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13.5 MHz impedance-loaded passive SAW sensor

13.5MHz 帯インピーダンス負荷パッシブ SAW センサ

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1. Introduction

In recent years, a surface acoustic wave (SAW) sensor has become an active area of research. SAW sensors have high sensitivities, do not require a battery to operate, and can be measured wirelessly in harsh environments [1]. 13.5 MHz band radio waves that are used in non-contact IC cards have the advantage that fewer operating error during correspondence. Because of these advantages, 13.5MHz SAW sensors are expected success as a passive wireless sensor that can be easily used in variety locations. This paper describes the fundamental properties and applications of 13.5 MHz impedance-loaded passive SAW sensor.

2. SAW sensor

The measurement system with the SAW sensor is shown in **Fig. 1**. When an interdigital transducer (IDT) receives input signal, the SAW is propagated on the substrate by inverse piezoelectric effect and reflected by a reflector on the SAW device. Reflected wave is converted to electrical signal at the IDT, and a signal is returned to the reader. Here, reflectivity of the reflector depends on the impedance of the reflector. Thus, if a classical sensor which impedance changes by physical quantity is connected to reflector, return loss has information of the classical sensor. We can measure physical quantity (temperature, humidity, pressure, etc.) without power supply and electric circuit at sensor.

The SAW device used was fabricated on a 128° YX-$LiNbO_3$. Electrode material of the IDT and reflector was an aluminum. Operating frequency was 13.5MHz.

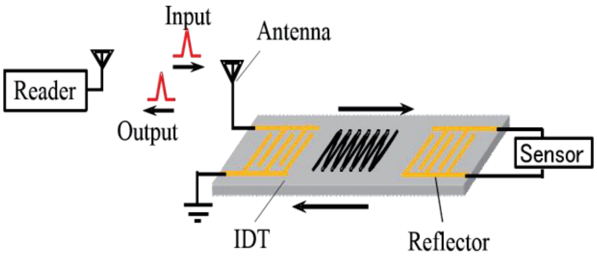

Fig.1　Measurement system in this study.

3. Fundamental characteristics

Echo amplitude was monitored by using a network analyzer (see **Fig. 2**). Capacitor was used to extend the sensing range of the sensor [2]. It can be seen the first echo amplitude emerges at 5 μs and is changed by the value of the resistor connected to the reflector. Relationship of the resistance and the first echo amplitude is shown in **Fig. 3**. Relationship of the capacitance and the first echo amplitude is shown in **Fig. 4**. The first echo amplitude was minimum for capacitor of 33pF.

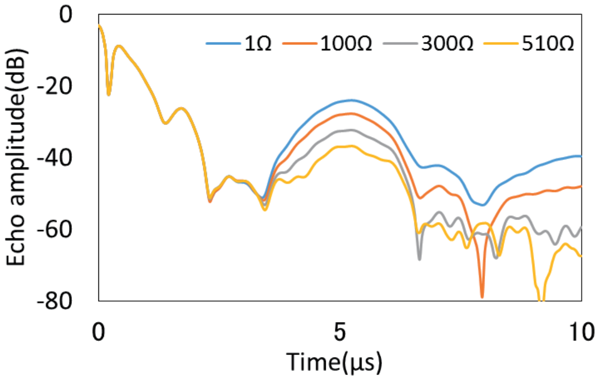

Fig.2　Time response.

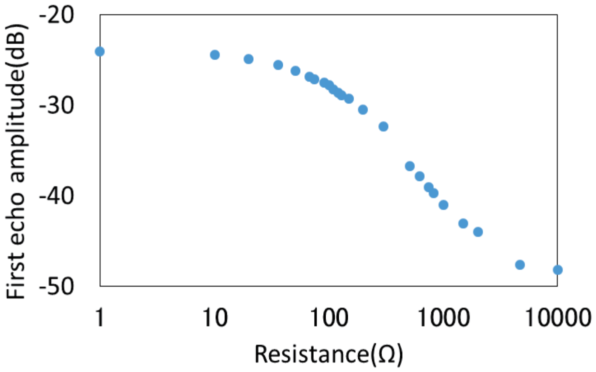

Fig.3　First echo amplitude as a function of resistance.

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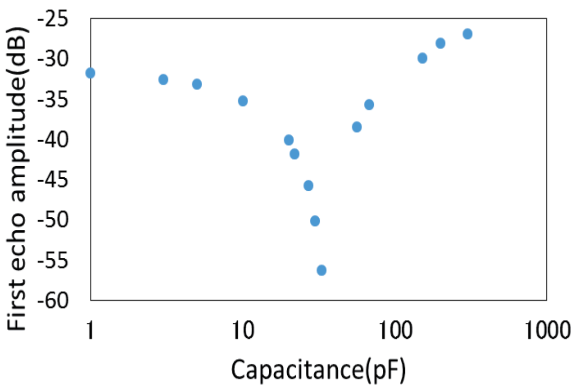

Fig.4 First echo amplitude as a function of capacitance.

From these characteristic, this sensor can measure various physical quantities when it is combined with the classical sensor.

4. Application to the vibration sensor

Based on the measurement results in previous section, we propose a passive vibration sensor using a parallel plate capacitor and the SAW sensor. The structure of the parallel plate capacitive sensor is shown in **Fig. 5**. The capacitance can be calculated by following equation:

$$C = \varepsilon \frac{S}{d} \tag{1}$$

Where ε, S, and d are the dielectric coefficient, electrode area, and interelectrode distance, respectively [3]. If the interelectrode distance changes due to vibration, the first echo amplitude changes based on the capacitance change as shown in Fig. 4. Therefore, we can detect a state of vibration by measuring the first echo amplitude.

In this paper, the first echo amplitude for the interelectrode distance was measured as fundamental research toward the realization of the passive SAW vibration sensor. The electrodes of parallel plate capacitor were made of capper plate. The electrodes had an area of 5 cm×5 cm. The electrodes were connected to the reflector of the SAW sensor, as shown in Fig. 5. In addition, one electrode was fixed, and another electrode was moved to an intended position by the z-axis stage whose resolution was 0.01mm. Capacitor of 33pF was connected in parallel to the electrodes for calibration and high sensitivity.

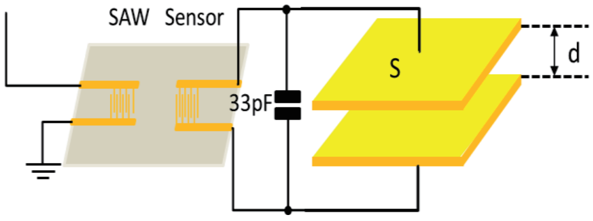

Fig.5 Structure of the parallel plate capacitive sensor.

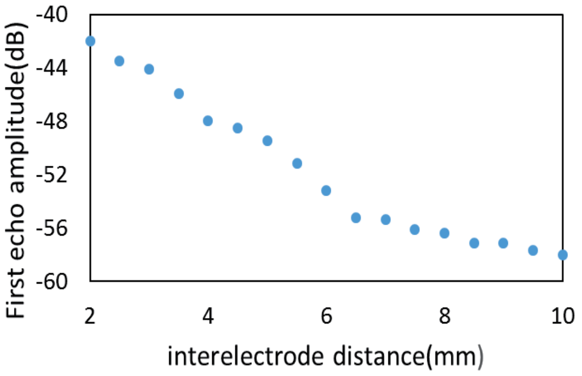

Fig.6 First echo amplitude for interelectrode distance.

First echo amplitude for interelectrode distance was measured by using the oscilloscope. The measurement result is shown in **Fig. 6**. The first echo amplitude was changed each time the interelectrode distance was increased 0.5 mm. Measurement result showed the possibility of detecting a vibration from the change of the first echo amplitude. It is necessary to adjust the electrode area for magnitude of the vibration.

4. Conclusion

In this paper, we describe the fundamental properties and applications of 13.5 MHz impedance-loaded passive SAW sensor fabricated. The sensor showed the potential to measure various physical quantities when it is combined with the classical sensor which impedance changes by physical quantity. Also, we propose a passive vibration sensor using a parallel plate capacitor and the SAW sensor. From the measurement result, proposed sensor showed the possibility of detecting a vibration. In future work, passive SAW vibration sensor will be carried out.

References

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