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A study on the development of quality assurance development and dose distribution for medical linear accelerator

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1. Introduction

The purpose of quality assurance (QA) in radiotherapy, which uses high-energy radiation in clinical application, is to provide the optimum dose to the tumor or to the target volume while minimizing the dose to normal tissue as well as the exposure of personnel. QA in radiotherapy includes all procedures that ensure consistency of the medical prescription and safe administration of that radiotherapy-related prescription, including the coincidence of light and radiation fields, radiation dose measurement, and radiation energy uniformity[1,2]. Due to such complicated procedures, previous QA programs suffer from several limitations in relation to measurement and evaluation. Therefore, in this study, we developed and evaluated a versatile dosimeter that retains accuracy, to realize an integrated QA protocol in clinical radiotherapy. A photoconductor was used as a radiation conversion material in the dosimeter.

2. Methods and Results

A linear accelerator (VARIAN iX) was used to conduct clinical verification and fundamental comparison of linearity, repeatability, and accuracy tests with 6MV, 15MV beam from LINAC were conducted for the produced sensor. The detection sensor showed the better performance than the commercially available dosimetry device.

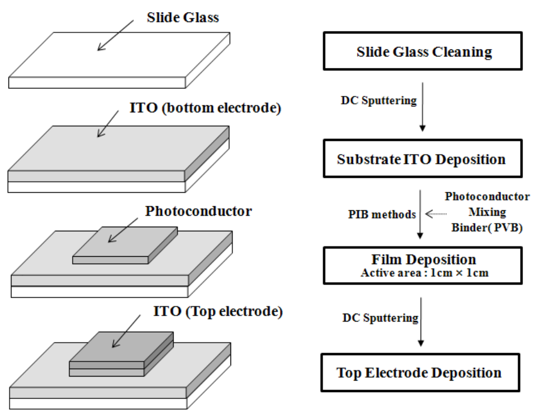

Fig. 1. Fabrication Process of Uni-cell type speciment

2.1 Material selection and Sample production

Beam pulse data was acquired for the precise verification of the detection sensor and the conformity with the photoconductor was also verified. The combinations of Lead Ⅱ iodide (PbI_2), Lead Ⅱ oxide (PbO), Mercury Ⅱ iodide (HgI_2), and Titanium Dioxide (TiO_2) were the candidate materials for the sensor. Sedimentation method, one of the Particle in Binder (PIB) methods, was used to produce the Uni-cell type specimens. Dark current, output current, rising time (10% ~ 90%), falling time, response delay were tested for the each specimen and the compound of TiO_2 and HgI_2 showed the best results.

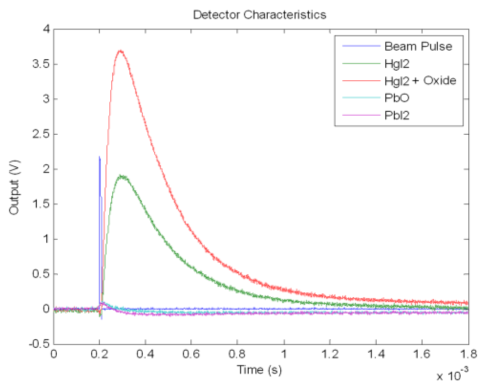

Fig. 2. Characteristic of Uni-cell type specimen.

2.2 Multi-pixel array

6×6 multi-pixel array with the compound were produced to test the capability of multi-pixel array and its application in small field. 6×6 multi-pixel array has the 1 mm pixel size, 1 mm pixel pitch, and 485 μm thickness so that the array can measure the small field. Analog-to-digital converter (ADC) converts an analog signal from a pixel to a digital signal and LabVIEW displays the signal patterns and saves them.

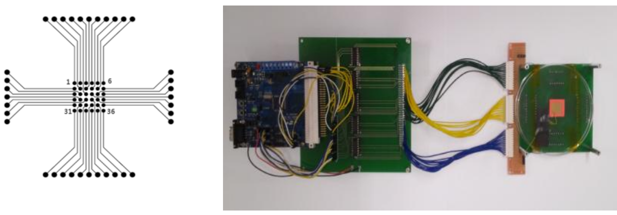

Fig. 3. Fabricated 6 × 6 Multi-pixel array sensor

2.3 Reproducibility

To prove the consistency of the system, high energy radiation of 100 MU with dose rate of 400 MU/min was irradiated to the center pixel and the results in dose were demonstrated in [table. 1].

As a result, maximum dose of 1.1426μC, minimum dose of 1.0365μC, average dose of 1.0682μC, standard deviation of 0.0356, and standard error of 1.127% were measured.

Table. 1. Measured Data of Reproducibility Experiment

Dose rate(MU/min) : 400

Step	Measuring Dose
1	1.1426
2	1.0338
3	1.0909
4	1.0203
5	1.1170
6	1.0468
7	1.0505
8	1.0365
9	1.0452
10	1.0489

2.4 Accuracy

The accuracy was proven by reading the dose value in each pixel with 10 repeated irradiation in the 6 MV, 400 MU/min and 100 MU condition for all 36 pixels and the results were shown in [figure.4].

For 100 MU, average dose for 36 pixels was 1.069972μC, and standard deviation of 0.0407 and standard error of 0.679% were measured.

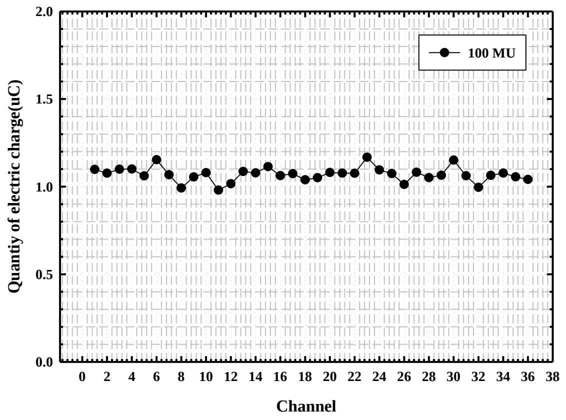

Fig. 4. Accuracy of 6 × 6 Multi-pixel array sensor

2.5 Linearity

The linearity test for the 6 x 6 Multi-pixel array sensor was performed under 6 MV, 400 MU/min dose rate condition with 10, 20, 50, 100, and 200 MU irradiations and the results were demonstrated in [figure. 36]. The R square values from the 9 pixels, channel 1, 6, 8, 11, 16, 26, 29, 31, 36, were 0.9997, 0.9997, 0.9991, 0.9995, 0.9995, 0.9992, 0.9996, 0.9997, 0.9995 respectively so the results can be said to be linear.

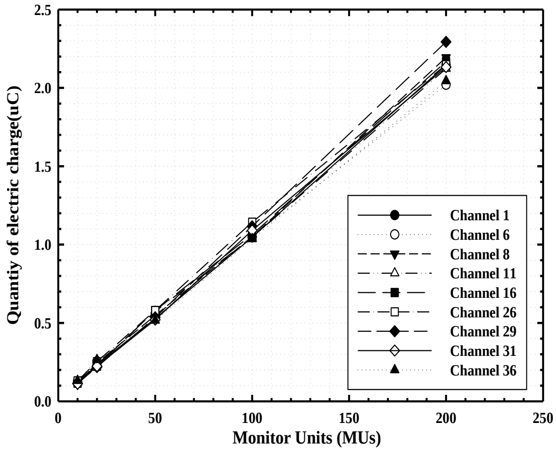

Fig.5. Linearity of Fabricated 6 × 6 Multi-pixel array sensor

3. Conclusions

It is considered that the superior dosimeter is necessary to perform such accurate quality assurance, and the dosimeter with x-ray conversion method shows many advantage comparing to the previous dosimeter with indirect conversion method. From this study, we verified the feasibility of the dosimeter with direct conversion method for the application in radiation therapy and expect that such dosimeter with direct conversion method would alternate the previous dosimeter with indirect conversion method in a few years. Therefore, it is necessary to carry out more study of the dosimeter with the direct conversion method in high energy radiation therapy. Also, the verification and experiments of the dosimeter with a variety of radiation energy like electron beam are needed.

ACKNOWLEDGMENT

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