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A Study of interaction SAW with LSPR

弾性表面波と局在表面プラズモン共鳴との相互作用に関する研究

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1. Introduction

A surface acoustic wave (SAW) propagates on a surface with concentrating its energy on the surface. One application of the SAW device is a droplet manipulation[1]. A localized surface plasmon resonance (LSPR) is an electric field enhancement phenomenon occurring around metal nanoparticles when external electromagnetic wave incidents to the particle[2]. In general, light is used for the external electric field. The phenomenon depends on the surrounding environment, so LSPR sensor is realized. When the LSPR sensor is integrated in the SAW device, a new micro fluidic system is realized. For the purpose, it is important to investigate the SAW – LSPR interaction. In this paper, gold nanoparticle (AuNPs) were fabricated on 128°YX-$LiNbO_3$ and the interaction was discussed.

2. Measurement system

Fig. 1 shows the measurement system used in this study. White light was irradiated from the halogen lamp to the substrate, and the reflected or transmitted lights were measured by spectrometer. In addition, an RF signal was fed to a interdigital transducer (IDT) on the 128°YX-$LiNbO_3$ for generating SAW. The reflected signal from the IDT was monitored using an oscilloscope.

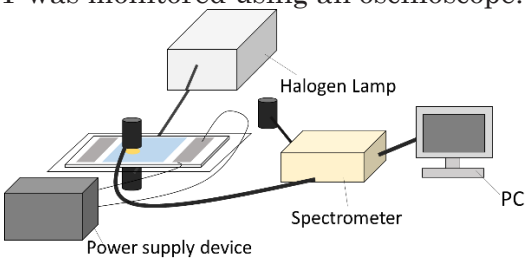

Fig.1 Measurement system

3. Method of making substrates

The typical device used for measurement is shown in **Fig. 2**. The IDT on the 128° YX - $LiNbO_3$ by photolithography using aluminum. Also, Gold thin layer was formed on the device. Then the device was annealed to create the AuNPs. The preparation conditions of substrate at this time are shown in **Table 1**.

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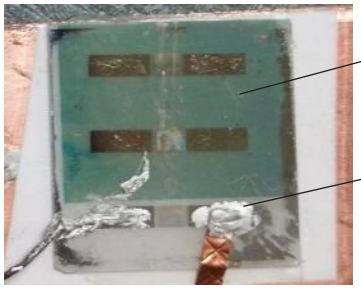

Fig. 2 The SAW device with AuNPs

Table 1 Preparation conditions of substrate

Substrate	Material of substrate	128° YX - $LiNbO_3$
	Size of substrate	23.0×20.0×0.1mm
IDT	Amount of aluminium	65mg
	Center frequency	57.4MHz
Gold nanoparticle	Amount of gold	4.9mg
	Annealing temparature	400° C
	Annealing time	8h

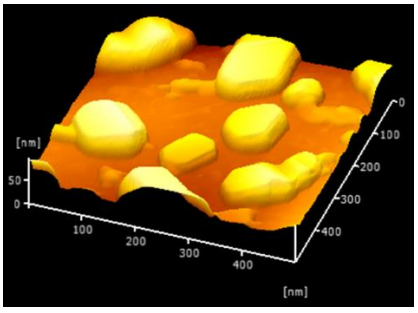

Fig. 3 AFM image of AuNPs on substrate

The reason for using annealing method is that it is inexpensive and can be reduce time as compared with electron beam writing method and chemical etching[3]. Furthermore, in order to confirm that AuNPs could be prepared, the surface of the substrate was observed using an atomic force microscope (AFM).

4. Results and Discussion

An AFM image obtained at that time is shown in **Fig. 3**. The results on the effect of SAW on LSPR are shown in **Fig. 4**. At this measurement, the applied power to the IDT was 1W.

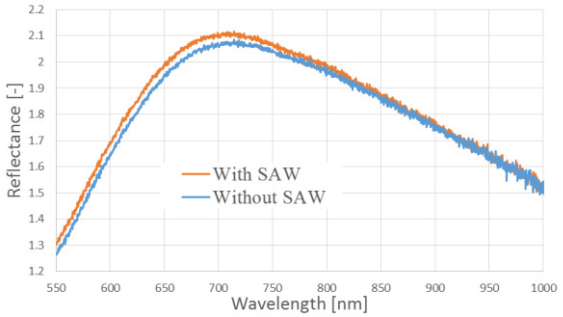

Fig. 4 Comparison of spectrum of LSPR with or without SAW

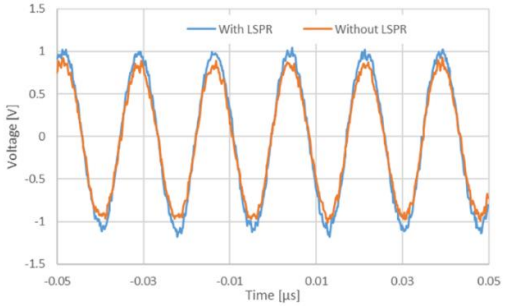

Fig. 5 Comparison of output signal from SAW device with or without LSPR

From Fig. 4, it is found that the reflectance increases due to SAW propagation and the peak wavelength is shifted in the short wavelength direction. Next, in order to investigate the influence of LSPR on SAW, we compared the case of irradiation with light and the case of not irradiating light. The results are shown in **Fig. 5**. The output signal from the SAW device with the LSPR is higher than it without the LSPR.This is because the electric field condition on the substrate surface changes due to the electric field excited by the LSPR. It is considered that these mutual relations are caused by changes in temperature and changes in AuNPs due to deformation of the substrate surface. One of the factors is that the electric field excited by the LSPR changes due to deformation of the substrate. **Fig. 6** shows a schematic diagram of the electric field distribution. Fig. 6 is shown that the electric fields excited by the LSPR are usually coupled, but if the height of the particles changes due to the deformation, the bond might break. Since the electric field weakens when the coupling is broken, it is considered that the absorption decreases and the reflectance increases. In addition, in Fig. 6, it shows the possibility of dive inside the substrate of the LSPR and influence polarization due to SAW. We believe that the presence of this will increase the voltage of the SAW when light is irradiated.

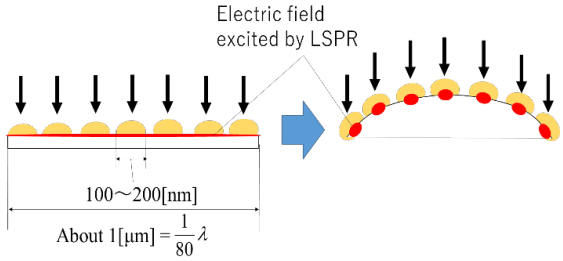

Fig. 6 Schematic diagram of electric field distribution changing by surface deformation

5. Conclusion

The peak wavelength of LSPR was shifted in the short wavelength direction by SAW and the reflectance increased. On the other hand, SAW was able to enhance its electric field by LSPR. However, the cause of these results and its mechanism have not been clarified unknown specifically. Further experiments and numerical analysis to explore the cause are required. The results have little effect on SAW and LSPR. This is because the obtained change is relatively small, and it is thought that it does not greatly affect the droplet conveyance and sensor sensitivity. Therefore, we actually need to develop a device to be detected by LSPR by transporting liquid droplets, and we would like to conduct concrete measurements.

References

1. J. Kondoh., Jpn. J. Appl. Phys. 57 07LA01 (2018)
2. P. K. Jiain, et al., Chemical Physics Letters, 487, pp. 153-164 (2010).
3. Z. Geng, et al., Sensors and Actuators B, 195, pp. 682-691 (2014)