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The Technique for I–V Characteristic Measurements of MOSFETs from Output Stage of MOS ICs

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Abstract

Experimental technique for measurements of I–V characteristics of MOSFETs from output stage of MOS ICs is developed and demonstrated using Schmitt trigger array 1594TL2T.

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1. Introduction

Fatal and parametric failures of digital CMOS integrated circuits (ICs) under ionizing radiation impact are directly connected with threshold voltage shifts and radiation-induced decreasing of the transconductance. The build-up of positive charge in the oxide and increasing of interface trap density during irradiation is main physical reason of both effects. It is sufficiently difficult to predict that the radiation hardness of complex circuit is the dependence of the threshold voltage and transconductance on total dose level in unavailable. This problem is typical if we are dealing with radiation tests of complex devices, for which fabrication technology features are unknown. However, in the great number of cases, it is possible to measure I–V characteristics of n- and p-channel MOSFETs from output stage of the IC. It enables us to determine the dependence of threshold voltage and transconductance for these transistors on total dose level to obtain the detailed information about radiation damage mechanism of the device under test. We develop corresponding technique to measure the I–V characteristics and apply it to investigate the radiation degradation of Schmitt trigger array 1594TL2T.

2. Materials and Methods

Description of the experimental technique include amplified electrical circuit diagram of the output stage of Schmitt trigger array 1594TL2T is presented in Figure 1. This circuit is typical for great number of CMOS digital integrated circuits. The connection diagram of the circuit to measuring devices is also presented in the figure. To open n-channel transistor, it is necessary to apply high voltage level to corresponding input of the IC. It connects the gate of the n-channel transistor through switch '0' to positive power supply bus and enables to set the gate-to-source voltage, which is equal to the supply voltage. The connection of voltage source E3 to the output terminal of the IC defines the gate-to-source voltage and the drain current can be measured by A3.

The same approach can be used to measure I–V characteristic of p-channel transistor. To perform this measurement process it is necessary to apply low voltage level to corresponding input terminal of the IC. It will connect the gate of the transistor to ground bus through switch 1.

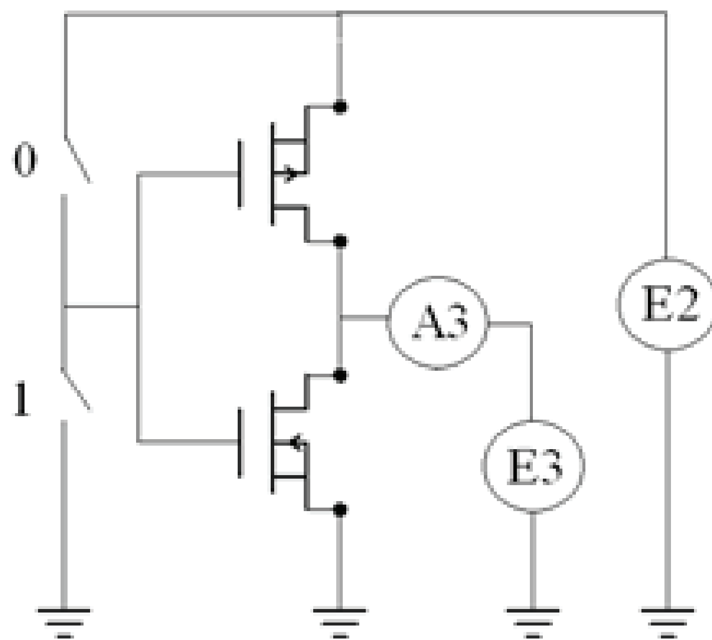

Figure 1: Simplified electrical circuit diagram of the output stage of Schmitt trigger array 1594TL2T.

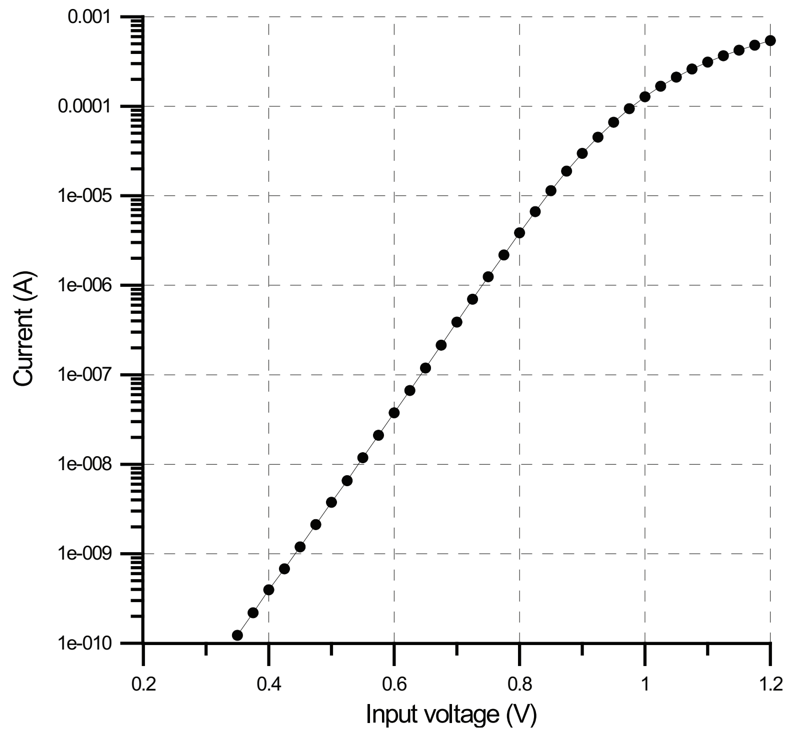

Figure 2: I–V characteristic of n-channel transistor from the output stage of Schmitt trigger array 1594TL2T.

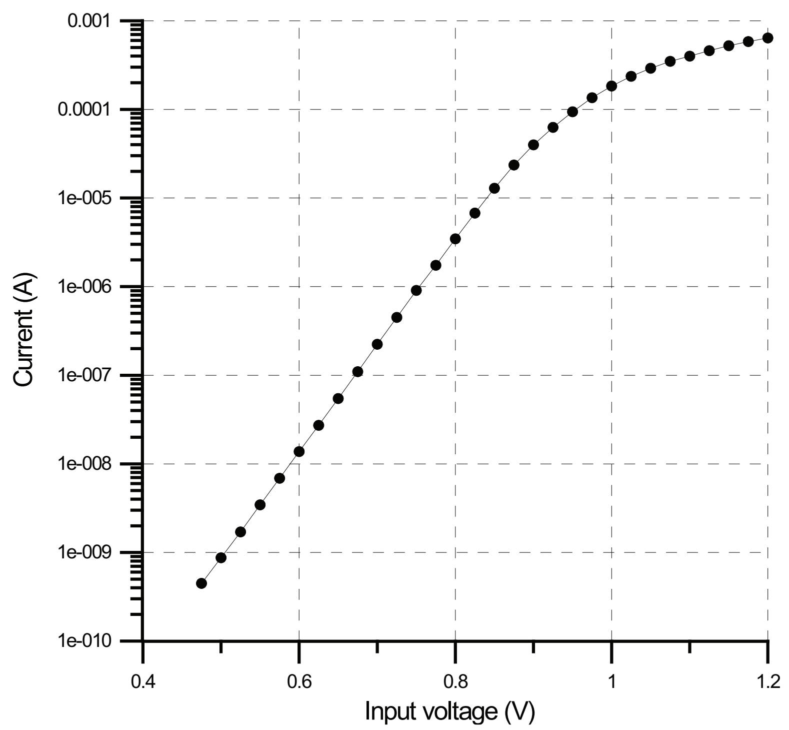

Figure 3: I–V characteristic of p-channel transistor from the output stage of Schmitt trigger array 1594TL2T.

3. Results

The measurements were performed using measure device, which are described in [1–3]. The I–V characteristic of the n-channel transistor from the output stage is presented in Figure 2, and the same characteristic of the p-channel transistor is plotted by Figure 3. The measurements can be performed for different total dose levels to investigate the transient process of the positive charge and interface trap build-up during the irradiation.

4. Discussion

Since electrical parameters of integrated circuits (ICs) depend on operation temperature, the devices [4, 5] for temperature control and monitoring are usually used during radiation test experiments. In our case, we didn't use the devices because the temperature dependence of electrical parameters for our devices under test is not significant.

5. Conclusion

The experimental technique for measurements of I–V characteristics of MOSFETs from output stage of digital integrated circuits is presented and implemented for Schmitt trigger array 1594TL2T. The results of the implementation are presented for n- and p-channel transistors. The applications of the technique can be very useful in investigation of the radiation induced transient processes in CMOS integrated circuits.

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