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ELECTRONIC READER DESIGN WITH RADFET (PMOSFET) DOSIMETER SENSOR

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Abstract. *In this study, a new reader has been designed to measure the amount of radiation dose detected by RadFET (pMOSFET) sensor. The designed reader calculates the voltage threshold voltage (Vth) shifts of the pMOSFET to determine radiation dose and display it on the Touch TFT LCD screen placed on the printed electronic circuit. It has been developed more in particular to be easily used in radiotherapy and other healthcare field which have radiation sources. The electronic board has also been developed to adjust and read the data for SiO_2 and Er_3O_2 sensor structured RadFETs. The electronic card has been designed with STM32F103 series processor that has 12-bit ADC resolution. In addition, specific Bluetooth circuit has been designed for communication. Thus, dose measurements versus date graph, personal details (name, age etc.) can be sent to personal computers and devices such as smart phones and tablets. Dose measurements can be currently kept by micro SD card.*

Keywords: *Dosimeter, Silicon dioxide SiO_2, Erbium oxide (Er_3O_2), Microcontroller, Dose measuring, Radiation dosimeters, pMOSFET dosimeters, RADFETs*

1. Introduction

Radiation measurements with the use of metal-oxide-semiconductor field-effect transistors (MOSFET) as a dosimeter are becoming more and more popular [1].

In this study, the electronic reader has been designed for pMOSFET sensors with the Er_2O_3 layer named NürFET. The sensor has been developing by Nuclear Radiation Detector Research and Application Center (NÜRDAM) located at Bolu, Abant Izzet Baysal University (AİBÜ). Software and hardware design of the electronic reader have been improved to exhibit high reliability and be compatible with MOSFET based sensors with different gate materials such as Er_2O_3 and SiO_2. The reader contributes to more convenient and efficient use of radiation dosimeters in various applications.

2. System Description

The purpose of the reader is to measure the signal from the detector device using the ADC converter and process that signal in the microprocessor to determine radiation dose in the accurate and reliable way.

Due to structure of the sensor; Gate, Source and Bulk pins have been connected corresponding sub-circuits. Dose measurement constitutively results from the change of threshold voltage (V_{th}) of the sensor. Thus, circuit diagram shown as follows has been enhanced (see Figure 1).

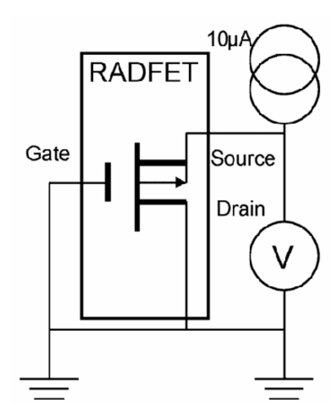

Figure 1. Connection required for measuring the threshold voltage (V_{th})

To measure most correct threshold data from the sensor, 10µA current should have been applied to the source and bulk terminals from the current source.

Voltage shifts at the threshold voltage of MOSFET via current supply of 10µA corresponds to the amounts of radiation dose [2][3].

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In order to evaluate the voltage values as radiation dose, voltage shifts must be processed with high resolution. The threshold voltage changes with received dose are shown in Figure 2 for both Er2O3 and SiO2 MOS-FETs produced by NURDAM [4].

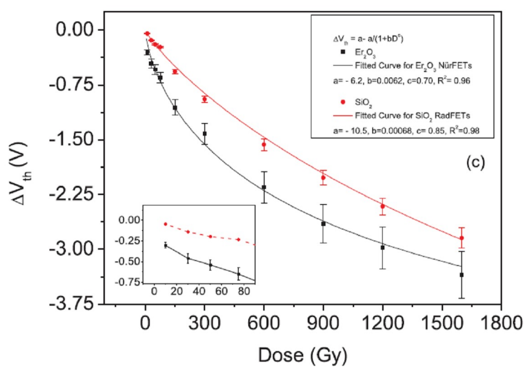

Figure 2. Threshold voltage shift dose relations for the devices.

The amount of radiation dose with the coefficients obtained as a result of this study, can be calculated when the following formula is applied [5].

$$\Delta V_{th} = a - \frac{a}{1 + bD^c} \tag{1}$$

The coefficients utilized for this formula have been obtained from threshold voltage - Dose calculations of Er_2O_3 structured sensors have developed by NÜRDAM. Herein, the value of the coefficient "a" has been calculated as; a = -6.2, the value of the coefficient "b" is b = 0.0062 and the value of the coefficient "c" is c = 0.72 correlatively. In this formula, variable "D" gives the amount of dose [4]. Also, the electronic reader has been designed to calculate static variables by algorithmic software and utilize the advantage of voltage shifts for measurement the amount of dose. Likewise, in case of using the SiO2 sensors, by added setup menu, the coefficients in the software of electronic reader change and measurements are always reliable, so that both the SiO_2 and Er_2O_3 structured sensors can be used.

Stm32f103 series processor has been used for dosimeter and all the algorithms have been controlled with a single processor. The sensor data read from the ADC unit has 12-bit resolution which gives accurate voltage shift measurement and dose computation [6]. Thus, external ADC modules are not needed [7].

The electronic reader also includes a memory module for storing dose measurement data. The information in the memory module includes the date and time of the measurement and the personal information of the person exposed to radiation. In addition, the memory card can be removed and inserted into the computers to backup the data.

A wireless communication module is also available to allow the instantaneous recording of measured data to be transferred to personal computers and smart devices. With the connection via Bluetooth, the stored data can be transferred quickly. If desired, it is also possible to connect the reader to the personal computer via wired connection and transfer data. Block diagram of circuit is shown in Figure 3.

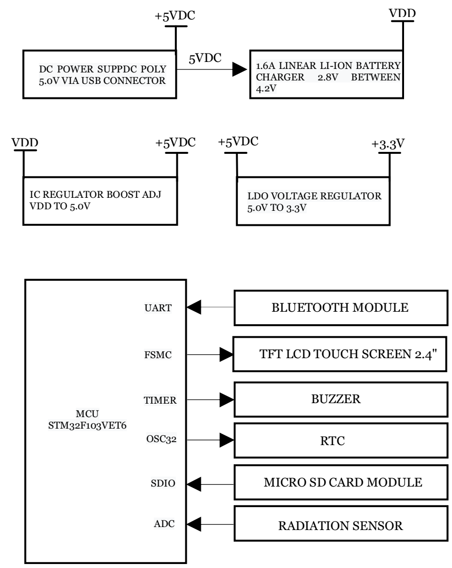

Figure 3. Block diagram of circuit

Touch TFT LCD screen is included to make the dosimeter easier to use by end-user. The dosimeter has a user-friendly interface and has been designed to be ergonomic. The electronic reader has a charging unit. Charging unit is compatible with universal charging systems, the battery can be charged with any phone charger.

3. Conclusion

The scientific benefits of the developed product provide insight into the use and processing of sensors of the same type. Thus, it will shed light on the science for the use of each structure resulting from the change of very low current and voltage values. With its touch color screen, wireless connection and memory card installation, a product that meets the requirements of a modern electronics device has been implemented. This product will provide ease of use especially in the health field. In the diagnostic methods that use devices such as x-ray and MR device, which are the source of radiation, the measurement of instantaneous radiation dose and instant processing of data are useful for both patients and operators compared to passive dosimeters. On the other hand, radiation dosimeters can be used to check whether cancer patients receiving radiotherapy receive the required dose and to make the treatment more efficiently. The electronic reader can also be used in military applications and nuclear radiation measurements.

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