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Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 67-68
13-15 November, 2012

Combination of a surface acoustic wave device and classical sensor for detecting physical quantity 1- Simultaneous detection method of physical quantity and temperature -

弾性表面波素子と物理量センサを組合せた物理量計測１－物理量と温度の同時計測－

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1. Introduction

Combination of a surface acoustic wave (SAW) device and classical sensor has been reported[1-3]. As classical sensors normally need temperature compensation, it is important to measure temperature simultaneously. In this paper, we propose a combination system of the SAW device and classical sensors for simultaneous detection of physical quantity and temperature. Two reflectors on the SAW device are needed for simultaneous detections of physical quantity and temperature[4]. However, using our proposed method, both properties are obtained by using one reflector.

2. Physical quantity measurement

2.1. Measurement system

Figure 1 shows the measurement system in this study. An RF signal from network analyzer was fed to an interdigital transducer (IDT). The SAW propagates on the SAW device and is reflected by the reflector. The reflected SAW is reconverted into the RF signal by the IDT. The signal is received by the network analyzer and a reflection response (S11) is measured. Reflection coefficient of the reflector depends on impedance of the classical sensor. Therefore, physical quantities are estimated from the S11.

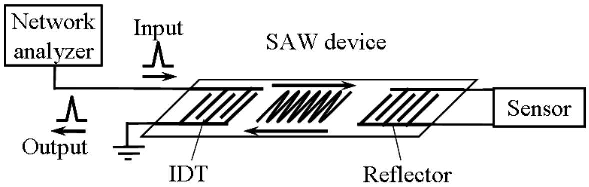

Fig. 1 Measurement system of the combined SAW devices and classical sensor

2.2. SAW device and classical sensor

A 128° YX $LiNbO_3$ was used for a substrate. The metal materials used for the IDT was aluminum. Operating frequency of IDT was 51.5 MHz. In this work, humidity sensor (HS-15P) and optical sensor (TPS610) were used for a classical sensor.

2.3. Results

S11 in time domain was measured by using network analyzer (**Fig. 2**). From Fig. 2, peak value of S11 was obtained around the 5.8μs. In this work, we measured the peak value of S11. **Figure 3** shows results of S11 as a function of humidity. **Figure 4** shows results of S11 as a function of optical power. The figures indicate that the relations between the sensor response and the physical quantity are liner. Therefore, physical quantity is estimated by measuring the peak value of S11.

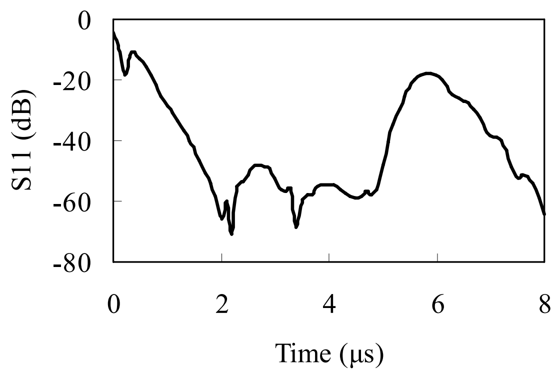

Fig. 2 S11 in time domain.

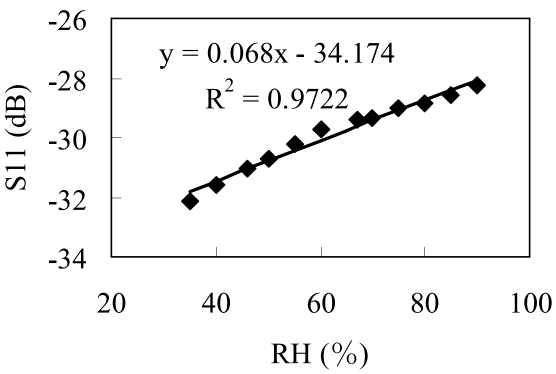

Fig. 3 Results of S11 as a function of humidity.

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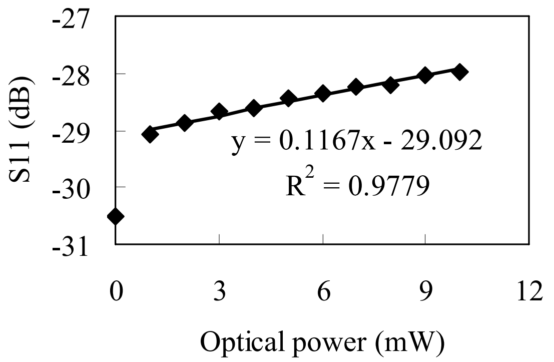

Fig. 4 Results of S11 as a function of optical power.

3. Temperature measurement

As the SAW velocity of 128° YX $LiNbO_3$ varies with temperature, the time response is also influenced. **Figure 5** shows the time response with impedance as a parameter. Normally, the temperature was estimated from peak time shift. However, from Fig. 5, peak time of S11 is depends on impedance. The temperature is not estimated from the peak time. On the other hand, from Fig.5, the time response is not varied around the 5.0μs when impedance is changed. Therefore, by evaluating time shift around the 5.0μs, temperature can be estimated. **Figure 6** shows the time response around the 5.0μs when temperature of SAW device was varied. From Fig. 6, it is found that the response shifts to the left, when temperature of SAW device was risen. This means that SAW velocity increases. We measured S11 at 5.0μs with changing the SAW device temperature. **Figure 7** shows the time shift as a function of the temperature. The reference was 20°C. Relationship between the time shift and temperature is linear. Therefore, the temperature and physical quantity are simultaneously estimated by measuring the relationship between the time shift and peak value of S11.

4. Conclusion

In this paper, we discussed simultaneous detection method of physical quantity and temperature by combining SAW device and classical sensor. The peak value of S11 was proportional to the physical quantity. Also, the time shift around the 5.0μs was proportional to the temperature. Therefore, the physical quantity and the temperature are simultaneously estimated by measuring the peak value of S11 and time shift around the 5.0μs. The SAW device is operated without a battery, and is available in wireless. Therefore, our method will be applied to a wireless sensing system.

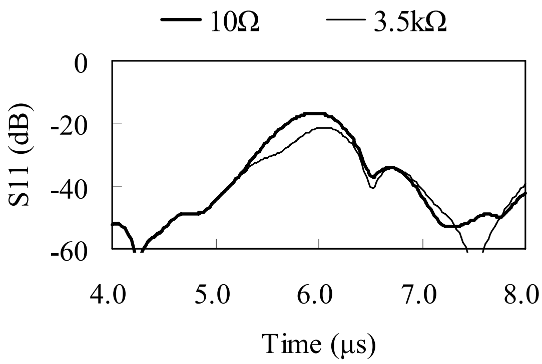

Fig. 5 Time response when impedance value of connecting reflector was varied

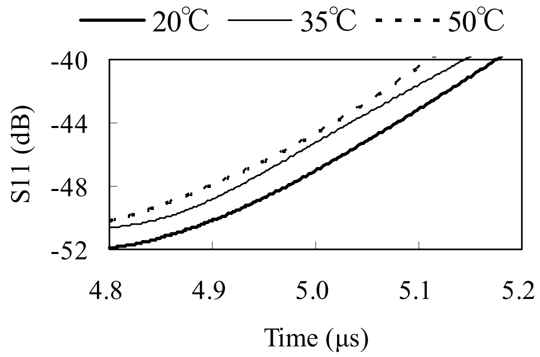

Fig. 6 Time response around the 5.0μs when SAW device temperature was varied.

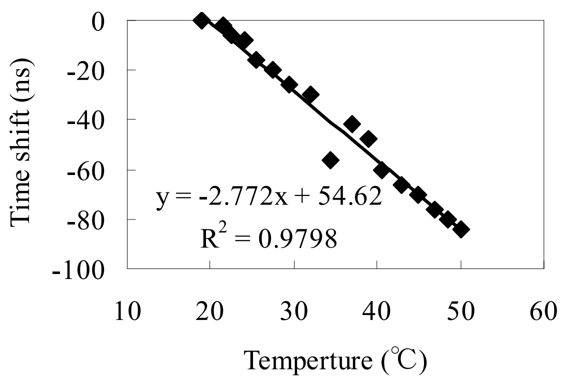

Fig. 7 Results of time shift as a function of temperature.

References

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