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Development and Evaluation of Large area Flexible Dosimeter for Surface Dose Measurement in Radiotherapy

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Radiotherapy has the possibility of adverse reactions due to overlapping dose at skin surface binding parts. Exposure of the skin to 2 Gy or higher doses can cause adverse reactions such as erythema, desquamation, and necrosis. To prevent them, the skin dose is predicted through a treatment planning system, but its accuracy is only 50 ± 25%. Thus, we need dosimeters that can accurately measure the skin dose from computed tomography images and calculated treatment plans in clinical practice. The existing skin dosimeters such as glass rod dosimeter and optically stimulated luminescent dosimeter check the point dose. However, analog-type integrated solid state dosimeters are difficult to analyze the dose of body surface and have low positioning accuracy because the attachment site is decided with naked eye.ˆ[1] Meanwhile, to overcome morphological limitations, materials based on flexible polymer-based thin film technology have been actively researched.ˆ[2] On the other hands, a photoconductor PbI_2 may show a mechanical softness as the silicon rubber binder is bound. Such PbI_2 represents the high atomic number and has a property of low leakage current when produced so that studies have been actively performed as a detection substance to measure high-energy X-rays.ˆ[3] As a basic study on a patch-type skin dosimeter, this study produced a PbI_2 dosimeter based on silicon rubber for the human skin using the particle in binder (PIB) method. To evaluate the performance of this dosimeter, reproducibility and linearity were evaluated by 1, 10, 100, 1000 and 10000 bending counts at 6 MV and 15 MV. The reproducibility was examined by irradiating a 1 Gy dose at the dose rate of 4 Gy/min 10 times repeatedly. The linearity was tested by irradiating 0.01 to 10 Gy doses at the dose rate of 4 Gy/min. Consequently, when the relative standard deviation(R-SD) as the evaluation criterion for reproducibility was set to 1.5% or lower, the S-RD of the 1000 bending count was 1.74% at 6 MV and the S-RD of the 10000 bending count at 15 MV was 2.2%. Thus, these results were higher than the criterion. When the coefficient of determination (R-Sq) as the evaluation criterion for linearity was set at 0.9900 or higher, the R-Sq of the 10000 bending count was 0.9730 at 6 MV and 0.9812 at 15 MV. Thus, these results were lower than the criterion. When the bending count increased to more than 10000, the performance showed fine variations. This study introduces a new type of flexible functional material and the problem of performance variations can be improved through further research using various electrodes.

[1] H. J. Lee, et al., Evaluations and comparisons of body surface doses during breast cancer treatment by tomotherapy and LINAC radiotherapy devices, 2017, Prog.Med.Phys. 28, 258.
[2] Hui Sun et al., Flexible X-ray detector based on sliced lead iodide crystal, 2017, Phys. Status Solidi RRL 11(2), 1600397.
[3] Y. J. Heo et al., Development of a stable and sensitive semiconductor detector by using a mixture of lead(Ⅱ) iodide and lead monoxide for NDT radiation dose detection, 2018, JINST 13, C03023.

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