DEVELOPMENT AND FIELD EVALUATION OF ISFET PH SENSOR INTEGRATED WITH SELF-CALIBRATION DEVICE FOR DEEP-SEA OCEANOGRAPHY APPLICATIONS

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ABSTRACT

An ISFET (ion sensitive field effect transistor) based pH sensor integrated with a microfluidic device for sensor calibration has been developed and evaluated in this study. A PDMS microfluidic device is mounted on a commercially available pH ISFET to supply pH standard solutions during filed operations. As a result of the first real filed deployment of the device at deep-sea environment, drifting problem of pH ISFET was successfully compensated and reliable seawater pH value was obtained.

KEYWORDS: Ion sensitive field effect transistor, pH, Polydimethylsiloxane, Deep-sea

INTRODUCTION

An ISFET pH sensor has been applied to environmental studies in the field of oceanography because of its durability and quick responses compare to glass made pH electrodes [1]. In this research, the ISFET pH sensor that integrated with a PDMS microfluidic device (Fig. 1) has been developed, evaluated and operated in the deep-sea environment. The PDMS microfluidic device is mounted on the pH ISFET to perform self-calibrations because the pH ISFET shows gradual drifting of sensor property during long-term pH measurements [2]. Microchannels on the PDMS microfluidic device enable to supply pH standard solutions or samples to an ion sensitive gate area of the pH ISFET.

PDMS-pH ISFET DEVICE

The PDMS microfluidic device was developed in 2 layers format to make a through hole chamber structure and microchannels (Fig. 2). The chamber structure that has an outlet and 3 inlets was fabricated onto a bottom layer PDMS and fixed on the pH ISFET. The chamber was connected to microchannels on a top layer PDMS. 2 inlets for pH standard solutions are connected to a plastic bag that filled with each seawater-based pH standard solution (amp: pH 6.7 and tris: pH 8.09) [3], respectively. Solenoid valves are used to control supply of each standard solution. The microchannel for sample water is directly opened to the environment without valve control to reduce dead-volume caused by additional valve, tubing and connector. Filter structure was placed on entrance of water samples to avoid channel clogging. An annular gear pump is connected to the outlet channel for continuous fluid pumping.

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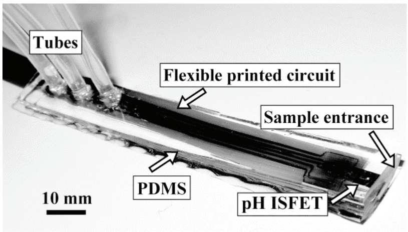

Figure 1. pH ISFET sensor integrated with the PDMS microfluidic device

Working principle of the device is illustrated in Fig. 3. When both of the valves for pH standards are closed, sample water is supplied onto the ion sensitive gate. When one valve is opened, both sample water and selected standard solution are comes into the chamber. Because of difference of pressure drop between the microchannels for the sample and the standards, only the standard solution flows through onto the ion sensitive gate and the pH ISFET can be calibrated.

RESULTS AND DISCUSSION

As a result of evaluation in a lab environment, values from pH ISFET indicated that the stream of sample water and standard solution was successfully controlled and pH of artificial seawater and standard solutions were correctly measured (Fig. 4). The developed sensor system was operated in real deep-sea environment in Jan. 2008 at Off-Hatsushima Island, Sagami bay, Japan (Cruise No. NT08-03). The pH sensor system was mounted on an underwater vehicle (HYPER-DOLPHIN, JAMSTEC, Japan). As a result, the pH ISFET with PDMS microfluidic device was successfully operated during the dive. With conventional calibration method, output signal from the pH ISFET was drifted (Fig. 5A). After a correction of the value by using all of the data obtained by *in situ* self-calibration, the effect of the drifting phenomena was successfully compensated and reliable average pH value of 7.7 was obtained at deep-sea bottom (Fig. 5B).

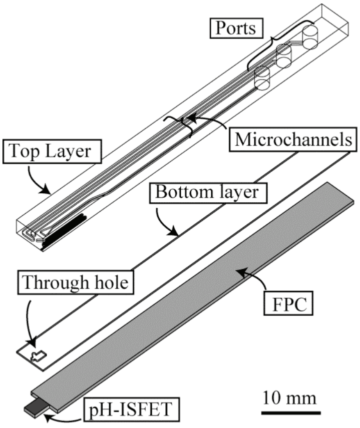

Figure 2. Schematic view of the PDMS microfluidic device.

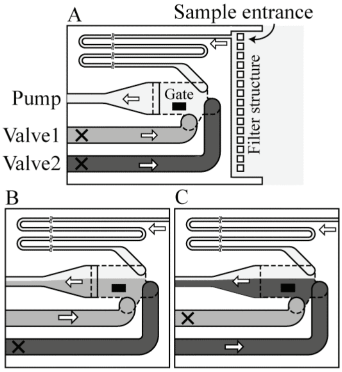

Figure 3. Schematic view of the PDMS microchannel. Arrows indicate flow direction. A: Both valves are closed. B, C: One of the valves is opened for calibration.

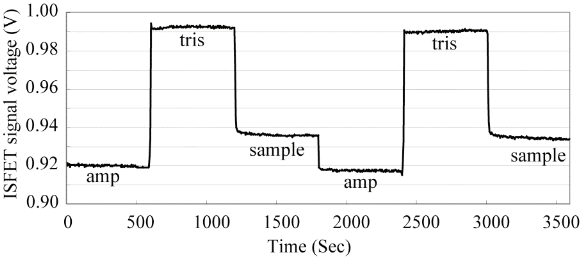

Figure 4. Evaluation of the self-calibration operation. 10 minutes for each state.

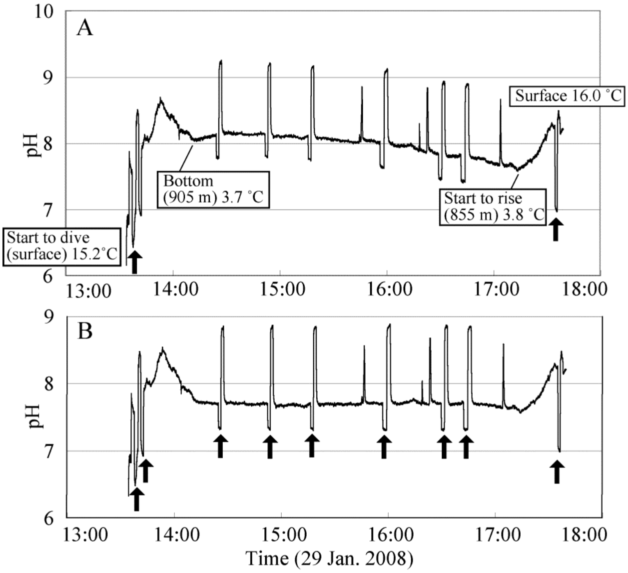

Figure 5. Result of the in situ operation of the device. Arrows indicate the calibration data used for calibration. A: Only 2 data were used to simulate conventional on board calibration. B: Corrected data by using all calibration data.

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