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Measurements of liquid using reflected type SH-SAW sensor

反射器型 SAW センサを用いた液体計測

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1. Introduction

A liquid sensor using a shear horizontal surface acoustic wave (SH-SAW) has been investigated. The SAW is exited by an interdigital transducer (IDT) fabricated on a piezoelectric substrate. When the IDT is connected to an antenna, it transform the received signal into a SAW. The SAW is reflected by the reflector on the propagation path (see Fig. 1). The reflected wave is reconverted into an electromagnetic wave by the IDT. If a liquid is loaded on the surface, arrival time is changed. Therefore, a wireless SAW sensor is realized. The features of a reflected type SAW sensor are passive measurement and operating without a battery. Nomura et al. reported reflected type SH-SAW wireless liquid sensor [2]. They have investigated probe type sensor. Our goal of this research is to realize a liquid flow system [3] with the wireless SH-SAW sensor. For this purpose, liquid measurements in the time domain was required. In this study, liquid measurements using the reflected type SH-SAW sensor are described. Linear relationships between ethanol concentration and time responses were obtained.

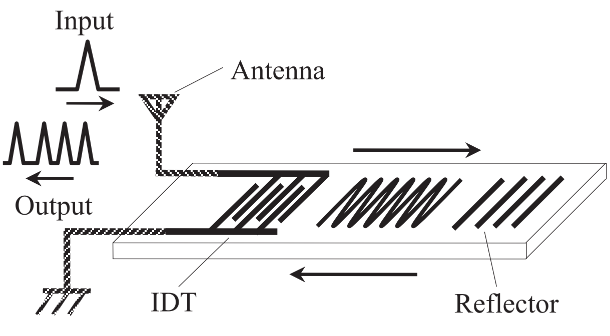

Fig. 1 Wireless SAW sensor with reflectors.

2. Experimental

A network analyzer (Agilent E5070B) was used to measure sensor response, S11, in the time domain. The reflected type SH-SAW sensor was connected with the network analyzer as shown in Fig. 2. The center frequency of the SH-SAW sensor was 100 MHz. Figure 3 shows that used SH-SAW sensor. The IDT and reflector were fabricated on a 36YX-$LiTaO_3$. The propagating surface is free. Liquid cell was placed on the surface. Distilled water and ethanol solutions with different concentrations (20, 40, 60, 80, 100 wt%) were utilized as test samples.

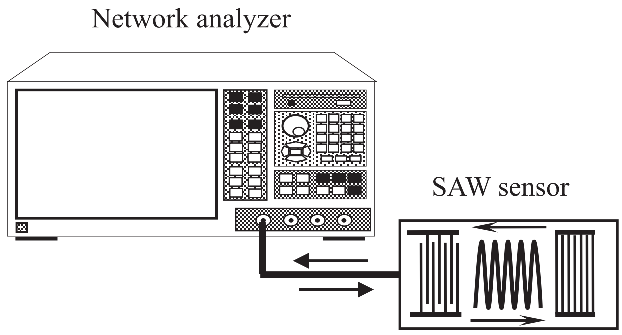

Fig. 2 Experimental set-up.

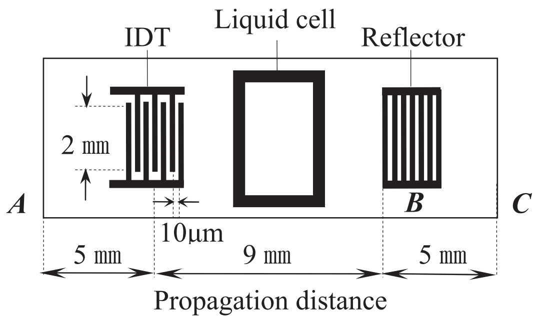

Fig. 3 Schematic drawing of reflected type SAW sensor.

3. Results and discussions

Figure 4(a) shows the time responses. Several peaks are observed. Peak *A* is reflected wave from left side edge (*A* in Fig. 3). As a liquid was not plased between IDT and left side edge, all responses agree. Peak *B* is reflected wave from reflector. Arrival time almost agree with the estimated time of 4.29 μs, which was calculated from SH-SAW velocity and distance. Peak amplitude and position are influenced by the loaded liquid. Peak *C* is reflected wave from right side edge (*C* in fig. 3). Peak values are also influenced by the liquids. In this paper, peak *B* was used to

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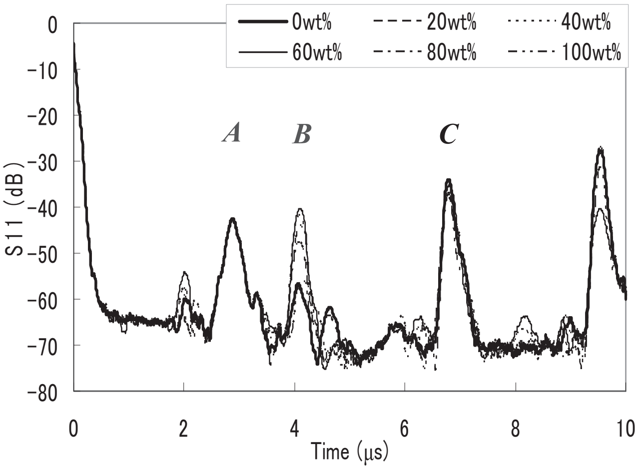
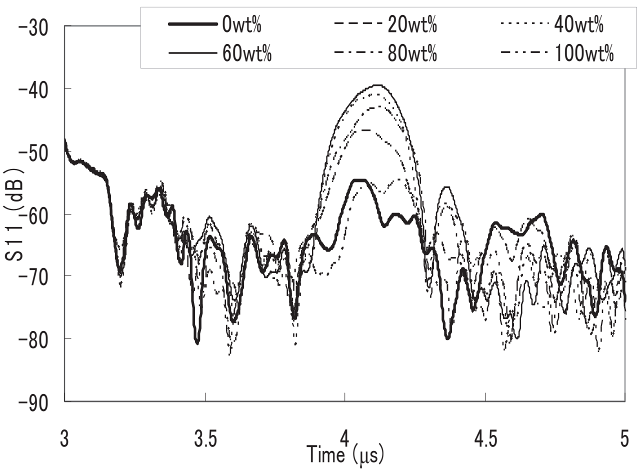
discuss the interaction between SH-SAW and liquids.

Figure 4(b) shows the magnification of peak *B* in Fig. 4(a). Values of S11 depend on the concentrations of the ethanol solutions. Peak arrival times and S11 are summarized in Figs. 5(a) and 5(b), respectively. Figure 5(a) shows that relationships between the peak arrival time and concentration are linear. Correlation coefficient, R, is 0.958. Therefore, by measuring peak arrival time, ethanol concentration is estimated. On the other hand, from Fig. 5(b), peak value of S11 shows parabolic profiles. The SH-SAW is perturbed by permittivity and viscosity of ethanol. As the propagating surface was free, the influence of permittivity is larger than that of viscosity. In this case, amplitude change is small [4]. Therefore, the mechanism of the change of peak values cannot explain on the basis of previous theory [4].



(a)



(b)

Fig. 4 (a) Measured result of ethanol solutions in time domain. (b) magnification of (a).

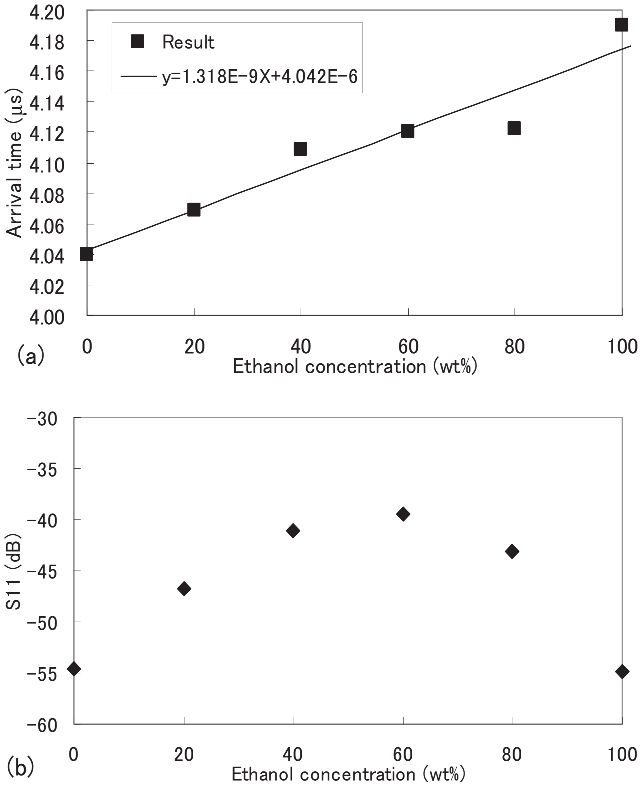


Fig. 5 (a)Peak arrival time and (b)peak value of S11 as a function of ethanol concentration.

4. Conclusions

Using a SAW sensor, a wireless sensor without a battery is easily realized. In this paper, we discussed liquid measurement using the reflected type SH-SAW sensor. The obtained results strongly suggest that the SH-SAW wireless sensor for liquid will be realized by measuring arrival peak time. In future work, we try liquid measurement using an antenna.

Reference

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