
[2] J. T. Robinson *et al.*, Opt. Express 16, 4296 (2008).
[3] J. Cai *et al.*, Material Research Society 2012 spring meeting, L1.5 (2012).

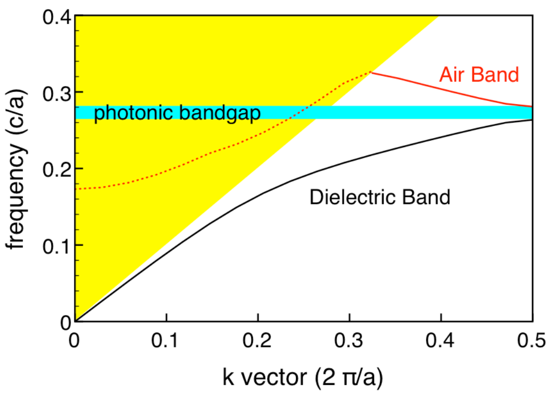

Fig. 1. A typical dispersion relationship for 1D Si PhC.

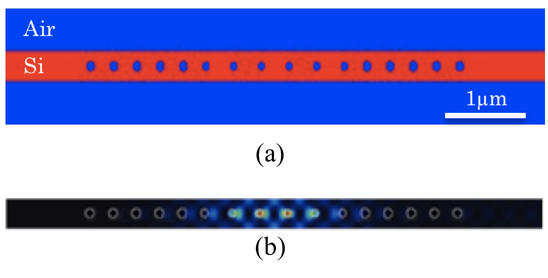

Fig. 2. (a) 1D PhC resonator used for the calculation, and (b) the calculated distribution of square electric field.