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Lateral Double-diffused Metal Oxide Semiconductor for Sensor Applications

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Abstract :
In this study, we applied LDMOS using floating gate structure for chemical pH sensors. We confirmed the pH response characteristics of the proposed device. With this approach, pH-sensitive devices can be fabricated for chemical and biological sensor applications. To demonstrate the properties, we performed a response experiment by changing the pH value from pH 4 to pH 10. Results showed that the sensitivity of the proposed sensor to detect pH buffer solution was 1.5 nA/pH. The result of sensor application experiment proved that the LDMOS can be used to realize a sensor in chemical and biological sensor applications. Therefore, the proposed device was expected to be applicable to the design of pH-sensing devices in chemical and biological sensor applications.

Key words: LDMOS, chemical sensor, pH, ISFET, floating gate.

Introduction

The pH sensors have been utilized in a wide range of applications, including support of basic research, monitoring the environmental condition, manufacturing and processing of food, and monitoring chemical processes.

A pH sensor based on a field-effect transistor (FET) was demonstrated by the employment of the structure of an ion-sensitive field-effect transistor (ISFET). The ISFET, first described by Bergveld in the 1970s, was introduced as the first miniaturized silicon-based chemical sensor [1]. Owing to their small size, low cost, low power consumption, fast response time, and excellent compatibility, ISFETs are superior to conventional ion-selective electrodes (ISEs) [2], especially in chemistry and biomedicine [3].

In general, lateral double-diffused Metal Oxide Semiconductor (LDMOS) transistor have been widely used in the high voltage switching ICs, which as RF power amplifier, level shifter, line driver, power management, since they are beneficial to simplify the circuit design [4]-[8]. However, as far as we know, no studies have been applied to chemical sensors and biosensors using LDMOS.

In this study, we propose a new structural design of LDMOS for chemical sensor applications. The proposed device was fabricated using conventional complementary metal-oxide semiconductor (CMOS) technology. Therefore, it has the advantages of easy fabrication, mechanical flexibility, and low cost [8]. Even though the LDMOS acting as a high voltage switching ICs element is widely used, there has been no report on the application areas related to the sensing of pH as immersed in the solution. The purpose of this study is to demonstrate that the LDMOS using floating gate structure makes the electrochemical sensor available and the characteristics of this device can be adaptable to pH detections. Due to the results, the proposed device was expected to get high sensitivity and good performance when it is used as a chemical and biological sensor.

Device Fabrication and Experimental Setup

A. Fabrication of Device

Fig 1 shows the schematic of a proposed device for pH sensor. The device has three terminals: source, drain, floating gate.

The LDMOS has a one-poly-six-metal structure implemented with standard CMOS technology using a conventional 0.18 μm logic process without any modifications. These devices were manufactured by Magnachip/SK Hynix Co. Ltd. as part of the Integrated Circuit Design Education Center Multi-Project Wafer (IDEC-MPW) service.

B. Experimental Setup

To demonstrate the pH response characterristics of the proposed device, we performed a response experiment by changing the pH value from pH 4 to pH 10. As shown in Fig 2, the voltage of reference electrode was varied from -7 to -12 V, and the pH values from 4 to 10 with constant source voltage at 4 V in order to get the pH-sensing characteristics of the device.

Experimental Results

In this work, we proposed a LDMOS using in sensor applications. According to this result, the experimental results exhibited that the I_S-V_G characteristics of pH sensors with a LDMOS. The sensitivity of the proposed sensor for detecting pH buffer solution was 1.5 nA/pH. The result of sensor application experiment proved that the LDMOS device can be used for chemical and biological sensor applications. In the furure studies, we aim to use the LDMOS for many chemical and biological sensor applications.

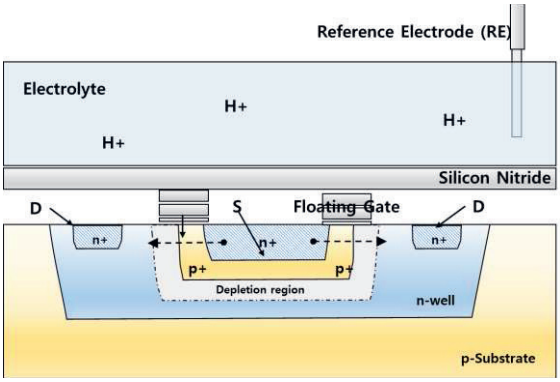

Fig. 1. Schematic showing the LDMOS for pH sensor application.

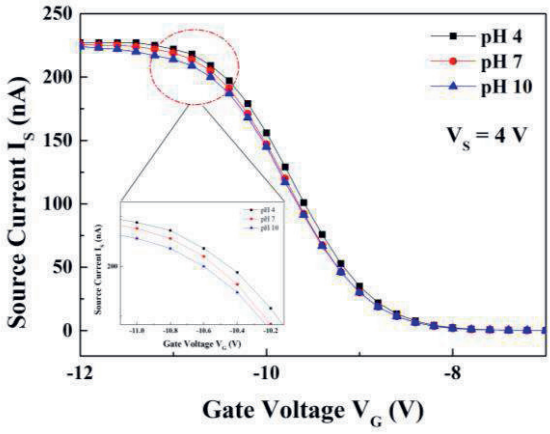

Fig. 2. I_S-V_G characteristics according to various pH values from pH 4 to 10.

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