UNIVERSITI TEKNOLOGI MARA

LIGHT AND TEMPERATURE EFFECT ON INVESTIGATION OF ION-SENSITIVE FIELD EFFECT TRANSISTOR (ISFET) SENSORS

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ABSTRACT

Ion-Sensitive Field Effect Transistor (ISFET) is a potentiometric device and most well-known as a pH measurement sensor. Nowadays, ISFET applications are widely used in those applications such as in biomedical, biochemical, agriculture and environmental monitoring. In viewing the capability of ISFET, there are two limitation factors of ISFET due to the open-gate configuration structure which are light exposure and temperature effect The layout design modification and characterization on the ISFET performance under wafer level and existing/commercial sensor are carried out in reducing the light effect. Several of metal shield design, passivation layer and isolation technique were designed using L – Edit Tanner Tools V12.6 software. The ISFET device is fabricated in the Fabrication Clean Room at MIMOS Berhad using standard CMOS 1 µm fabrication of MIMOS technology. In order to accomplish the reliable characterization on wafer level test, the semiconductor characterization system consists of HP 4145B Semiconductor Parameter Analyzer, Macromanipulator prober and source measure unit (SMU) were utilized. In testing for the analysis of the commercial sensor, three types of standard buffer solution: pH 4, pH 7 and pH 10 and reference electrode were used to analyse the ISFET performance during the experiment. In investigating the temperature effect on the ISFET performance, the effect of channel width-to-length (W/L) ratio on MOSFET-ISFET structures was investigated from simulation and experimental approach. A metal-oxide-semiconductor field-effect-transistor (MOSFET) has been adopted to investigate the isothermal point of an ion-sensitive FET (ISFET), which is needed to suit the readout interfacing circuit of an ISFET sensor. The MOSFET structure with different W/L ratio has been characterized in order to see the effect of W/L ratio to the isothermal point. The Keithley 236 Parameter Analyzer and Semi-auto prober micromanipulator system were used to measure the drain-source current (I_{DS}) versus gate to source voltage (V_{GS}) curves at various temperatures from 30 °C to 60 °C. The simulation result showed that the reduction of W/L ratio can decrease the isothermal point and this was proven by the actual measurement. An investigation towards the responding of light and temperature effect was continued on the modification of ISFET to EGFET sensor using TiO_2 sensing membrane. From the modifying sensor, EGFET has shown a good performance in reducing the light and temperature effect.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF RESEARCH

Sensor technology is a swiftly growing field that has significant potential in improving reliability, operation, serviceability, and utility of many engineering systems. History has revealed that improvements in material science and engineering have been significant drivers in the development of sensor technologies. A new era in sensor technology was guided by the development of large-scale silicon processing, permitting the exploitation of silicon to create new methods for transducing physical phenomena into electrical output that can readily processed by a computer [1]. Sensors have become more extensive and essential in the modern industrial world, instead the applications range from sophisticated industrial processes to common consumer products. In fact, the manufacturing industry has led to the use of advanced sensors in monitoring and controlling its industrial processes. Mostly, these sensors are based on well-established technologies that sense external factors for example temperature and also basic product characteristic, such as imperfection, weight and thickness. In addition, advances in materials, science and engineering have paved the way for the development of new and more capable sensors [1]–[3].

Based on trends in sensor technology, recent sensor development is trending toward increased complexity in sensor systems. Micro-fabricated semiconductor devices are crucial components of many biochemical sensors with CMOS technology implementation that have fast response, low cost, small size, low power consumption, and higher accuracy [1], [4]. Development in material technology will enable better control of material properties and behavior, thereby offering possibilities for new development of sensor with advanced features, for instance greater loyalty, lower cost and increased reliability [4]–[6].

During last three decades, different types of chemical sensor were developed. Ion-Sensitive Semiconductor Field Effect Transistor (ISFET) is one of the most well-known FET-based silicon sensor in device semiconductor. One of the important thing in the development of a whole series of sensors for the measurement of physical and