High Sensitive Detection of Prostate Specific Antigen Using Photonic Crystal Nanocavity Resonator

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Introduction

Over the past several decades, a considerable number of studies have been made for the identification and the quantitative analysis of biomolecules for the diagnosis, and evaluation of complex diseases, such as cancer [1]. Rapid and early diagnosis is demanded for the aging society [2] to providing better quality of life as well as to minimize the healthcare expenses [3].The sensing mechanism of the photonic crystal (PhC) is that the effective refractive index of the sensing area is changed by the activation of target biomaterials. Proposed biosensors have been used to detect prostate specific antigen (PSA) that is responsible for prostate cancer. The schematic of proposed device is shown in Fig. 1(a).

Fabrication process

Silicon on insulator (SOI) wafer was used to fabricated the proposed sensor device [4].The SOI substrate has a top silicon layer of thickness 300 nm on a 1.1 μm buried oxide layer. A 110 nm thick oxide layer was thermally grown as an intermediate layer of pattern transfer. An electron beam (EB) sensitive photoresist, ZEP-520A was spin coated onto the oxide layer. An electron beam lithography system was used to define high resolution patterns on the resist. The patterns were then developed by xylene and isopropyl alcohol. In order to transfer this pattern into the Si layer we used reactive-ion etching (RIE) and inductively coupled plasma (ICP) using CF_4 and Cl_2 gas respectively. In a final step, wet etching by diluted hydrofluoric acid (HF) was used to remove SiO_2 mask. SEM image of the fabricated device is shown in Fig. 1(b).

Discussion and Conclusion

The antigen-antibody reaction method is shown in Fig. 2. In Fig. 2(a), the receptors are randomly oriented. We used very special method S-tag that helps to bind protein G onto the sensor surface by aligning the one direction. To detecting a very small of biomarker in human blood are very important for early diagnosis of severe diseases. The experimental results are shown in Fig. 3(a). We succeeded in sensing the antibody–antigen reaction using photonic crystal double nanocavity resonator sensor employing PSA marker as an example target. By optimizing the immobilization of the target biomarker, we detected the PSA concentration as low as 0.01 ng/mL. The Langmuir's fitting curve is shown in Fig. 3(b). Thus, our PhC based double nanocavity resonator may be promising candidate as practical biomolecules sensor in the medical diagnosis.

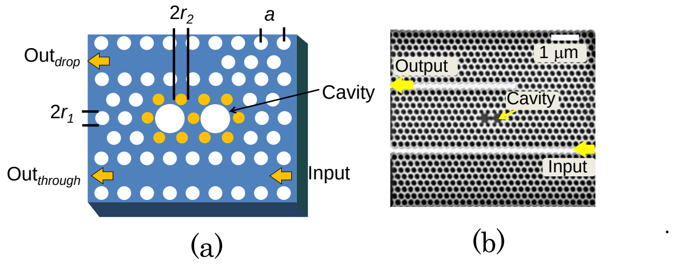

Fig. 1 (a) Schematic of proposed device and (b) scaning electron microscopic image.

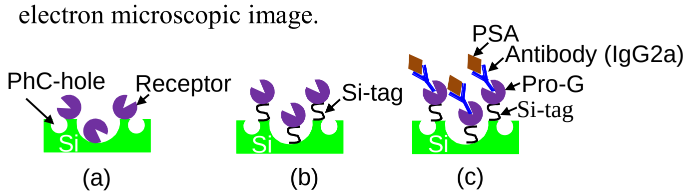

Fig. 2. Role of Si-tag (a) without Si-tag (b) with Si-tag and (c) role of Protein G.[3]

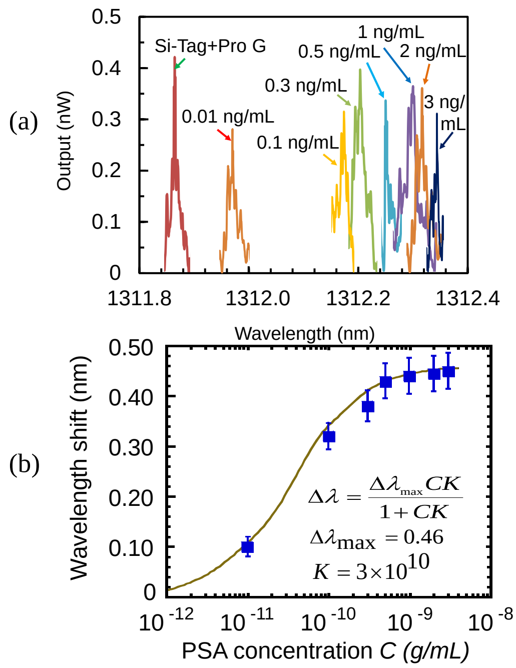

Fig. 3. (a) Experimental results of various PSA concentration and (b) Langmuir's fitting curve with experimental results.

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