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Flow Connecting Type SH-SAW Methanol Concentration Sensor for Direct Methanol Fuel Cells

直接メタノール燃料電池向け流路設置型 SH-SAW メタノール濃度センサ

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1. Introduction

With expanding functions of mobile IT gadgets, such as smart phones, their battey duration time has been continuing to shorten. In addion to these situations, due to the tremendous earthquake on March 11, 2011 in eastern Japan, necessity of wide variety of electric power generating methods have been realized. A direct methanol fuel cell (DMFC) is one of the most promising candidates of next generation mobile power sources. Methanol, which provides electricity to DMFC, preserves electricity more efficient than conventional lithium-ion battery in same weight. The energy preserving efficiency is quite important. Energy storage efficiency brings long-lasting and/or lighter power source to final products. In order to operate DMFCs at optimal electricity generating efficiency, maintaining the concentration of methanol in the fuel is absolutely imperative. In case lower concentration fuel, generating electricity can be reduced. On the other hand, higher concentration causes a methanol cross-over, which is a fuel consumption without electricity generation. The cross-over leads not only unwanted fuel waste, but also shortening DMFC's lifetime. While optimal concentraion value vary among configuration of DMFC, around 1M (~3% by weight) is widely used [1]. For the purpose of monitoring methanol concentrations, wide variety of sensing method has been developed [2]. Though proposed methods has respective advantages, ultimate device which satisfies all of the requirement from DMFC does not exist. Surface acoustic wave based methanol concentration sensor has been developed as one of the promising technology for DMFC's fuel control. SAW based device suits massproduction, because SAW technologies have been widely used in the communication industory for over the past several decades and well established production technologies. Thease SAW advantages bring significant benefits to DMFC in price reduction. A purpose of our study is to provide SH-SAW methanol concentration sensors to DMFC manufacturs in reasonable price and easy-to-use configuration.

2. Test model configuration

Previous trial products were assumed to be used at a fundamental experiment. The former products are called dip type sensor because they are directly dipped into specimen liquids [3][4]. Dip sensors have an advantage of easy to use in fundamental experiment. However, in the actual DMFC applications, the dip type sensors face typical difficulties, such as sealant problem and bubble contact onto the sensor surfaces. Sealant problem is connected with DMFC's reliability. On the other hand, bubbles deteriorate sensing capabilities seriously. To solve these problems flow-cell type sensor has been developed, schematic drawing and photograph of the prototype are shown in **Fig. 1 and 2**. The prototype consists

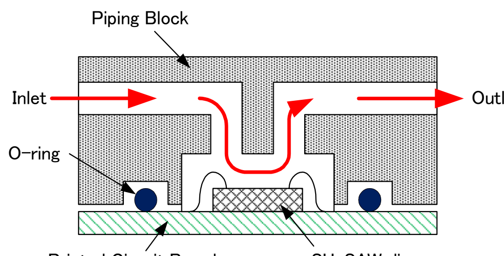

Fig. 1 Cross-sectional view of developed flow-cell type Methanol concentration sensor

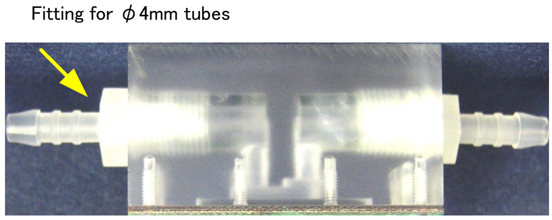

Fig. 2 Photograph of fabricated flow-cell type Methanol concentration sensor

of a SAW device mounted printed-circuit board (PCB) and a piping block which specimen methanol aqueous passes. The PCB and piping block are sealed with a conventional O-ring. On the piping block, commercial ϕ4mm size barbed tube-fittings are attached for easy installation into every DMFC system.

3. Experiment and Result

In order to investigate fundamental measurement response of the flow type sensor, we measured methanol concentration following capability of the SH-SAW sensor system. An experiment was conducted by adding accurately measured pure methanol into circulating a certain amount of deionized water. Measured concentrations of methanol aqueous are 0wt% (deionized water), 0.5wt%, 1wt%, 2wt%, 5wt%, 10wt%, and 15wt%. Finally, to confirm the repeatability of the sensor, produced methanol aqueous was replaced by deionized water for measuring 0wt% concentration again. Schematic drawing of the experimental setup is shown **Fig. 3**. In this experiment, methanol concentration was measured as phase shift of SAW device. Measured phase shift is shown in the left axis of **Fig. 4**. This result shows concentration following capability is extremely quick. In all measured concentration, phase shift values have been stabilized within a few second. A correlation between phase shift and methanol concentration has been derived from an experiment with the dip sensor [4]. Derived standard curve shows phase gradient is about 2.4

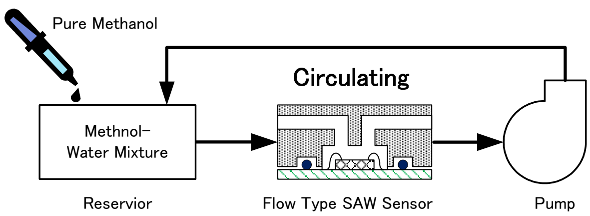

Fig. 3 Schematic drawing of methanol concentration following experiment setup

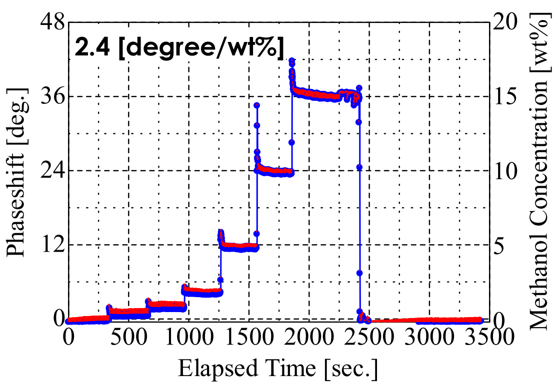

Fig. 4 Measured phase shift value and calculated methanol concentration

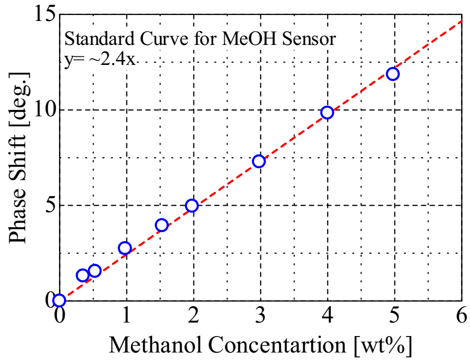

Fig. 5 Derived correlation between methanol concentration and phase shift using dip type sensor

[degree/wt%], **Fig. 5**. By applying this coefficient to the measured result, finally, methanol concentration is obtained as right axis of Fig. 4. This result is in excellent agreement with prepared methanol aqueous concentration value. This agreement shows that both dip type system and flow type system have same phase-concentration correlation. Besides, as for bubble problem, during this around one hour experiment discontinuous phase jumps were not detected. This is assumed to be due to bubbles were kept away from sensor surface by the effect of liquid flow.

4. Conclusion

To solve bubble and sealant problems, which may affect on stable measurement, flow type SH-SAW sensor has been developed and evaluated. In the evaluation, the developed flow type system showed same measurement characteristics as dip type system. This fact demonstrates system configuration does not affect fundamental properties of SH-SAW sensors. Especially, a concentration following capability is excellent; in many cases sensor output value stabilized in a few seconds. The bubble and sealant problems, which are motivation for this development, have been well resolved in the initial stage. However, these problems require long term follow-up measurements.

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