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Elastic moduli, photon, neutron, and proton shielding parameters of tellurite bismo-vanadate (TeO_2–V_2O_5–Bi_2O_3) semiconductor glasses

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ABSTRACT

In this research, elastic moduli, photon, neutron, proton, and alpha particle shielding parameters for tellurite bismo-vanadate (TeO_2–V_2O_5–Bi_2O_3) were estimated and theoretically presented. Makishima–Mackenzie's (M-M) model and Phy-X/PSD software were used to achieve the required calculations. Young's modulus varied from 72.68 to 59.41 GPa while shear modulus varied from 28.75 to 23.66 GPa. Bulk modulus changed from 51.34 to 40.51 GPa, while Poisson's ratio changed from 0.264 to 0.255. The trend of the projected range for alpha and proton particles follows the order: $(TVB00)_{Range}$ > $(TVB05)_{Range}$ > $(TVB10)_{Range}$ > $(TVB15)_{Range}$ > $(TVB20)_{Range}$ > $(TVB25)_{Range}$. The mass attenuation coefficient of the TVB glasses follows the order: $(TVB00)\mu_m$ < $(TVB05)\mu_m$ < $(TVB10)\ \mu_m$ < $(TVB15)\ \mu_m$ < $(TVB20)\ \mu_m$ < $(TVB25)\ \mu_m$ at all energies. The MFP follows a similar trend as HVT, where TVB00 glass has the highest MFP and HVT among the considered glasses. The lowest range of Z_{eff} was achieved TVB00 glass and the highest for TVB25 glass. The *f*-factor of the TVB-glasses were almost equal due to similar number of electrons per unit mass. The variations in buildup factors with photon energy were identical for all glass materials and penetration depth (mfp). Results revealed that the inclusion and increase of Bi in the TVB-glass systems improves its radiation shielding capacity.

1. Introduction

The ease at which glass composition can be altered to obtain desired structure, physical properties, and higher function abilities in diverse areas of technological applications has made glass an interesting material to material scientists and engineers [1,2]. This has also brought improvement and diversification into the quality and applications of glasses now available. Furthermore, the demand for cheap, environmentally friendly, durable, and corrosion resistant materials has placed glass in the spotlight of research all over the world [3–8]. Among glass materials that have received great attention in recent times are oxide and chalcogenide glasses [9–14]. This is because of their attractive qualities such as: low cost, high transmission range, excellent optical, and electrical properties [5–14]. These have made them applicable in areas such as photonics and optical fibers. These areas of application are expanding as new research findings are being documented.

Research has shown that silicate, borate, phosphate, germinate, and tellurite oxides come tops among glass formers [15,16]. Among these, tellurite oxide-based glasses have received even more attention [16–24]. Addition of Bi_2O_3 to glass composition has been observed to change the physical and optical properties of glasses [25]. TeO_2–V_2O_5 glass has also shown improved properties when varying Bi_2O_3 contents were added [26]. This is likely to increase the ability of tellurite-vanadate glasses in many areas including structural and shielding against ionizing radiation.

Due to the deadly effects of ionizing radiation, radiation protection has become a fundamental aspect of all radiation applications. The use of radiation shielding has become one of the most effective measures that can be adopted for radiation protection [27,28]. Glass materials with their optical transparency, durability, and other superior quality to concrete as a shielding material are gaining wide acceptance for this role. Many glass materials have been investigated for their radiation shielding efficiency with wonderful results [12–14,22–24,26–28].

The definition of a glass acceptable for shielding of ionizing radiation would depend on the type of shielding (source or structural), type of radiation and energy, available space, structure, cost, mobility etc. Glass materials used for shielding applications must have high radiation

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