Fabrication of an optomechanical resonator with a two-interface surface plasmonic structure for the wavelength detection

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An optomechaniccal resonator has been researching in order to detect the wavelength for stabilization of light source in the optical communication field. Thus far, wavelength detection had been achieved by optomechanical resonators with nano-fins[1], Yagi-uda nanoantenna array[2] as plasmonic structures. Plasmonic structures were used in order to give the wavelength dependence of heat absorption to a resonator, and wavelength was detected by measuring the resonant frequency change induced by the change in the heat absorption. In this study, an optomechanical resonator with a two-interface surface plasmonic structure was fabricated for higher wavelength resolution.

Figure 1(a) shows a scanning electron microscope (SEM) image of an optomechanical resonator with a two-interface surface plasmonic structure. A resonator and a two-interface surface plasmonic structure were made from Au, Ti and SiO_2, as shown in Fig. 1(b) and Fig. 1(c). A two-interface surface plasmonic structure with SiO_2 hole array was designed by rigorous coupled-wave analysis, and the optomechanical resonator was fabricated as shown in Fig. 2. Diameter of resonator was approximately 7 µm, and diameter and pitch for SiO_2 hole array were 906 nm and 1050 nm, respectively. Thickness of SiO_2/Ti/Au/Ti/SiO_2 were 116 nm, 5 nm, 75 nm, 5 nm and 280 nm, as shown in Fig. 1(c).

Wavelength detection characteristics were evaluated using an optical heterodyne vibrometer, as shown in Fig. 3(a). In this study, vibration was measured under the vacuum of 5×10^{-3} Pa, and the second vibration mode was observed because the resonant frequency shift was larger. Initial resonant frequency of the second vibration mode without laser irradiation was 20.12 MHz. And, light with wavelength of 1550-1562 nm as a measurement object was irradiated using a wavelength-variable laser. Resonant frequency was shifted with a change in the wavelength, as shown in Fig. 3(b). Resonant frequency depended on the absorption rate. And we found that the wavelength resolution for unpolarized light was 0.92 pm. This indicates that the optomechnical resonator has superior performance for the wavelength detection. Fabrication and wavelength detection characteristics of an optomechanical resonator will be reported in detail.

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1 E. Maeda and R. Kometani, Abstract of The 59th International Conference on Electron, Ion and Photon Beam Techonology & Nanofabrication (EIPBN2015), P14-04 (2015).
2 J. Oishi, M. Goto, H. Yamaguchi, E. Maeda and R. Kometani, Abstract of 41th International Conference on Micro and Nano Engineering (MNE2015), Tue-C-p92, (2015).

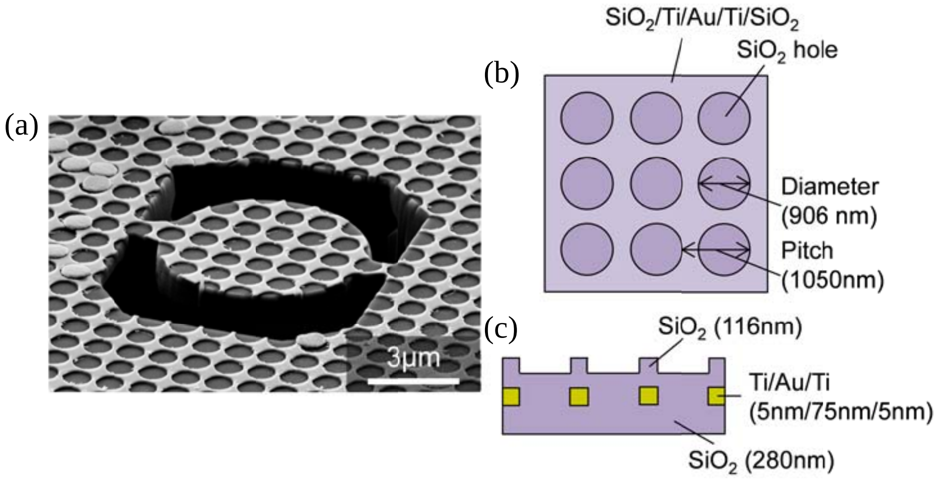

Figure 1: Optomechanical resonator with a two-interface surface plasmonic structure: (a) SEM image of an optomechanical resonator, (b) Schematic of a top surface of a two-interface surface plasmonic structure with a SiO_2 hole array, (c) Schematic of a cross-section of a two-interface surface plasmonic SiO_2/Ti/Au/Ti/SiO_2 structure.

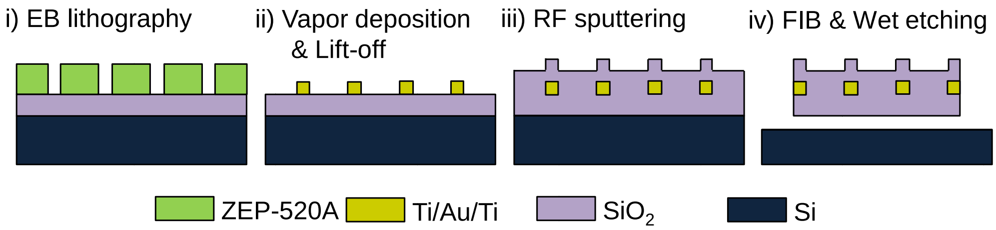

Figure 2: Fabrication process of an optomechanical resonator: A two-interface surface plasmonic structure was fabricated by EB lithography, lift-off process and RF sputtering, and it was formed as a mechanical resonator by focused-ionbeam (FIB) and wet-etching process.

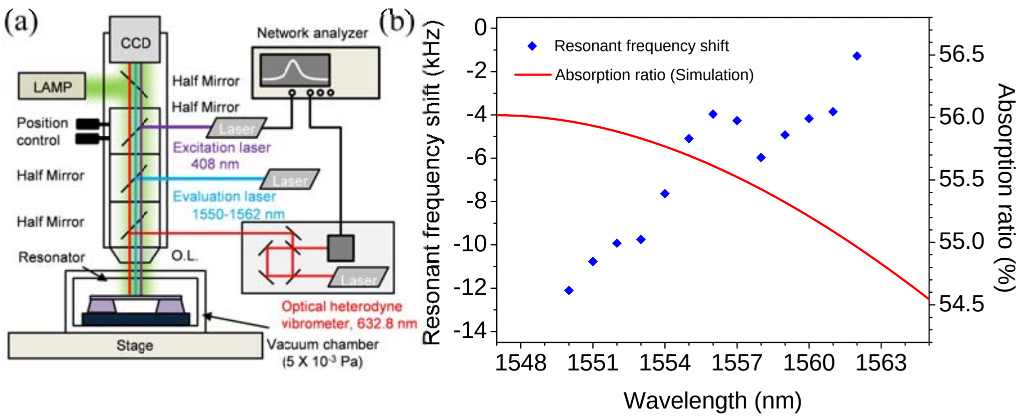

Figure 3: Characteristics of vibration and wavelength detection of an optomechanical resonator: (a) Experimental setup for evaluation, Vibration of a resonator was excited by photothermal excitation using a laser with a wavelength of 408 nm. (b) Relationship between wavelength, resonant frequency shift and a simulated absorption rate.