Simple optical ultrasound detector with surface plasmon resonance

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Background, Motivation and Objective

Photoacoustic microscopy (PAM) has attracted attention as a high contrast and non-invasive imaging technique. However, the spatial resolution of PAM is not a suitable for imaging small cells due to narrow frequency band of the ultrasound transducer. In recent years, surface plasmon resonance (SPR) sensors have been reported as ideal ultrasonic detectors with high-spatial resolution and ultra-flat frequency response [1]. The SPR sensor is rewarded as a promising optical photodetector for photoacoustic imaging. SPR sensors detect signals due to the changes in the reflective index near the surface. In this study, ultrasound measurements were experimentally performed using a simple SPR sensor.

Methods

A SPR stress sensor (Ag layer: 53 nm, BK7 glass prism) was fabricated as shown in Fig.1 (a). In the experiments, a single sinusoidal wave of 0 to 50 V at 2 MHz was applied to the ultrasound transmitter (Japan probe, IWC-B2K10I). The maximum pressure values of the ultrasonic waves were checked using a calibrated PVDF ultrasonic transducer. The experimental system was composed of a solid state laser (mcp-300, wave length: 532 nm) as shown in Fig. 1(b). The laser light is divided into the reference light and the detection light by a half mirror. Each light entered the differential photodiode. Using a lock-in amplifier, signals were measured with a high S/N ratio.

Results/Discussion

Figure 1(c) shows the detected signal intensity. The intensity increased by increasing the pressure of ultrasound. The signal intensity showed nonlinear behavior which should be investigated precisely, however, the sensitivity was good and similar to the PVDF transducer [2]. Figure 1(d) shows the reflective index changes (ΔR) against the sound pressure. The stronger the sound pressure was, the more the reflectivity changed. In addition, the experimental data showed almost similar tendencies with the theoretical estimation from the sound pressure at the surface of the SPR sensor. The SPR sensor has a very simple structure without cables, which can be used as a compact and convenient ultrasound transducer for PAM and other measurements.

[1] M. Xu et al., Rev. Sci. Instrum., **77**, 041101 (2006).
[2] Y. Nakamura et al., J. Acoust. Soc. Am., 94, p.1191 (1993).

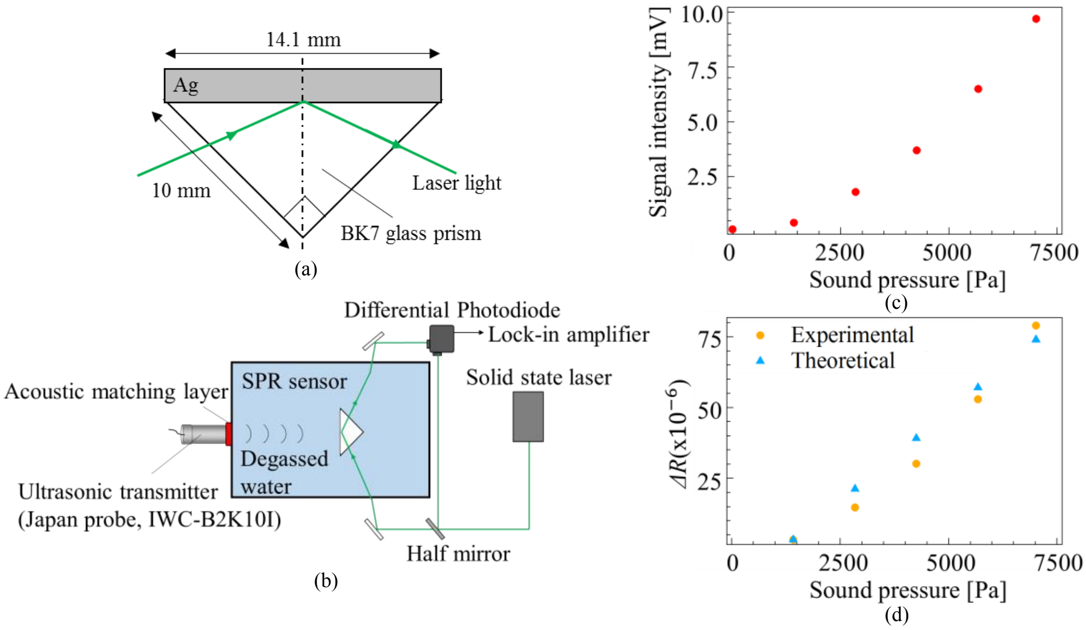

Fig. 1 (a) Structure of the SPR stress sensor. (b) The measurement system used. (c) Signal intensity detected by the SPR sensor. (d) Reflectivity variation as a function of sound pressure.