X-ray photoelectron spectroscopy (XPS) and radiation shielding parameters investigations for zinc molybdenum borotellurite glasses containing different network modifiers

ABSTRACT

Zinc molybdenum borotellurite glasses containing different network modifiers with the nominal composition of 60 TeO_2–10 B_2O_3–10 MoO_3–10 ZnO–10 MO (MO = Li_2O, Na_2O, K_2O, MgO, CaO, and PbO) were prepared by melt quenching method. The X-ray photoelectron spectroscopy (XPS) studies allow to monitor the structural modifications leading to the formation of bridging oxygens (Te–O–Te, B–O–B, Mo–O–Mo, and Te–O–Mo bonds) and nonbridging oxygens (Te = O, Te–O^-M^+, Mo–O^- bonds in the MoO_6 octahedral units, Zn–O bonds from ZnO_4) with the addition of alkali (Li, Na, and K), alkaline (Mg, Ca), or heavy metal (Pb) oxides. The Te 3d localized core-levels spectra show an asymmetry due to the existence of different Te-based structural clusters and were fitted with three contributions such as Te ions in TeO_4 trigonal bipyramid configuration, Te ions in TeO_3^- trigonal pyramid configuration and TeO_{3+1} polyhedra, respectively. The analysis of the Mo 3d spectra indicates prevailingly Mo^{6+} ions only. The Zn 2p core-level XPS spectra demonstrate that the zinc is mainly coordinated by four oxygen atoms. The essential radiation shielding parameters were studied for the prepared glasses in the photon energy range 1 keV to 100 GeV using WinXCom software program. Parameters like mass attenuation coefficient (μ/ρ), effective atomic number (Z_{eff}), and mean free path (MFP) are evaluated. Further, by using geometric progression method, exposure buildup factor (EBF) values were also calculated in the incident photon energy range 0.015–15 MeV, up to penetration depth of 40 mfp (mean free path). The macroscopic effective removal cross sections ($\sum_R$) for fast neutrons have been calculated. The maximum values of μ/ρ and Z_{eff} were found for PbO-introduced glass though it possesses a lower value for MFP and EBF. The obtained results indicate that PbO-based glass is the best radiation shielding material among the studied glasses.

Keyword: X-ray photoelectron spectroscopy; Radiation shielding parameters; Zinc molybdenum borotellurite glasses; Network modifiers