First Latin-American Congress
on Solid State Dosimetry and Radiation Measurements
13-17 September, 2021

COMPARISON BETWEEN PHOTODETECTORS, TRANSISTORS AND A ZnO NANODEVICE UNDER STANDARD DIAGNOSTIC X-RAY BEAMS

VALENÇA, C. P.V. [1], GONÇALVES FILHO, L.C. [1,2], ALVES, A. N. [1], MACEDO, M.A. [3], SOUZA, D.N.[3], and SANTOS, L.A.P. [2,4]

[1]Universidade Federal de Pernambuco (UFPE), 50740-545, Recife, PE, Brazil, divanizia@gmail.com
[2]Comissão Nacional de Energia Nuclear (CNEN/CRCN-NE), 50740-545, Recife, PE, Brazil,
[3]Departamento de Física, Universidade Federal de Sergipe (UFS), 49100-000, São Cristóvão, SE, Brazil
[4]Scients, 53645-337, Igarassu, PE, Brazil

Introduction: The thin film of zinc oxide (ZnO) semiconductors is not normally used as an x-ray photon sensor and this study intends to show results of such material to become radiation detectors of energy ranges for medical diagnostic use. The damage of the ionizing radiation in typical electronic components (such as transistors) occurs due to the defects generated either in the semiconductor crystal or insulating oxide layer. This change in the electrical characteristics of transistors compromises their long-term use by operating as x-ray detectors. This work offers some comparisons made with a ZnO nanodevice and other semiconductor devices, including photodiode, phototransistor, bipolar junction transistor (BJT), and MOSFET.

Material and method: The AJA Orion 5-HV sputtering system was used to build the ZnO nanofilm samples by the sputtering technique using a 100W RF source, with 50.8 mm diameter high-purity ZnO target, manufactured by Macashew Tecnologias.

The electrical characterization procedure consisted of applying a polarization voltage ranging from 0–50 V to the ZnO nanofilm, in steps of 10 V. For this type of characterization, a 6430 Keithley source-meter was used. The electrical resistance of the samples, R_{ZnO}, was also monitored using a Fluke 8508A primary standard multimeter. Four types of commercial electronic components were used to compare the chosen devices with the ZnO semiconductor thin film.

Each device is differently biased, and the current i_d must be simultaneously measured. For all commercial devices, an EFF1705 Scients electronic system [1] was used. The measurement procedures made with the ZnO nanofilm and photodetectors were performed without laboratory light to minimize the effect of ambient light.

All experiments were performed with three standard x-ray beam qualities (standard x-ray spectra), corresponding to the typical tube potential range used for medical diagnosis.

Results: The ZnO nanodevice electrical characterization is displayed in Figure 1, which, according to Ohm's Law, has the electrical resistance R_{ZnO} = 5.0 GΩ (±0.3) at a temperature of 22.7 ºC (±0.2) and relative humidity 65.4% (±1.2). The ZnO nanofilm thickness was also analyzed and the average calculated to 660 nm (±10).

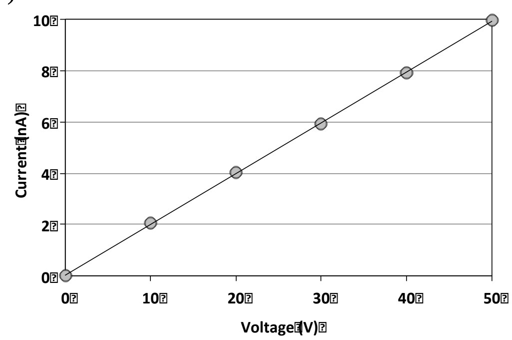

Figure 1. ZnO nanofilm electrical characterization for two samples with thickness about 660 nm.

For three radiation qualities, the current produced by the ZnO semiconductor nanofilm was observed to be approximately three times larger than the ionization chamber signal, at any applied dose rate selected in the x-ray tube.

Conclusions: Based on the comparisons made between these devices, the existence of advantages and disadvantages of the ZnO nanodevice are be recognized. Basically, it can be summarized that, although the ZnO nanodevice produces a slightly stronger signal than the ionization chamber, semiconductor devices present a much stronger signal than the innovative ZnO nanofilm operating as a radiation detector.

References:

1. http://scients.com.br/produto/