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Development of methanol sensor using SH-SAW for direct methanol fuel cells

SH-SAW を用いたダイレクトメタノール燃料電池用メタノールセンサの開発

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1. Introduction

Recently, fuel cell has been required as next generation energy because of environmental issues. A direct methanol fuel cell (DMFC) is one of the fuel cells [1]. The DMFC is expected to be used for mobile phones or laptops. The efficiency of DMFC depends on methanol concentrations, so it requires methanol sensor. We have investigated a shear horizontal surface acoustic wave (SH-SAW) sensor for it [2]. When liquid is placed on a sensor substrate, the SH-SAW sensor detects several liquid properties, such as permittivity, conductivity, viscosity, and density. Additionally, the SH-SAW sensor has many advantages, such as high accuracy, robust and low cost. It is expected to be applied for an alcohol sensor.

In this paper, we present a methanol senor using SH-SAW for the DMFC. First, aging of the SH-SAW sensor is tested. Second, binary mixture solutions of methanol and formic acid are measured.

2. Experimental

A 36YX-$LiTaO_3$ was used as the SH-SAW sensor substrate. On the substrate, a floating electrode unidirectional transducer (FEUDT) was fabricated [3]. The FEUDT can reduce the TTE and improve the insertion loss. The center frequency of the sensor was 51.5 MHz.

Experimental system is shown in Figure 1. The signal was fed from a signal generator to the SH-SAW sensor and the output was monitored by a vector voltmeter.

To measure solutions in high temperature, we used desktop high temperature chamber, for changing liquid temperature from 25 to 80 ℃.

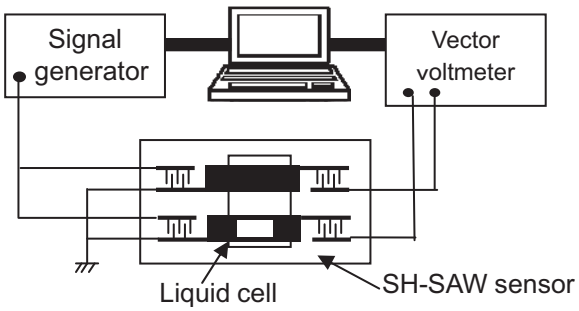

Fig.1 Measurement system.

3. Results and discussion

When the SH-SAW sensor is used for methanol concentration monitor in the DMFC, it is continuously utilized. Due to the electrode reaction in the DMFC, several components, for example formic acid, are generated. If the SH-SAW sensor is influenced by those, realization of the SH-SAW sensor for the DMFC is impossible. Therefore, influence is tested. Circulating solution of 80 ml in the DMFC was extracted. The SH-SAW sensor was dipped in it. Then, those was kept at 80℃. Figure 2 shows that frequency characteristics before and after 744h in the solution. The both results agree well. Therefore, we conclude that the SH-SAW sensor is not influenced by the solution in the DMFC.

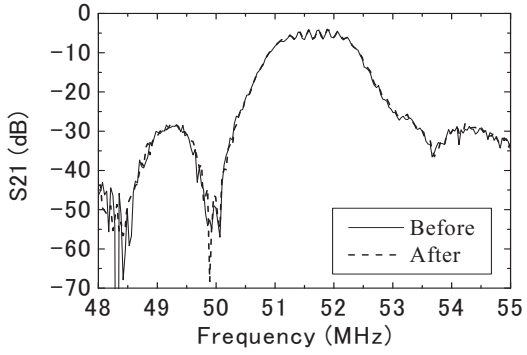

Fig. 2 Frequency characteristic of SH-SAW sensor before and after 744h in the DMFC.

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Secondly, we measured methanol solution at the concentration of 3, 5, 7, 10, 20 and 30 wt%. The measured temperature was varied from 25 ℃ to 80 ℃. Figure 3 shows the results. Reference was distilled water at 25 ℃. The results agree with previous ones, which were measured by a SH-SAW sensor with an IDT [3]. Linear relationships between temperature and phase shift are obtained. Also, at high temperature, the SH-SAW sensor can measure methanol concentration with high sensitivity.

Finally, we measured the mixture solutions of methanol and formic acid. During electrode reactions in the DMFC, formic acid is generated. Figure 4 shows the measured result of mixture solution and methanol concentration is fixed at 3 wt%. As methanol concentration increases, the phase shift increases due to the permittivity. As formic acid concentration increases, the phase shift decreases and amplitude ratio is decreased due to the conductivity. We also measured mixture solution for methanol concentration 10 and 20 wt%. Each concentration can be estimated using ΔV/V -Δα/k plane as shown in Fig. 5, where ΔV/V and Δα/k are derived from phase shift and amplitude, respectively. Using ΔV/V and Δα/k, we expect to estimate the concentration of methanol in the mixture solution.

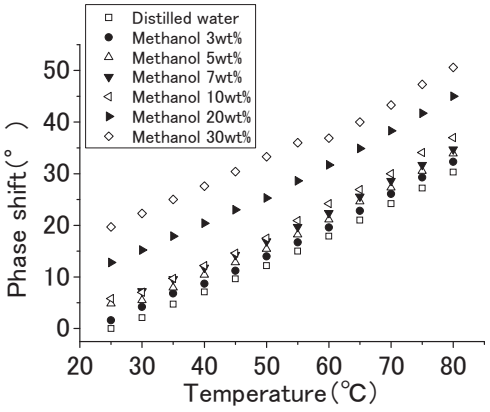

Fig. 3 Experimental result of methanol solution measuring phase shift.

4. Conclusion

In this paper, methanol solution was measured using the SH-SAW sensor for practical use in the DMFC. We found that the SH-SAW sensor is not influenced from circulating solution in the DMFC. This means that the SH-SAW sensor using 36 YX-$LiTaO_3$ can be applied to methanol sensor for the DMFC.

Methanol solutions were measured from 25 to 80℃. Furthermore, mixture solutions of methanol and formic acid were measured, because formic acid is involved in the circulating liquid in the DMFC. From the results of mixture solutions, methanol concentration will be obtained from the phase shift or ΔV/V. For practical use, developed SH-SAW sensing system with compact and low cost is required.

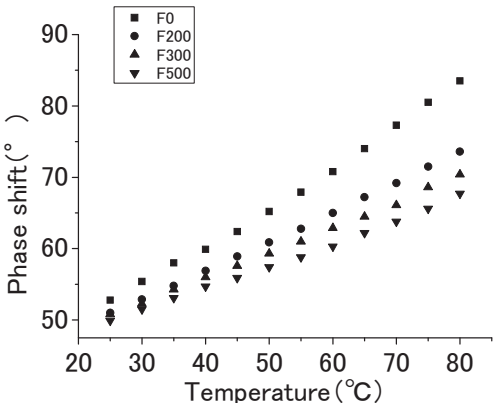

Fig. 4 Experimental result of mixture solution measuring phase shift.

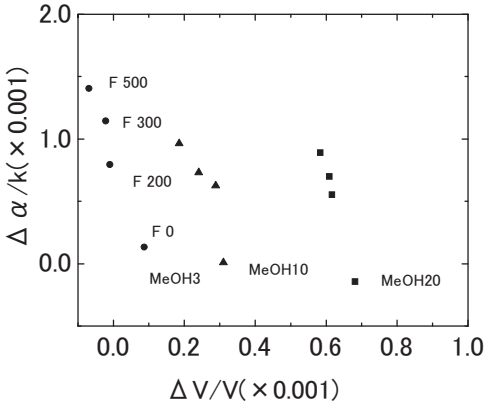

Fig. 5 Measurement result of mixture solutions on (ΔV/V)－(Δα/k) plane at 25℃.

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