Design and Development of Gd_2O_2S:Tb phosphor compound coupled Lead iodide photo dosimeter for gamma-ray detecting

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Introduction

- 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.

Experimental Procedure

Fabricate detector

- In this study, the addition of PbI_2 were prepared by screen printing a material way, the lower electrode was prepared by depositing Au and the upper electrode of ITO. [Fig. 1].

- Material size : 1 × 1 cm
- Base material : PbI_2, TiO_2
- Method : Particle-In-Binder(PIB)
- Run condition : 70℃ , 8hour
- Electrode : Indium tin oxide (ITO), Au

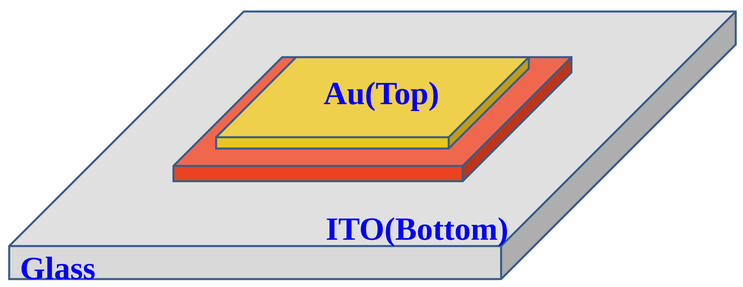
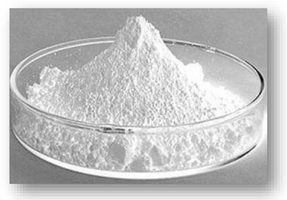


FIG.1 Fabrication method of detector

PbI_2

- PbI_2
  - high spatial resolution
  - high absorption



Gd_2O_2S: Tb

- Gd_2O_2S: Tb
  - Fill in spare space
- Binder
  - A surface active agent
  - PVB

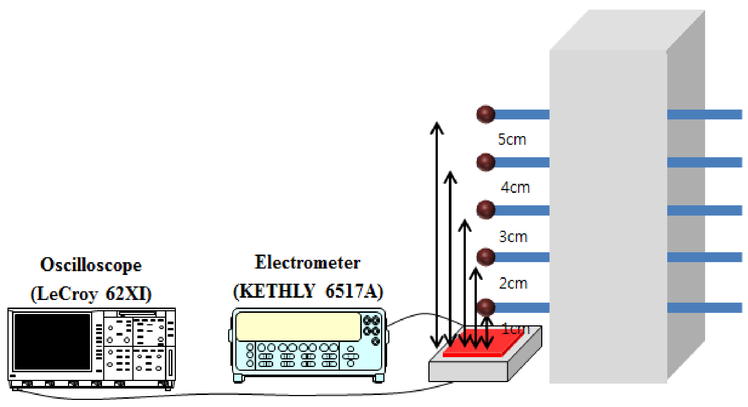


FIG.2 Evaluation method of the fabricated detector

Evaluation method

- After the SSD was fixed at 1 to 5 cm, the radiation response properties depending on changes in the radiation energy and energy intensity were confirmed. Also, The instruments used were an electrometer and an oscilloscope.
- In case of reproducibility testing, the charge detected by the fabricated detector was measured by maintaining identical geometric conditions for the radiation measurement systems and repeating 10 cycles of radiation.
- To optimize the thickness of the phosphor coupled PbI2 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.

Result & Discussion

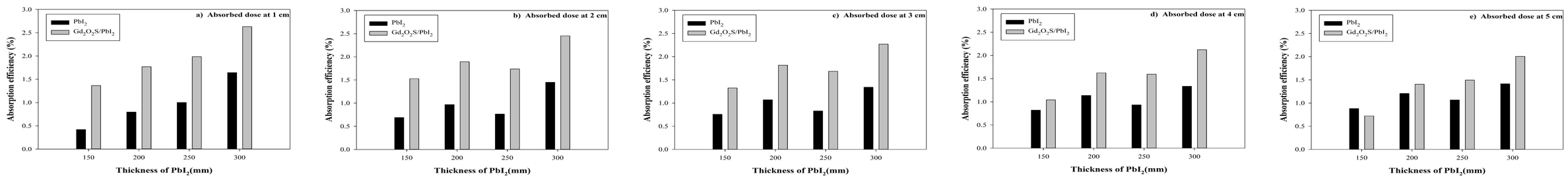


FIG.3 Absorption efficiency according to distance

- From the experimental results, the 180 μm Gd_2O_2S:Tb coupled 200 μm - PbI_2 dosimeter proposed in this work exhibited a low dark current and excellent gamma-ray sensitivity, and in particular, excellent linearity of increasing distance according to x-ray exposure dose [Fig.3].
- The measured dark currents were below 100 pA/cm^2 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/cm^2 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.

Conclusion

- In this study, as a result of measuring the sensitivity according to the distance between the source and the sensor, most showed a high signal collection amount at a distance of 3 cm or less.
- In addition, a similar signal in the 2 nA band collected at a distance of 3 cm or more was confirmed as a scattering signal due to the decay of the Ir-192 source.
- When the distance between the sensor and the source is increased and the measurement is performed, it is considered that it is possible to express the dose curve as well as the dose range in the future by using the difference in the amount of the collected signal.
- In addition, by using a semiconductor sensor, it is converted into an electrical signal without a developing process, so that signal distortion does not appear and a quantitative signal amount can be checked in real time.

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