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Design abd Development of Gd2O2STb phosphor compound coupled Lead iodide photo dosimeter for gamma-ray detecting

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In general, superior spatial resolution is expected from the direct detection type, in which Ion-chamber-type detectors and Si diodes based on the radiation–ionization phenomenon are used for high-energy dose detection. However, because the ion chamber has a high work function, the speed for collecting electrons and holes is slow, and thus, the dose-detection characteristic deteriorates. In addition, because of the low electron–ion-pair detection rates in ionization chambers, signal detection may decrease in response to the temporal changes during the continuous detection of high-energy radiation, resulting in a possible decrease in the reproducibility and sensitivity to signals. In this paper, the thin coplanar lead iodide(PbI_2)films as a photosensitive converter requiring only a few tens of volts of bias, associated with a thick columnar coating of phosphor layer, were simulated and designed. PbI_2, which was used in this study, is a very important material with technological applicability as a room-temperature radiation detector. It is a wide-band-gap semiconductor (Eg > 2.0 eV) with a high environmental stability efficiency[1]. In this structure, gamma rays are converted into visible light on a thick Gd_2O_2S:Tb phosphor layer which is then converted to electric charges in a thin PbI_2 layer. The electron-hole pairs can also be generated from gamma-ray interaction in the PbI2 photoconductor, which can improve the generation efficiency of electric charges. To optimize the thickness of the phosphor coupled PbI_2 multilayer structure in range of iridium-192 gamma ray energy, the gamma-ray absorption was estimated using the MCNPX code. In addition, the photoluminescence and electrical measurements of phosphor coupled PbI_2 dosimeter were evaluated. From the experimental results, the 180 μm Gd_2O_2S:Tb coupled 10 μm - PbI2 dosimeter proposed in this work exhibited a low dark current and excellent gamma-ray sensitivity, and in particular, excellent linearity to x-ray exposure dose. The measured dark currents were below 100 pA/cm2 at an electric field of 1 V/μm for PbI_2. The preliminary sensitivity measurements give a signal in the range of about 12.6 and 4.2 nC/cmˆ2 for 250μm Gd_2O_2S:Tb / PbI_2 and 250 μm PbI_2 at the exposure conditions respectively. The results of this research suggest that the new coplanar gamma -ray dosimeter with a hybrid-type structure can resolve the following problems: high sensitivity from the conventional dosimeter, and low conversion efficiency from the indirect conversion method.

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[1] R. Ahuja et al., Electronic and optical properties of lead iodide, J. Appl. Phys. 92(12) (2012) 7219-7224.

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