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Consideration of the Effect of Acoustic Flow from a Surface Acoustic Wave Device on a Localized Surface Plasmon Resonance Sensor

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1. Introduction

Currently, liquid testing in medical and biotechnological experiments requires mixing liquids in one device to make a new liquid, moving the liquid to another device, and testing the liquid. In this process, impurities are mixed into the liquid when moving the liquid from one device to another, or the liquid is spilled. To solve these problems, this study integrates a surface acoustic wave device (SAW device), which can mix liquids, and a localized surface plasmon resonance sensor (LSPR sensor), which can inspect liquids [1, 2]. The integration of the SAW device and the LSPR sensor will allow for the simultaneous mixing and inspection of liquids on a single device, eliminating the need to move the liquid and thus solving the problems of impurities in the liquid and spills.

2. Experimental system

Fig. 1 shows the experimental system used in this study. A comb-shaped electrode (IDT) for SAW excitation was fabricated on a crystal, and then gold nanoparticles (AuNPs) were formed by deposition of a thin gold film followed by short-time annealing and rapid cooling [3]. AuNPs were irradiated with light from a white light source, and the reflected light was detected by a spectrometer to obtain LSPR characteristics. An AC voltage was applied to the IDT to excite the SAW.

3. Results and Discussion

Distilled water and ultrapure water were used in the experiment to examine the effect of bubbles in the droplets. The relationship between the excitation time and LSPR is shown in **Figs. 2 and 3**. Measurements were taken multiple times. Fig. 2 shows that the increase and decrease of the peak wavelength are larger when distilled water is used. On the other hand, Figure 3 shows that the increase or decrease of the peak wavelength is small when ultrapure water is used. This is because the effect of air bubbles in the droplet is removed. The relationship between the dielectric constants of the surrounding media and LSPR is shown in **Fig. 4**. The dielectric constants of water and air are 1.77 and 1, respectively. Therefore, these results indicate that the use of ultrapure water can reduce the change in the peak wavelength due to the effect of bubbles generated by the acoustic streaming. **Figs. 5 and 6** show the appearance of the substrate before and after SAW excitation when distilled water is used, respectively; it can be seen that no bubbles are generated before SAW excitation, but bubbles are generated after SAW excitation.

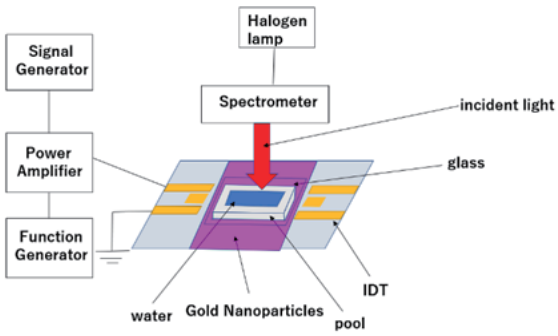

Fig. 1 Experimental system in this study.

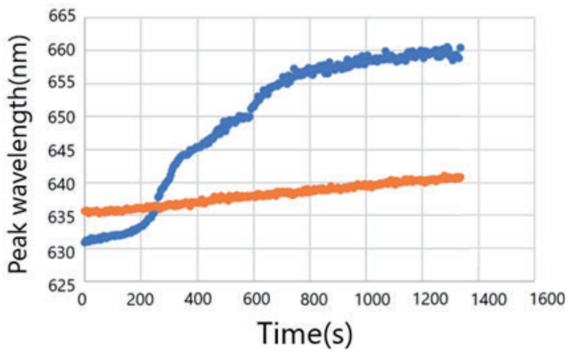

Fig. 2 LSPR peak wavelength of distilled water during SAW generation.

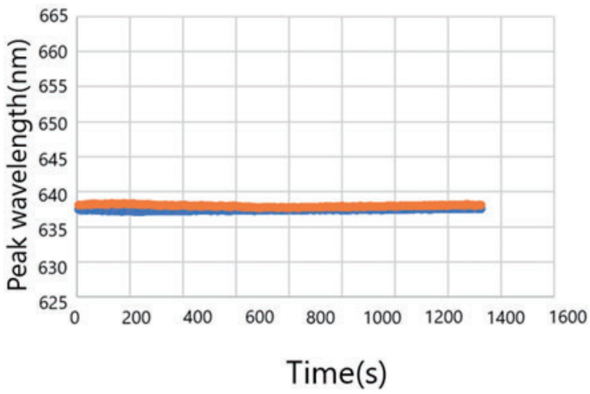

Fig. 3 LSPR peak wavelength of ultrapure water during SAW generation.

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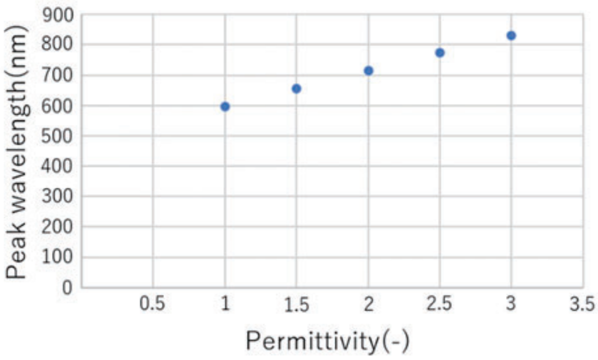

Fig. 4 LSPR peak wavelength as a function of permittivity (particle diameter: 15 nm, number of particles: 2, distance of particles: 1 nm)

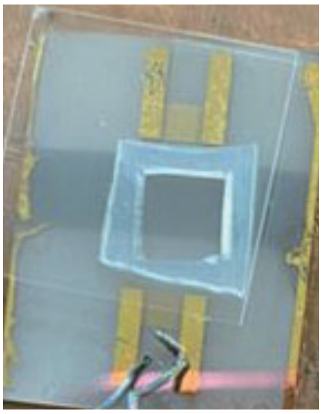

Fig. 5 Before SAW excitation.

Fig. 6 After SAW excitation. Bubbles are observed.

5. Conclusion

The effect of integrating a surface acoustic wave device with a localized surface plasmon resonance sensor is discussed. It was found that by removing air bubbles from the droplet, the effect of acoustic streaming from the SAW device on the sensor could be minimized.

References

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