Correction of Sensor Inaccuracy Arising from Drift based on a Signal Processing Technique

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Abstract

A compensation technique for correction of drift will be presented which allows accurate monitoring of sensor response without the need for frequent recalibrations. This technique is based on signal analysis in the time-domain, and requires accurate characterization of drift as well as the ability to distinguish between drift and low-frequency noise. The validity of this technique has been verified by *in vitro* continuous monitoring of pH under conditions approximating acute metabolic acidosis using a Si_3N_4-gate pH-sensitive ISFET[1,2]. While development of a physical model for drift in pH-sensitive ISFET's[3,4,5] was undertaken in an attempt to find a solution for device instability, the proposed technique considers the influence of drift on the dynamic behavior of the sensor and is independent of the exact cause of drift. In our presentation the proposed corrective scheme will be discussed from a theoretical standpoint, and the requirements for its applicability will be outlined. The most significant results from application of this scheme to *in vitro* correction of instability in pH ISFET's will be demonstrated.

Instability in sensor response, commonly known as drift, introduces the need for frequent recalibrations, thereby increasing operating costs. While drift is generally ascribed to aging and environmental factors, the specific causes of drift are difficult to identify, particularly in light of the random nature of this phenomenon. Development of physical models for drift compensation is, therefore, a challenging task. The relatively slow, temporal variation characterizing drift, however, can be of value to its correction, if this phenomenon can be distinguished from sources of low-frequency noise, such as the inherent $1/f$ noise in semiconductors or transmitted noise originating from an external source of vibration. Since progress in semiconductor technology has resulted in a significant reduction in $1/f$ noise, in the absence of a major source of transmitted low-frequency noise, the lower limit on the frequency of the stimuli monitored by the sensor is imposed by drift. The proposed method is based on continuous monitoring of the change in the sensor output signal over sufficiently small intervals of time, and is equivalent to deriving the sensor response by integrating the differential of the output signal arising only from changes in the analyte concentration.

A Si_3N_4-gate pH-sensitive ISFET was biased in the feedback mode at a drain-to-source current of 100 μA and was exposed to a pH=7 buffer solution with 0.05M phosphate monobasic and 0.142M KCl concentrations. The ISFET was used for continuous monitoring of pH under conditions approximating severe acidosis conditions. In order to simulate acidosis, the pH drop was induced by adding 50 μL of HCl at 5min intervals and the gate voltage was monitored at 3-second intervals. During this experiment, the pH was also monitored using a Piccolo Plus™ pH meter with an accuracy of ±0.01 pH unit. The ISFET pH response during the experiment is shown in Fig. 1, where the initial large drift magnitude can be readily identified. The resulting decrease in pH estimated based on our corrective scheme is compared with that measured using the pH meter in Fig. 2.

References

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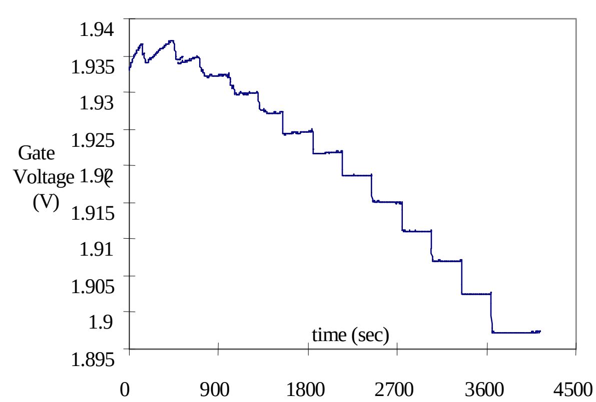

Fig. 1 pH Response of a Nitride-gate ISFET

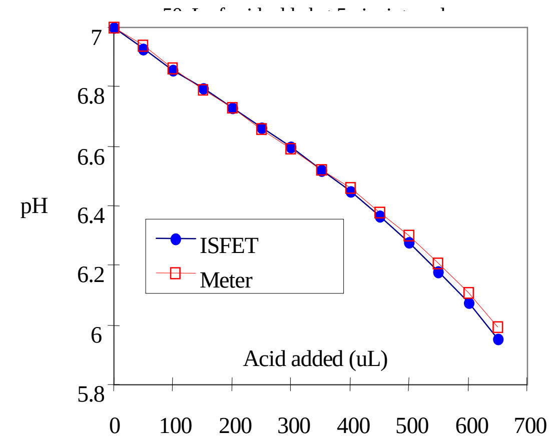

Fig. 2 Measured vs Corrected pH

50uL 2N HCl added every 5min