ARTICLE IN PRESS

Ceramics International xxx (xxxx) xxx

Contents lists available at ScienceDirect

Ceramics International

journal homepage: www.elsevier.com/locate/ceramint

A comparative study of the radiation dose response of $(ZnO)_x(TeO_2)_{1-x}$ thin films for high energy X-ray application

M.M. Idris [a,b,*], I.O. Olarinoye [a], M.T. Kolo [a], S.O. Ibrahim [a], U. Rilwan [c,**], M.I. Sayyed [d,e]

[a] Department of Physics, Federal University of Technology, Minna, Nigeria
[b] Department of Physics, Nasarawa State University, Keffi, Nigeria
[c] Department of Physics, Faculty of Natural and Applied Sciences, Nigerian Army University, P.O. Box 1500 Biu, Borno State, Nigeria
[d] Department of Physics, Faculty of Science, Isra University, Amman, Jordan
[e] Renewable Energy and Environmental Technology Center, University of Tabuk, Tabuk, 47913, Saudi Arabia

A R T I C L E I N F O

Handling Editor: Dr P. Vincenzini

Keywords:
I-V characteristics
X-ray radiation
Thin-film sensor
Zinc oxide
Tellurium dioxide

A B S T R A C T

The current research work determines the X-ray radiation effects on the current–voltage (I-V) characteristics of zinc oxide-doped tellurium dioxide thin film as a dosimetric material for X-ray detection and measurement. Five thin-film samples of $(ZnO)_x(TeO_2)_{1-x}$ (where x = 0.0 wt% (D1), 0.2 wt% (D2), 0.4 wt% (D3), 0.6 wt% (D4), and 1.0 wt% (D5)) were prepared with an aqueous solution of zinc acetate dehydrate and tellurium dioxide precursor on a soda-lime glass substrate using the spray pyrolysis technique. XRD study revealed a polycrystalline structure of the films and showed diffraction peaks belonging to paratellurite TeO_2 and wurtzite ZnO in all film samples. A peak shift was observed, indicating the presence of ZnO in the TeO_2 crystal lattice. FESEM imagery revealed roughness and the film grain size, which decreased when the concentration of ZnO increased. The optical assessment showed superior transparent behavior in the spectrum of visible light and a minor fall in the optical band-gap value when the concentration of ZnO increased. The I-V characteristic obtained for all the thin-film samples showed a linear increase of current as a function of the applied voltages and X-ray doses ranging from 0.0 to 6.0 V and 50–250 cGy, respectively. The I-V characteristic response of the thin-film samples studied were in the order of D3 > D1 > D2 > D4 > D5. The thin films' dosimetric sensitivity (minimum measurable dose) values were in the range of 0.610–2.180 $mAcm^{-2}Gy^{-1}$ (0.4590–1.6390 mGy) for D1, 0.370–0.940 $mAcm^{-2}Gy^{-1}$ (1.0640–2.7030 mGy) for D2, 0.610–2.280 $mAcm^{-2}Gy^{-1}$ (0.4390–1.6390 mGy) for D3, 0.00200–0.005280 $mAcm^{-2}Gy^{-1}$ (189.3940–357.1430 mGy) for D4, and 0.00040–0.00150 $mAcm^{-2}Gy^{-1}$ (250.0000–666.6670 mGy) for D1. The R^2 value (linearity error) of the I-V plots were in the range of 0.879–0.951 (0.0025–0.0057) for D1, 0.966–0.998 (0.0006–0.0025) for D2, 0.869–0.913 (0.0035–0.0065) for D3, 0.860–0.952 (0.000009–0.00005) for D4, and 0.922–0.978 (0.000002–0.000004) for D5. The ZnO-TeO_2 thin-film sensor is therefore a candidate material that can be used for miniaturized radiation measuring devices that can be accommodated in smart devices such as smart watches and smart phones.

1. Introduction

The understanding of ionizing radiation and its technological applications has significantly improved human lives. The scientific application of radioisotopes and the ionizing radiation from both natural and artificial sources can be found in many domains, such as research, food processing, medicine (diagnosis and treatment), power generation, and security [1–7]. However, depending on the radiation quality factor, the absorbed dose, and the biological tissue exposed, uncontrolled exposure to ionizing radiation can pose hazards for humans, the biota, and devices [8]. X-rays play a significant role in contemporary medicine through the diagnosis and treatment of various medical conditions such as cancer. Since radiation exposure has detrimental effects [9–12], it is critical to monitor the radiation dose received by patients, medical personnel, industrial workers, and the general public in processes involving ionizing radiation applications [13,14]. Dose measurement is

* Corresponding author. Department of Physics, Federal University of Technology, Minna, Nigeria.
** Corresponding author. Department of Physics, Faculty of Natural and Applied Sciences, Nigerian Army University, P.O. Box 1500 Biu, Borno State, Nigeria
E-mail addresses: idrismustapham@nsuk.edu.ng (M.M. Idris), rilwan.usman@naub.edu.ng (U. Rilwan).

https://doi.org/10.1016/j.ceramint.2025.03.290
Received 15 May 2024; Received in revised form 14 March 2025; Accepted 20 March 2025
Available online 20 March 2025
0272-8842/Crown Copyright © 2025 Published by Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

Please cite this article as: M.M. Idris et al., *Ceramics International*, https://doi.org/10.1016/j.ceramint.2025.03.290