Gurukul International Multidisciplinary Research Journal (GIMRJ)*with* International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2504I5VXIIIP0077

e-ISSN No. 2394-8426
Monthly Issue
APR-2025
Issue–IV, Volume–XIII

Quality Enhancement of Clinical Dosimeter by using Solid-State Diode Detector in Radiotherapy Technique

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Abstract

At Centre for Medical Radiation Physics, semiconductor diode as dosimeters for radiotherapy and mixed radiation fields were developed and tested. Now a day, measurement and verification of the dose quantity given to the patient is most important for the better results in the clinical practice for that quality assurance of clinical dosimeter is essential in radiotherapy technique. In this study a solid-state diode detector used for measurement of dose given to the cancer patient in radiotherapy techniques for that indigenous developed phantom used for quality assurance with diode detector. In this study we used the photon beam of energy 6 MV and 15 MV and kept focused on the linearity, dose rate dependence and angular dependence of diode. The diodes exhibit angular dependence in the range from 0.98 to 1.01. It was observed that studied diode exhibited good dose linearity which was independent of dose rate at very minimal angular dependency. Also, it is observed that the directional properties of studied diode have very good response. The studied diode has excellent response with high energy beam with respective to linearity, dose rate dependence and angular dependence. Solid state diode has better application of dosimeter in cancer treatment.

Keywords: Solid State Diode Detector, Radiotherapy, Dosimeter, Quality Enhancement.

Introduction

All The modern radiotherapy modalities used sophisticated tools for quality assurance in a phantom and during the treatment. In the advanced radiotherapy treatment, verification of the dose quantity given to the patient dose is most important in the clinical practice. Therefore, quality assurance by the dosimeters is very important for this different detectors as well as Phantom were used. We used solid state diode detector instead of the ion-chamber detector because semiconductor solid state diode detectors having numbers of advantageous features like high spatial resolution, manufacturing reproducibility, very small in size, etc. There for solid state diode are the better options in radiotherapy technique for quality assurance (QA), In some cases, diodes exhibit less energy dependency whereas greater stability therefore to establish accuracy dosimeter diodes are comparatively better in measurements as compare to an ion chamber [1-5]. At Centre for Medical Radiation Physics (CMRP), a semiconductor dosimeter developed for radiation therapy (RT) as well as mixed radiation fields and tested in clinical settings. As semiconductor diodes possess numbers of qualities such as inexpensive/less cost,

they are not requiring any bias, measurement of transverse dose, response at low energies, etc therefore diode have their important place in the clinical dosimetry. Also, the distributions of energies were independent of transverse position. The diodes are plays important role because they are available for a suitable current integrator array [6--14].

The diodes are designed and used to compensation of energy by the filtration but the problems regarding energy dependence still remain and their use in energy beam is limited in dosimetry whereas spectral quality of energy beam does not change. The measurements profile, to checks the constancy in dose, etc. Diodes are energy independent because ratio of stopping power to depth or energy does not change significantly. The energy dependence of the diode is qualitatively similar to the energy dependence films [15-20]. The atomic number of the silicon (Z = 14) is relatively high as compared to that of water or air hence silicon diodes show energy dependence with the non-uniform quality photon beams and the temperature coefficient of the diode should be measured and it is taken into consideration for the precise used of dosimetry measurements. With periodical recalibration we can overcome the possibility of damage in the diode due to radiation. The time dependence of diode response in the passive range provides precise information regarding equivalent path length of the diode with the availability of fast multi-channel data loggers. The possibility of use end of range which discriminate between the volume to be spared and target volume when diode array/ diode are placed in a body cavity distal to the target volume. The angular dependency of the diode is playing an important role when the angle of the incidence energy beam was significantly changed. The angular dependency effects should be considered for the comparative measurements by a detector which is angular independence [21-26]. In this study we used solid state diode detector for quality assurance in the measurement of dose given to the patient in radiotherapy technique for 6 MV and 15 MV energy beam.

2. Methodology

2.1 Dose Linearity and Reproducibility:

In this study we investigated the diode's dose reproducibility as well as examine its linearity of diode response related with dose. The sensitivity of the diode towards the minimum dose was measured with 50 cGy to 600 cGy known value doses. We arranged SDD 100 cm between machine and detector. For each dose the dosimeter readings were noted and take's it's averaged after that the percent standard deviation were computed.

2.2 Dependencies of Dose Rate:

In this study we investigated whether the diode detector responses are depend upon the dose rate when diode exposed to the different rate of dose with a (10 × 10) cm^2 field size. The dose rate dependence was measured in indigenously design and developed PMM phantom. 100 cm (SDD) source to surface distance is keep for these measurements and 100 to 600 MU dose rate were arranged.

2.3 Angular Response:

For measurement of angular dependence of the diode, the indigenous PMMA phantom was used in our study. The axis of rotation is kept perpendicular with surface area and angular

response of diode was studied by exposing diode at different gantry angle ranging in between 0 to 90 and 270 to 360 degree.

2.4 Diode Calibration

Before the clinical use recalibration of the diode is essential every time. To address the issue related phantom correction and to avoid uncertainty in the setup, a field size (10 x 10) cm^2 arc plan was generated. In indigenous phantom the treatment planning system determine the response of diode according to the planned TPS dose. It's helped to minimised the effects of variations in the daily linac output. Also, the attenuation of energy beam at different parts of treatment couch taken into consideration. At Iso-centre 200cGy dose was planned. The phantom was irradiated with diode and recorded diode response and then determine the calibration coefficient. It's help to calculate dose quantity for volumetric arc therapy (VMAT) quality assurance. The calibration coefficient helps to decide dose quantity in treatment planning system.

Using diodes (ISORAD, Sun Nuclear, USA) specific quality assurance to the patient was performed. By using indigenous phantom, the patient's dose was measured with diode. The position of the diode in the phantom corresponding to low dose and high dose the gradient and at the centre of the phantom the lasers were aligned. The measured dose was compared to the dose treatment planning system.

2.5 IVDTM Reader:

Four standard input channels can be expanded up to 52 channels and it was interface via a compact Control Module/windows PC software. After the treatment delivery has over the IVD 2 delivers dose data in real-time. Without the need to process disposable dosimeters the excellent reproducibility measurement of ISORAD™ detector helps to minimize cost, time and complication.

3. Result & Discussion

3.1,1 Dose Linearity of Diode for 6 MV Energy:

In present study diode used for the central axis dose for treatment measured and compared the measured value with calculated dose from treatment planning system. In this, conformal arc treatments, does not include any modulation of the beam. Therefore, for complex treatment we used diode with indigenous phantom confidently.

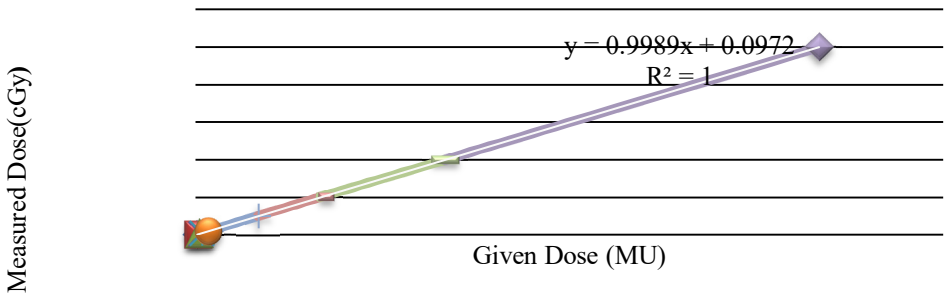

Figure 1: Applied dose and measured dose for linearity of diode.

From Fig. 1 it was observed that diode shows linear response from 1 cGy to 500 cGy and stander deviation is within standard range and reported the average variation between calculated and measured value of the dose.

3.1.2 Dose Rate Dependence of Diode for 6 MV Energy:

Fig. 2 indicates the dose rate for 6 MV energy. In this study dose was delivered to diode with different (100 to 600 MU/min.) dose rate and it shows that, the diode response was independent on dose rate. Angular response of diode is shown in Fig. 3. We observed that, diode shows higher response at angle 60 degree and 300 degree in clockwise direction.

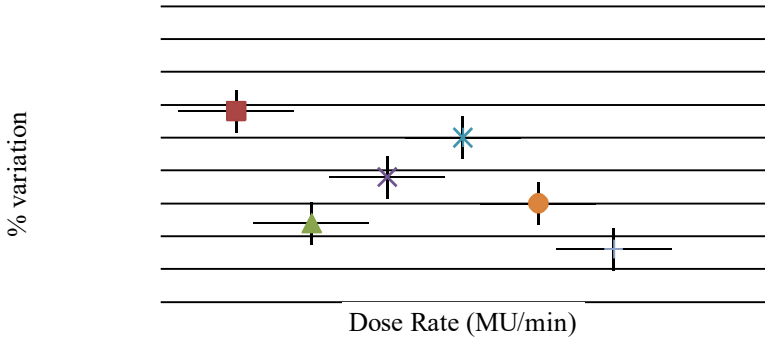

Figure 2: Diode dose rate of for 6 MV energy.

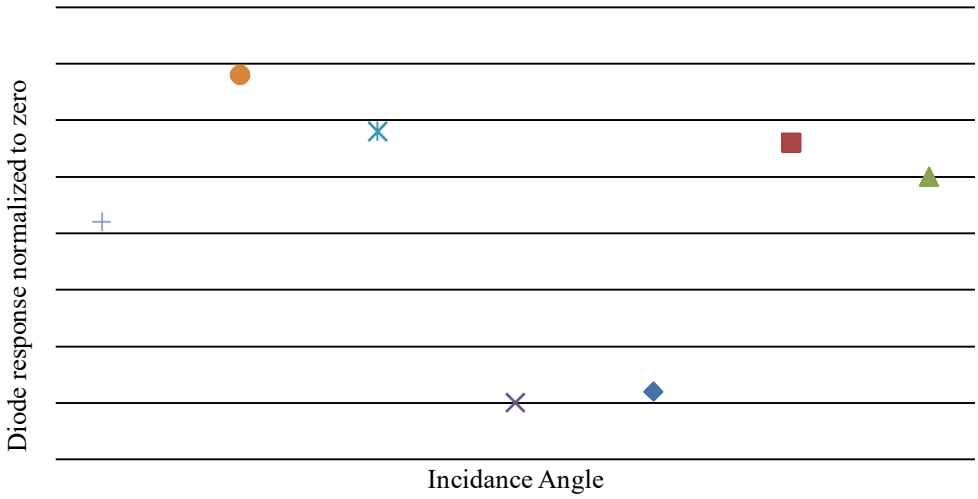

Figure 3: Angular response of diode for different gantry angle.

3.2 Characteristics of Diode for 15 MV Energy:

3.2.1 Dose Linearity:

From Fig. 4 we conclude that the response of diode for 15 MV energy for dose range 1 cGy to 500 cGy was linear.

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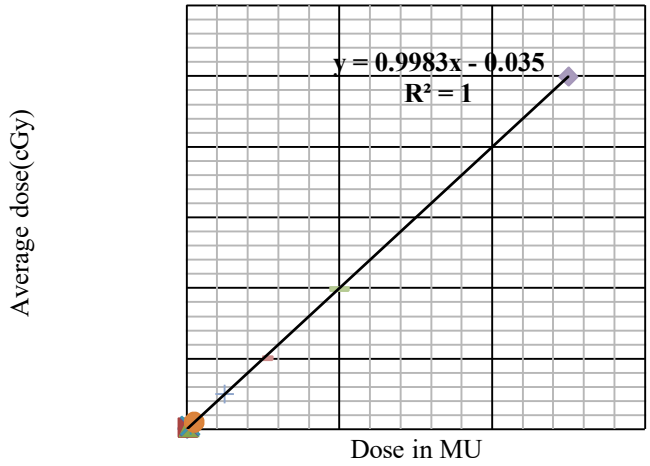

Figure 4: Dose linearity of diode for 15 MV energy.

3.2.2 Dose Rate Dependence:

The dose delivered to the diode with different dose rate 100 to 600 MU/min. and diode response observed. Fig. 5 indicates the diode dose rate response for 15 MV energy. It was observed that, diode response was independent of dose rate.

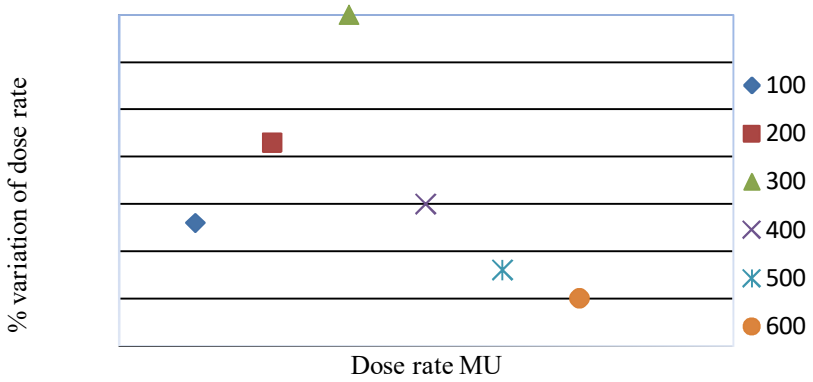

Figure 5: Diode dose rate response for 15 MV energy.

3.2.3 Angular Response for 15 MV Energy:

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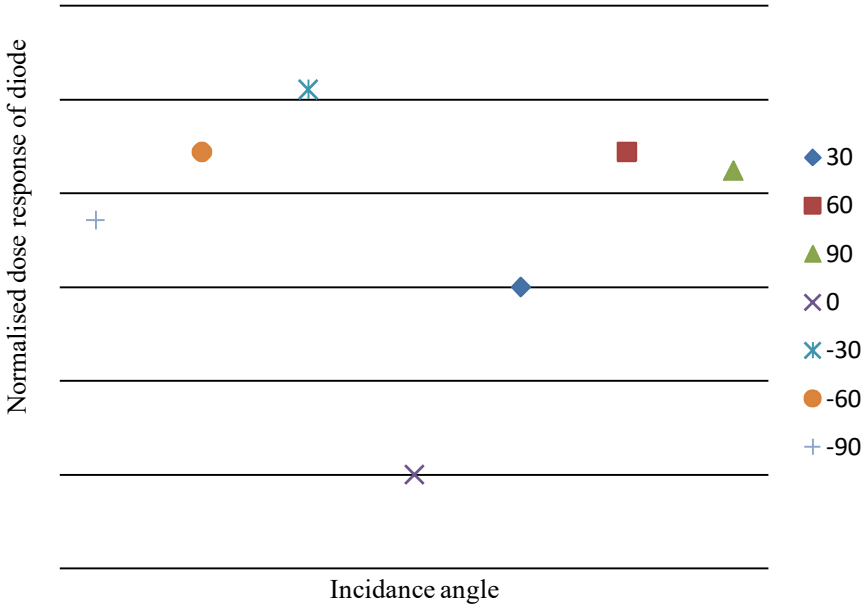

Figure 6: Diode angular response for 15 MV energy.

Fig. 6 shown the diode angular response for 15MV energy. The angular dependence of the diode was found in between 0.98 to 1.01. It is observed that, in the studied range the diode exhibits good linearity with linearity coefficient. Also, studied range of the dose rate; the diode response was independent of dose rate and the linearity of the diode reported in form of linearity coefficient. The diode angular dependence match with the reported values and results are in very good agreement with reported data. The diode shows good dose linearity, independent of dose rate with very minimum angular dependence.

4, Conclusion

The quality assurance in advance radiotherapy technique were achieved with the help of solid-state diode detector. With the help of studied solid-state diode detector, accurate measurement were done for quality assurance as well as reproduce the data. The diode parameters measured for accurate calibration of probe for the angular testing as well as it's sensitivity. It was recognized that, the specific angular ranges were used to performed calibrations for the long-term reproducibility. From this study it is cleared that diode has excellent response with high energy beam with respective linearity, dose rate dependence, angular dependence. For advanced and special radiotherapy technique, this study validated the use of solid state diode detector in the treatments like TSET and IMRT. The diode exhibited a good quality of reproducibility, reliability and stability of the dosimeter. These diodes has proven it's utility and useful quality in the quality assurance of dosimeter in radiotherapy technique for cancer treatment.

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