Optomechanical resonator fabrication with the surface plasmon antenna for the wavelength detection

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Recently, the high accuracy and low cost wavelength detector is demanded in the optical communication field in order to stabilize the light source. And, a novel principle was needed to achieve the high accuracy wavelength detection. Therefore, a wavelength detection using a nanomechanical resonator and a plasmonic nanostructure was proposed in this study. Nanomechanical resonator enables us to detect various small physical quantities using vibration. [1] And also, plasmonic nanostructure is coupled strongly with the light. [2] Therefore, we expected the high accuracy wavelength detection by using a nanoresonator and a plasmonic nanostructure. In this study, an optomechanical resonator with a plasmon antenna was fabricated, and its performance was investigated.

Figure 1(a) shows the optomechanical resonator fabricated in this study. This optomechanical resonator has the Au/diamond-like carbon (DLC) prasmonic nanostructure on the Si membrane resonator, as shown in Fig. 1(b). Figure 2 shows the fabrication process of a resonator. Thickness of Au, DLC and Si membrane were 70 nm, 150 nm and 50 nm, respectively. Pitch of the periodic Au/DLC plasmon antenna was 1460 nm. Au/DLC plasmon antenna structure was used in order to give the wavelength dependence of heat absorption to a Si membrane resonator. Therefore, wavelength can be detected by resonant frequency changes induced by thermogenesis depended wavelength.

Wavelength detection properties were evaluated by a light irradiation onto the center of a resonator, as shown in Fig. 3(a). In this experiment, wavelength-variable laser (wavelength: 1350 nm - 1565 nm) was used as a light source. Laser power and spot diameter was 0.13 mW and 5 μm, respectively. Also, excitation of a resonator was carried out by He-Ne laser with a wavelength of 408 nm. And, vibration properties were measured in the vacuum by an optical heterodyne vibrometer. Fig. 3(b) shows the changes in the vibration properties before and after irradiations of laser with wavelength of 1550 nm and 1555 nm. As a result, resonant frequency was changed from 2.506 MHz to 2.495 MHz. We found that the wavelength detection resolution was 0.024 nm by the spectrum analysis. This implies that a resonator has enough performance for wavelength detection in the optical communication. Fabrication and characteristic of the optomechanical resonator with a plasmon antenna will be reported in detail.

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[1] K. L. Ekinci and M. L. Roukes: Rev. Sci. Instrum. **76**, 061101 (2005).
[2] C. Genet and T. W. Ebbesen: Nat. **445**, 39 (2007).

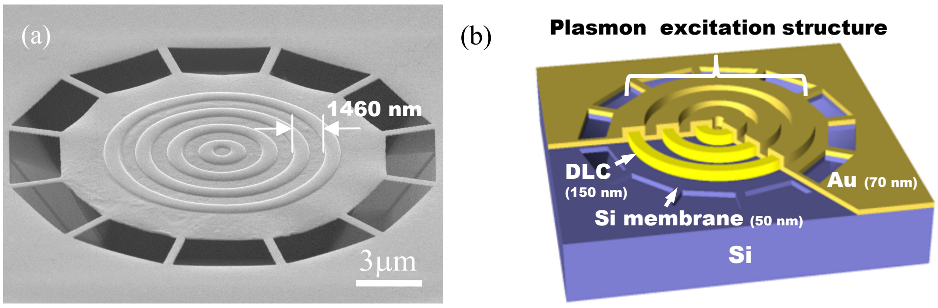

Figure 1: Optomechanical resonator fabrication with the surface plasmon antenna: (a) SEM image of Optomechanical resonator fabrication, (b) schematic of cross-sectional structure

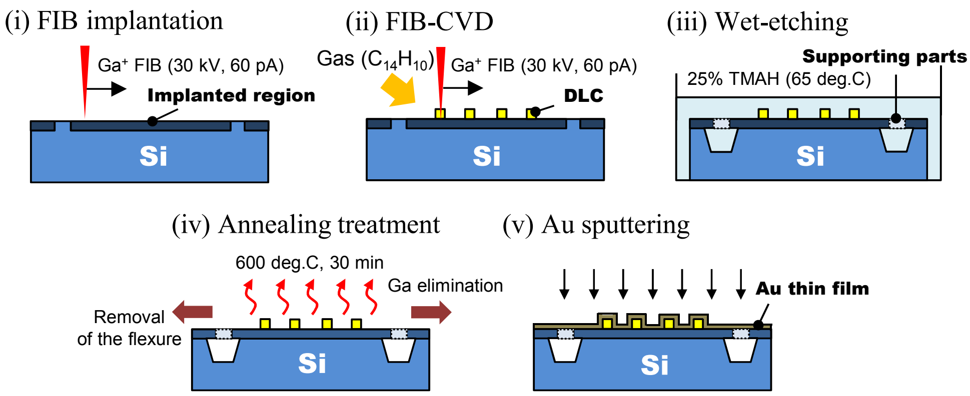

Figure 2: Fabrication process of the optomechanical resonator with the surface plasmon antenna: (i) Si membrane resonator patterning by FIB implantation (Ion dose: 7×10^{15} ions/cm^2), (ii) DLC periodic structure fabrication by FIB-CVD using *phenanthrene* ($C_{14}H_{10}$) as a gas source (Ion dose: 150×10^{15} ions/cm^2), (iii) TMAH wet-etching of Si substrate, (iv) annealing treatment for the flexure removal, (v) Au sputtering.

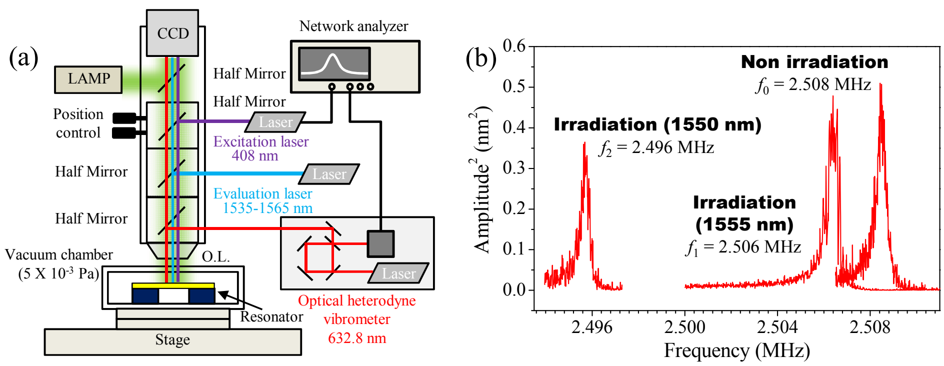

Figure 3: Evaluation of wavelength detection characteristic: (a) schematic of evaluation, (b) changes in vibration property before and after laser irradiation (wavelength: 1550 nm and 1555 nm).