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Development of Methanol Sensor Using Shear Horizontal Surface Acoustic Wave Devices for Direct Methanol Fuel Cell

横波型弾性表面波素子を用いた DMFC 用メタノールセンサの開発

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1. Introduction

A direct methanol fuel cell (DMFC) can generate power using methanol (MeOH) solution as fuel. It is promising as an electric source for mobile devices, small vehicles and so on. As output power of the DMFC is depended on concentration of MeOH, it is necessary to keep optimum concentration range of MeOH. Therefore a MeOH sensor is needed.

We have developed MeOH concentration sensor using shear horizontal surface acoustic wave (SH-SAW) [1]. The feature of SH-SAW sensor is to detect viscosity and density product, conductivity, permittivity of liquids at the same time [2]. As relationship between the concentration and the permittivity of methanol is linear, the SH-SAW sensor can detect MeOH concentration. In this paper, we discuss influence of sensor frequency for MeOH detection.

2. SH-SAW sensor and measurement system

Fig. 1 shows a schematic of the SH-SAW sensor. Dual delay lines were fabricated on the 36YX-$LiTaO_3$. One delay line was electrically shorted and affected by mechanical perturbation. The other is electrically opened and affected by mechanical and electrical perturbation. Electric perturbation was obtained by detecting differential signals. A floating electrode unidirectional transducer (FEUDT) was used for generating and receiving SH-SAW.

Fig. 2 shows the measurement system. In order to simulate the operating environment of DMFC, the measurement system consists of a pump circulating liquid, a constant temperature reservoir, a flow cell, a signal generator, a vector voltmeter and an SH-SAW sensor. The measurement was carried out by loading liquid on the sensing area of sensor through the flow cell. The temperature controlled chamber was used for changing temperature. Phase shift and amplitude ratio between delay lines were obtained using the vector voltmeter. The center frequencies of SH-SAW sensors used were 51.5 and 155 MHz.

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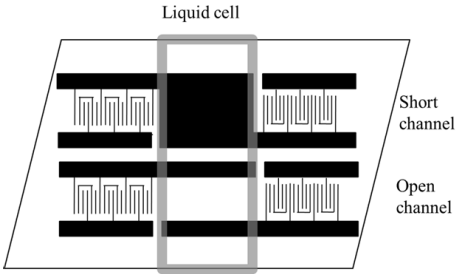

Fig. 1. Schematic of SH-SAW sensor.

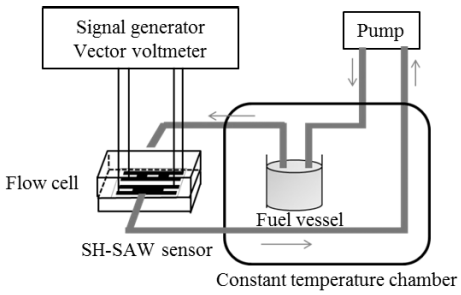

Fig. 2. Measurement system.

3. Results and discussion

3.1 MeOH concentration

The concentration range of MeOH solution used in DMFC is from 0 to 20wt%. We carried out the measurement of varying MeOH concentration in the concentration range. **Fig. 3** shows the measurement result. The frequency of SH-SAW sensor used in the measurement was 155MHz. Measured concentration of MeOH solution was1, 3, 5, 10, and 20 wt%. The sample liquid temperature was kept at 20 °C.

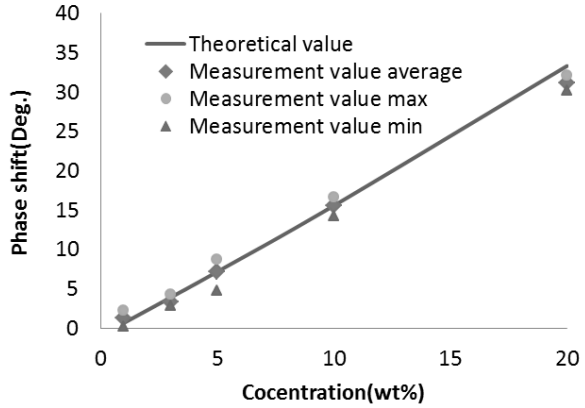

Fig. 3. Phase shift as a function of methanol concentration.

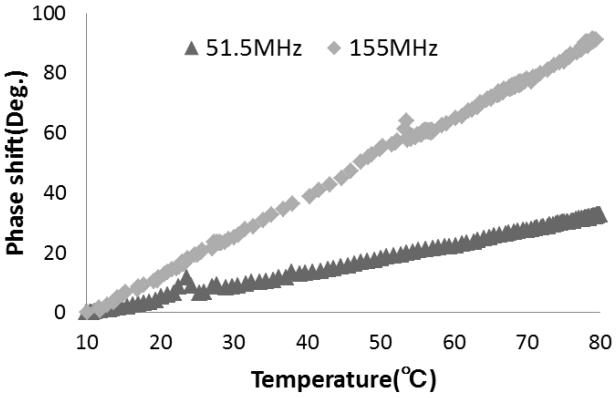

Fig. 4. Phase shift as a function of temperature.

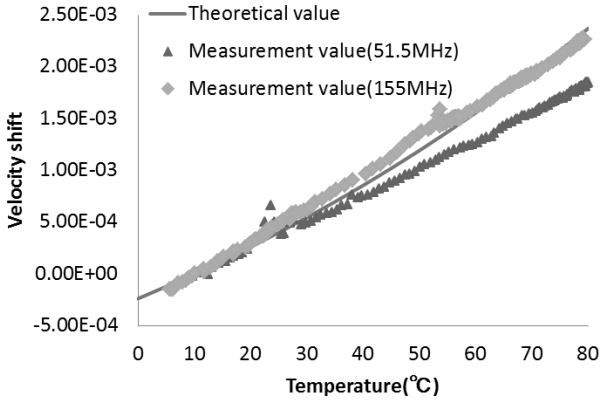

Fig. 5. Velocity shift as a function of temperature.

Sensor responses were obtained phase shift relative to distilled water (0 wt%). Phase shift linearly increases as the concentration increase. To confirm the validity of the response, the measurement value obtained was compared with the theoretical value obtained from the sensor sensitivity equation [1]. The measurement value was much the same as the theoretical value. Therefore, it is shown that the SH-SAW sensor is capable of measuring MeOH concentration based on the theory of the sensor sensitivity equation.

3.2 Influence of temperature

The operating temperature range of DMFC is approximately from 10 to 80°C. We carried out the measurement of varying MeOH solution temperature in the temperature range. The center frequencies of SH-SAW sensors used in this measurement were 51.5 and 155 MHz. The results are shown in **Fig. 4**. Measured concentration of MeOH solution was 3 wt%. Sensor responses were obtained phase shift relative to 10 °C. Phase shift increases linearly as the temperature increase. 155 MHz sensor has a higher sensitivity than 51.5 MHz one. To confirm the validity of the sensor responses, the measurement values obtained were compared with the theoretical value obtained from the sensor sensitivity equation. The velocity shift is derived from the phase shift. The result of velocity shift compared the experimental values with the theoretical value is shown in **Fig. 5**. The experimental value of 155 MHz sensor is much the same as the theoretical value, because 155 MHz sensor is insulated from the influence of conductivity of MeOH. Therefore, it is shown that the SH-SAW sensor of 155 MHz is capable of measuring based on the theory of the sensor sensitivity equation in the operating temperature range of DMFC.

4 Conclusion

In this paper, we describe the application of MeOH sensor using SH-SAW for the DMFC. The concentration range of MeOH solution used in DMFC is from 0 to 20 wt%. From the result of the measurement, it was shown that the SH-SAW sensor is capable of measuring MeOH concentration based on the theory of the sensor sensitivity equation in the concentration range, when the temperature MeOH solution is constant. The operating temperature range of DMFC is approximately from 10 to 80 °C. From the result of the measurement, it is shown that the SH-SAW sensor of 155 MHz is capable of measuring based on the theory of the sensor sensitivity equation in the operating temperature range of DMFC.

In future work, an experiment to connect SH-SAW sensor in DMFC will be carried out.

References

1. S. Endo, et al; Jpn. J. Appl. Phys. , Vol.51 (2012), 07GC19.
2. J. Kondoh; IEEJ. C. **131** (2011) 1094. [In Japanese]