Fabrication of optomechanical nanoresonators elastically coupled in series by focused-ion-beam for wavelength measurement

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Optomechanical resonator has been attracting attention in order to measure the wavelength. The wavelength change is converted to change in heat by plasmonic structures and detected by measuring the resonant frequency shift.[1] In this method, detection resolution is dependent on Q factor and Q factor reduces when the resonator absorbs heat.[2] In this study, we used nanomechanical resonators elastically coupled in series. The antisymmetric resonant mode of coupled two resonators significantly changes by applied stress.[3] By measuring the amplitude change, the Q factor independent thermal detection is achieved. As plasmonic structures, we used half bull's-eye structures. The half bull's-eye structures absorb light with a specific wavelength and conduct the irradiated light to the resonators.[4] By placing the plasmonic structures beside the resonators, we made it easy to tune the resonators for high resolution wavelength measurement.

Optomechanical resonator was fabricated by techniques using focused-ion-beam (FIB). FIB enables us various nanofabrications. The resonators were fabricated by FIB ion implantation, wet-etching and DC sputtering process. The dose was 1.0 x 10^{16} ions/cm^2 and the acceleration voltage was 30 kV. The central part for coupled two resonators was fabricated by FIB etching. The dose was 3.0 x 10^{19} ions/cm^2. After wet-etching, Si was etched and a hollow pillar supporting two resonators remained. The half bull's-eye structures were fabricated by focused-ion-beam chemical vapor deposition (FIB-CVD). In this process, 30 kV Ga^+ FIB was used under phenanthrene ($C_{14}H_{10}$) gas atmosphere. Dose was 1.0 x 10^{16} ions/cm^2. Finally, au thin film layer was forming on these structures by sputtering. Figure 1 shows SEM image of the resonators and plasmonic structures.

Resonant characteristics were measured by using an optical heterodyne vibrometer. Vibration of the resonator was excited by irradiating semiconductor laser with the wavelength of 408 nm onto the central coupling part and measured by irradiating He-Ne laser with the wavelength of 632.8 nm onto the right resonator. NIR laser with the wavelength of 1535, 1545 and 1565 nm was irradiated individually on the left half bull's-eye structure. The optical output power was fixed at 2.0 mW for each NIR laser. The amplitude of antisymmetric resonant mode changed with changes in wavelength shift from 1535 ~ 1565 nm, as shown in Fig.2. This result implies that nanomechanical resonators elastically coupled in series achieve sensitive wavelength measurement.

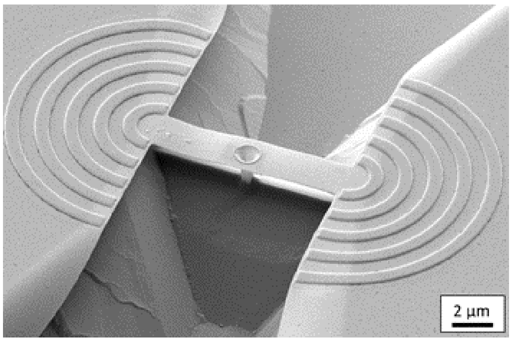

Figure 1: SEM image of nanomechanical resonators elastically coupled in series with half bull's-eye structures

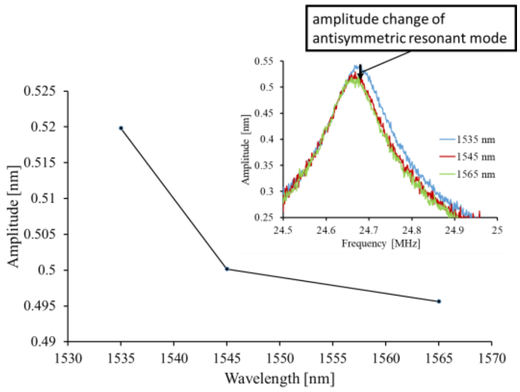

Figure 2:Relationship between the wavelength change of irradiated laser and the amplitude of antisymmetric resonant mode

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