3Pb3-1

Examination of identification method of passive SAW sensor using mass load effect

質量負荷効果によるパッシブ SAW センサの識別方法の検討

Naoki Horikawa[1†], Jun Kondoh[2], Shinji Baba[3] ([1]Shizuoka Univ.)
堀川直起[†]，近藤淳，馬場信爾 (静岡大学)

1. Introduction

A wireless sensor can be realized by using surface acoustic waves (SAW) [1]. So far, application to physical sensors such as temperature and pressure and chemical sensors such as gas sensors has been studied[1]. Also, an impedance-loaded SAW sensor combined with an impedance variable sensor has been studied[1,2]. When multi-point measurement with existing sensors is performed, the number of wires required is more than twice the number of sensors. However, replacing those with wireless SAW sensors eliminates the need for wiring. As an application example of such a passive sensor, the aging of bridges over 50 years after construction has become a serious problem in recent years, and there is a health monitoring system (SHM) for them. We are considering the application of sensors that combine pressure sensors and vibration power generation sensors with SAW devices to SHM [2]. In addition, since SHM requires multipoint measurement, it is important to identify the SAW sensor. Whereas the SAW sensors are identified based on the response amplitude of the reflector electrodes1, there are problems such as multiple reflections between electrodes, and the amplitude of the time response depending on the distance between the antennas. In addition, the orthogonal frequency method has a problem with bandwidth. Therefore, in this study, we focused on discrimination by phase rather than amplitude.

In this study, we propose an identification method based on the mass loading effect (**Fig. 1**). By loading a loading film on the SAW propagation surface, the SAW velocity is changed and the phase is changed by the mass loading effect. In addition, the phase shift is read by changing the film thickness for each device by utilizing the fact that the amount of phase shift changes depending on the size of the film thickness of the loaded film. This phase change is applied to the identification. So far, we have examined the relationship between the loaded mass and the phase by simulation and experimental verification using a perturbation solution for the mass loading effect, and clarified that it is possible to distinguish by the load mass[3]. In this paper, from these results, we conducted the necessary consideration and additional experiments for the actual identification using the mass loading effect.

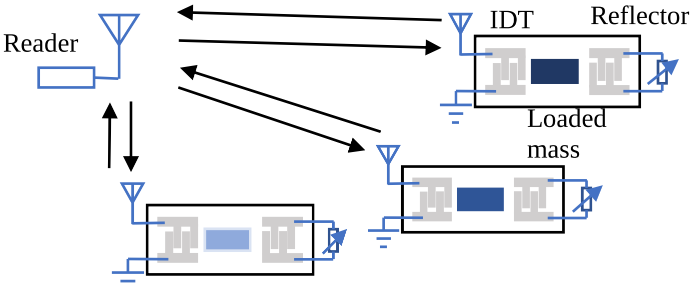

Fig. 1 Schematic of concept of this study.

2. Experiments and discussions

Fig. 2 shows the measurement results of the change in film thickness and phase shift when a gold thin film is used as the loaded film. The piezoelectric crystal is 128YX-LiNbO3, and the SAW frequency is 50MHz, which is the result of measuring the transmitted signal. From this result, it can be seen that the one-period phase shift changes at a film thickness of about 7 nm. For example, considering identifying seven devices in the system shown in Fig. 1, if the film thickness is set every 0.5 nm and the time difference of about 3 ns can be read with an oscilloscope, the identification can be performed using the phase shift.

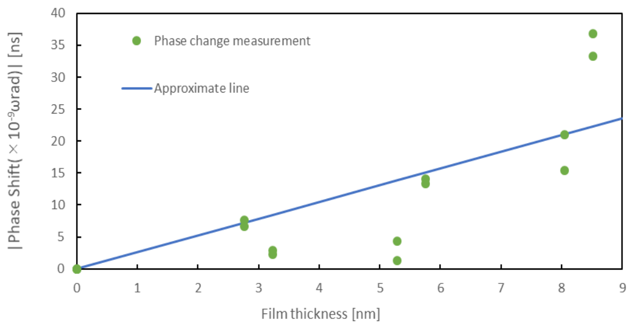

Fig. 2 Relationship between loaded mass and phase shift

kondoh.jun@shizuoka.ac.jp

performed. Comparing the results in Figs. 5 and 6, it can be confirmed that the phase shift is shifted by about 10°. We think that this result can be used for identification by performing averaging processing.

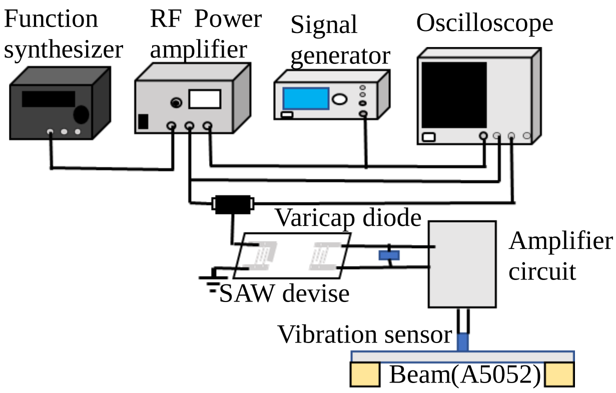

Fig. 3 Experimental system

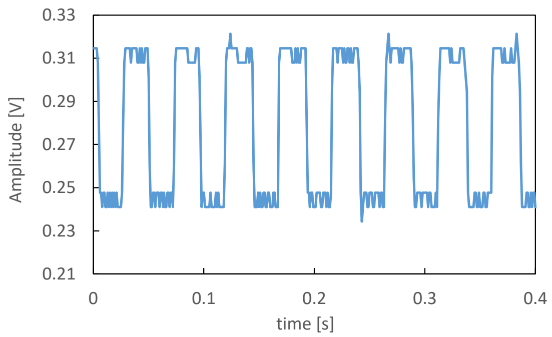

Fig. 4 Amplitude change of received signal

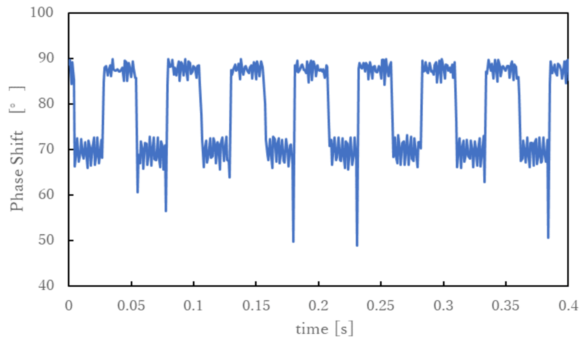

Fig. 5 Phase Shift of received signal

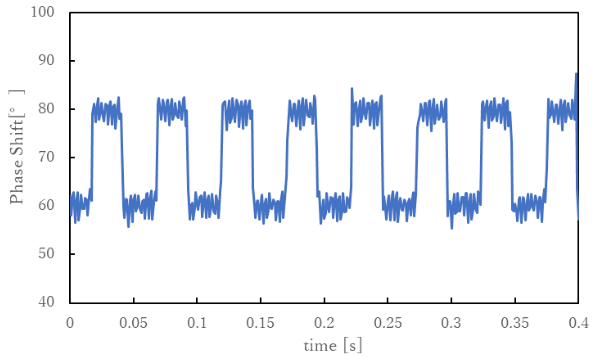

Fig. 6 Phase Shift (with film)

In addition, by using the same SAW device for the sensor unit and the identification unit as shown in Fig. 1, the reaction and phase shift of the sensor can be read with one received signal. An experiment was conducted in which the reaction and phase difference of the sensor were measured simultaneously in the experimental system shown in **Fig. 3**. This is a vibration measurement system in which a vibration sensor that combines a vibration power generation type sensor and a varicap diode is installed in the center of the fixed beam at both ends. Aluminum alloy (A5052) was used as the beam material. The beam was vibrated by the vibration generator. The burst wave was applied to the IDT and the reflected signal was measured. The measurement was performed at 10 ms intervals using the segment memory function of the oscilloscope. The piezoelectric crystal has 128YX-LiNbO3, and the SAW frequency is 50MHz. **Fig. 4** shows the measurement result of the amplitude change of the received signal measured as the reaction of the sensor, and **Fig. 5** shows the measurement result of the phase shift. From these results, it can be seen that the sensor response and phase difference can be measured at the same time. From Fig. 5, the phase shift fluctuates at regular intervals, and the frequency of the fluctuation coincides with the frequency of the oscillator. In addition, **Fig. 6** shows the phase shift measurement results when a gold thin film was loaded on the same SAW device and the same experiment was

4. Conclusion

In this study, we proposed a method of discrimination by phase shift using the mass loading effect and conducted the necessary consideration and additional experiments to actually perform the discrimination using the mass loading effect. We considered the number that can be identified from the relationship between the loading membrane and the phase shift. We also proposed a method of combining the sensor unit and the identification unit and showed that it is possible to measure the reaction and phase shift of the sensor at the same time by experiments.

A future task is to study how to decompose the received signal when the signals from multiple devices are received in an overlapping manner.

References

1. L. Reindl, et al., IEEE Trans. UFFC 45, p. 1281(1998)
2. M. Oishi, et al., Jpn. J. Appl. Phys., vol. 55, 07KD06 (2016).
3. N. Horikawa et al, USE2020(2020).