Optical Materials 114 (2021) 110897

Contents lists available at ScienceDirect

Optical Materials

journal homepage: http://www.elsevier.com/locate/optmat

Research Article

Evaluation of radiation shielding capacity of vanadium–tellurite–antimonite semiconducting glasses

Y.S. Rammah [a], I.O. Olarinoye [b], F.I. El-Agawany [a,*], K.A. Mahmoud [c,d], Iskender Akkurt [e], ElSayed Yousef [f,g]

[a] Menoufia University, Faculty of Science, Physics Department, 32511, Shebin El Koom, Egypt
[b] Department of Physics, School of Physical Sciences, Federal University of Technology, Minna, Nigeria
[c] Ural Federal University, 19 Mira St, 620002, Yekaterinburg, Russia
[d] Nuclear Materials Authority, P. O. Box 530, El Maadi, Cairo, Egypt
[e] Süleyman Demirel University, Faculty of Arts and Sciences, Physics Department, Isparta, Turkey
[f] Research Center for Advanced Materials Science (RCAMS), King Khalid University, P. O. Box 9004, Abha, 61413, Saudi Arabia
[g] Physics Dep., Faculty of Science, King Khalid University, P. O. Box 9004, Abha, 61413, Saudi Arabia

A R T I C L E I N F O

Keywords:
Vanadium-tellurite glasses
Shielding properties
Monte Carlo simulation
SRIM

A B S T R A C T

Effects of antimony trioxide (Sb_2O_3) on the shielding features of ternary tellurite-vanadium- antimonite glasses were investigated. The glasses chemical composition are described by 40TeO_2-(60-x) V_2O_5-xSb_2O_3: 0 $\leq$ xSb_2O_3 $\leq$10 mol%. The mass attenuation coefficients (MAC) were simulated using Monte Carlo simulation code (MCNP-5) and estimated theoretically via WinXcom program for 15 keV up to 15 MeV photon energy. Alpha and proton stopping power and projected range were computed utilizing the SRIM program. Furthermore, other effective shielding parameters like linear attenuation coefficient (LAC), desired shield thickness, and effective atomic number were calculated relying on the estimated MAC values. The photon's accumulation within the studied glasses in terms of buildup factors has been estimated via the EXABCal program. The MAC shielding capacity's output findings revealed an increment from 28.9 to 31.3 cm^2/g with increasing the Sb_2O_3 ratio from 0 to 10 mol %, respectively. The glass samples coded TVS0 recorded the largest (Σ_R) among all studied samples. Results concluded that raising the Sb_2O_3 insertion ratio is significantly enhances the TVS shielding capacity. Thus, the investigated glass samples are good candidates for several nuclear protection applications.

1. Introduction

Formerly, semiconducting glasses have been extensively studied through two categories: oxide and chalcogenide glasses. The chalcogenide glasses doped with transition metal oxides (TMOs) exhibit unique physical, optical, mechanical, electrical, thermal, semiconducting, and radiation shielding properties [1–12].

Recently, glass materials in their different structures significantly affect most modern applications such as laser medium, optical switching instruments, optoelectronic materials, and space technology [13–15]. Besides, glasses can be applicable in medical applications in CT scans, windows, and doors in nuclear medicine. For the characteristics mentioned above, glasses got more attention to be utilized as an alternative radiation protection material instead of rocks, bricks, concrete, alloys, and polymers materials [9–12,16–18].

From our best acquaintance that tellurite, phosphate, borate, and silicate-based glass networks are the best glass candidates due to their excellent characteristics, for example (low cost and ease molding, low melting points, high transparency, and good thermal stability) [8–10]. Being a material that holds high refractive indices, linear and non-linear, as well as its best shielding capacity against ionizing radiations, TeO_2 based glasses have attracted many researchers to prepare such structures and investigate their features in many fields of applications [11,15, 19–22]. Therefore, glasses with TeO_2 as a former have many beneficial uses in the solid-state lasers' applications, memory switching instruments, and solar cells [23–25].

Commonly, vanadium oxide (V_2O_5) is also an excellent glass former and enhances the synthesized glasses' magnetic and electric properties

* Corresponding author.,
E-mail addresses: dr_yasser1974@yahoo.com (Y.S. Rammah), olarinoyeleke@gmail.com (I.O. Olarinoye), fouaadesmael@yahoo.com, fouad.ismail520@science.menofia.edu.eg (F.I. El-Agawany), kmakhmud@urfu.ru (K.A. Mahmoud), iskenderakkurt.emr@gmail.com (I. Akkurt), omn_yousef@yahoo.com (E. Yousef).

https://doi.org/10.1016/j.optmat.2021.110897
Received 12 December 2020; Received in revised form 3 February 2021; Accepted 5 February 2021
Available online 20 February 2021
0925-3467/