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Methanol sensor using shear horizontal surface acoustic wave sensing system

横波型弾性表面波センシングシステムを用いたメタノール濃度センサ

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1. Introduction

The feature of shear horizontal surface acoustic wave (SH-SAW) sensor is to detect viscosity and density product, conductivity, and permittivity of liquids at the same time[1]. In this work, we focus on the permittivity measurement and apply this feature to methanol (MeOH) sensor for direct methanol fuel cell (DMFC) [2, 3].The fuel of DMFC is MeOH solution. The battery charge is not necessary for DMFC. It also can be miniaturization. In this case, high concentration of MeOH solution is used as fuel. In constant, the small percent of MeOH solution is used for high-power one. The output power is depended on concentration of MeOH. This concentration needs to put under monitoring at all time. The way to do this is to calculate from output voltage. However, MeOH sensor for DMFC that cheap and high accuracy is not existance. Therfore, we carry out reserch and development regarding MeOH sensor using SH-SAW. In this paper, we describe on the concentration measurement baseed on the operating temperature of DMFC and the aging characteristic concerning MeOH solution.

2. SH-SAW sensor and measurement system

Fig. 1 shows a schematic of SH-SAW sensor. Two delay lines were fabricated on the 36YX-$LiTaO_3$. One delay line is electrically shorted and affected by mechanical perturbation. The other has free surface area and affected by mechanical and electrical perturbation. Only electric perturbation can be obtained by detecting differential signal. A floating electrode unidirectional transducer (FEUDT) is applied for generating and receiving SH-SAW. The SH-SAW sensor was bought from Japanese Radio Co. Ltd. The measurement was carried out by loading liquid on the sensing area of sensor. A constant temperature reservoir was used for changing temperature. The measurement system consists of a signal generator and a vector voltmeter. Phase shift and amplitude ratio between delay lines were obtained by using the vector voltmeter. The center frequency of our SH-SAW sensor was 51.5MHz. MeOH solution which concentration has been adjusted was used for the experiment. Distilled water at 25°C was used as the reference.

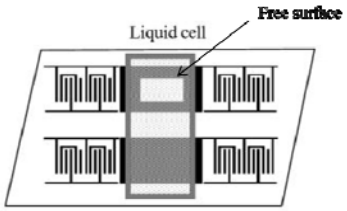

Fig. 1. Schematic of SH-SAW sensor.

3. Results and discussion

The highest operating temperature of DMFC is 80°C. Also, the lowest temperature is different according to the installation environment. Then, in this experiment, temperature was changed from -5°C to 80°C at intervals of 5°C. Experiment results of the phase shift and amplitude ratio between distilled water and MeOH solutions are shown in **Fig. 2**. The relative permittivity of MeOH decreases by the temperature rise (Fig. 2(a)). As a result, the phase shift increases thus the velocity increases. Therefore, the obtaining results are reasonable. The responses are seemed to vary at the high temperature. It is assumed that bubbles are generated on the sensor surface. On the other hand, amplitude ratio is almost constant compared with the temperature (Fig. 2(b)). Amplitude ratio remains static if electrical conductivity is zero. Therefore, this result is also reasonable.

Then, the experiment that was rapidly changed the temperature from 10°C to 80°C was measured. **Fig. 3** shows the results for the 3wt% MeOH solution. The result of measuring the temperature has been changed at intervals of 5°C for comparison is also shown in figure. Both results agree well.

The DMFC generally operates for a long period. Hence, the long time stability of SH-SAW sensor at constant temperature condition was examined. When the temperature has kept 55°C, the bubbles are appeared. Therefore, the experiment

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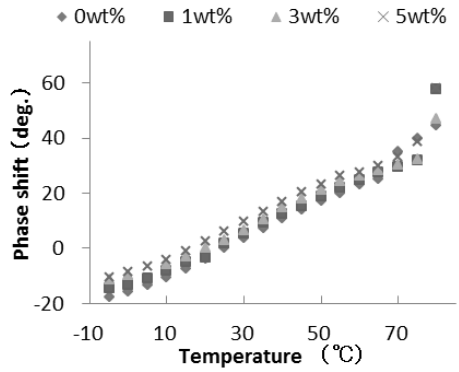
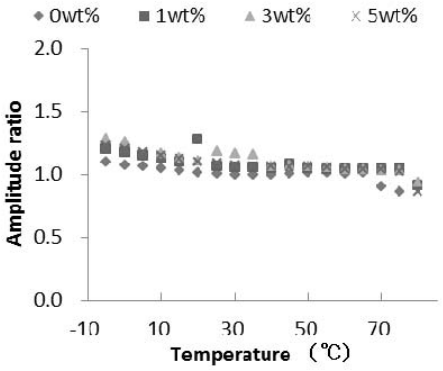


(a)



(b)

Fig. 2. (a) Phase (b) amplitude ratio as a function of temperature. Parameters are MeOH concentration.

was performed at 25°C that the bubbles are not generated. In this experiment, distilled water at each measuring time was used as the reference. From **Fig. 4**, phase shift has the stable value. These figures are parallel with the time axis, and no drift.

Countermeasure of bubbles is important in practical application. In above experiment, sample liquid is sealed in a pool. However in fact, the liquid fuel is circulated in DMFC. We consider that adhered bubbles may be possible to peel away. Therefore, we conduct the experiment circulated MeOH solution by pump. The result of 3wt% MeOH solution is shown in **Fig. 5**. In cases where pump don't use, by the effect of bubbles, phase shift is increased with time. Compared with this case, result of using pump has constant value.

4. Conclusion

In this paper, we report on the results of a study of methanol sensor using SH-SAW sensing system for DMFC. From the present study, the SH-SAW sensor responses depend on the concentration of MeOH under the environment for the temperature changed and long time period. Also, we can show that it is possible to remove the bubbles by circulating liquid with pump. However, we only take account of the concentration of MeOH solution. However, as a matter of fact, the formic acid is generated into MeOH solution by the electrode reaction. The formic acid changed the electrical characteristic of liquid. Accordingly, it is necessary to conduct an experiment considering of this matter.

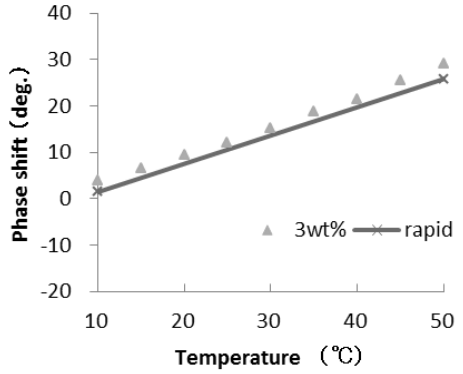


Fig. 3. Influence of the temperature rapidly rising.

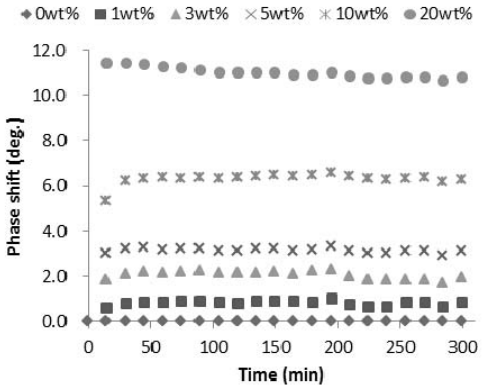


Fig. 4. Long time stability of the SH-SAW sensor with MeOH solution.

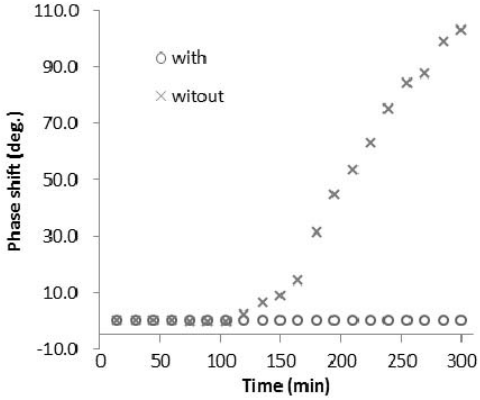


Fig. 5. Comparison of the results when there is circulation with and without pump.

References

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