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Effect of Radiation on Germanium Doped SiO_2 Fibres

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

We report comparative effect of radiation on Germanium incapacitated Optical fibres and commercially available TLD-100. The experiments were carried out using Siemens linear accelerator (LINAC) Primus Multileaf Collimator (MLC) 3339 to deliver photon and electron beams. The Harshaw model 3500 TLD reader with WinREMS software were used in this experiment. Both media were irradiated with 6 x10^6 eV electrons and 6 x10^6 volts photons beam. We found a good linearity for TL dose in the range from 20 to 240 mGy. Comparative studies of these compounds indicate that the TL responses using photon and electron irradiation are similar and the average intensity is enhanced by about 1.30 times in electrons than those for photon irradiation. The information of the mini review report of this paper presents in valuable for clinical linear accelerators applications.

Keywords: Optical fiber; dosimetry; thermoluminescence; electron; photon.

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1. INTRODUCTION

Studies on thermoluminescence dosimetry (TLD) is very much interest because they are well established dosimetric technique and widely useful in clinical, private and ecological monitoring of radiation. The effect of Ge-doped optical fiber focus to dosimetric uses through electron and photon irradiation is a great importance for practical purpose. The smallest quantifiable dose and vigorous dose variety of TL substance depend on the sensitivity of the calculating method. The progress of sensitive of TL reader for phosphor materials is very significant. It is a competitive work to find the suitable beam for desirable yield of TLD materials. Many researches have been carried out to find a better dosimeter material [1-2].

Most recent studies in thermoluminescence focus on investing and developing the commercial use of optical fibre as TLD material. Compared to TLD, the doped optical fibres propose a capability to fabricate small width in mm range and provide the option of manufacturing a TL dosimeter that offers extraordinary spatial resolution. In addition, these fibres offer to determine dose superlatively to Bragg-cavity. It remains significant precise evalution of doses, for silica glass [3].

We investigated a TL report of oxygen-doped fiber for dissimilar type of irradiation [4,5]. Aluminums and germanium doped fibers and TLD-100 showed dosimetric properties fading, re-use, energy response, reproducibility, and linearity using electron and photon irradiation [6-12]. But comparative studies of TL response with photon and electrons field for individual Ge-doped optical fibres are not studied yet. The intention of this review article gives the details TL possessions of phosphor materials for the dosimetric presentations. The photon-electron irradiation response on Ge-SiO_2 materials as well as TLD-100 would play an important role to choose suitable beams for specific TL materials.

2. BASIC THEORY

Thermo luminescence is a method of excitation of electron to a greater energy state by an incident radiation. Then, the excited electron is trapped by imperfections in the crystal. By warming the crystal, the excitation energy will be out as light. This process is applied in quantitative measurement of radiation exposure. There are some aspects that require to be observed for the select of a TL substantial with esteem to several applications. Usually the properties of thermoluminescence are proportional to response with a large range of doses, an energy response as constant as possible, a good sensitivity, low fading and low self-irradiation due to natural radionuclides in the TLD materials.

3. EXPERIMENTAL METHODOLOGY

The Harshaw 3500 model of TLD reader with WinREMS software were used in this experiment. The method comprises of main apparatuses: TLD reader, WinREMS software, a personal computer (PC), which is linked to the reader through a sequential communications port.

A basic drawing of a TLD reader is displayed in Fig. 1. It comprises of a plan Chet for insertion and warming the TLD, a PMT for identifying the thermoluminescence light release and transforming it into an electrical signal and hot gas (nitrogen or air) for warming methods. The TL component might be excited using warm gas or plan Chet. The thermoluminescence yield of emission is a role of the TLD temperature.

The experiments were carried out using Siemens linear accelerator (LINAC) Primus Multileaf Collimator (MLC) 3339 to deliver photon and electron beams. The sample preparation, manufactured of doped fibers, annealing, encapsulating, irradiation and TL measurements were presented in ref. [7-8]. Twelve gelatine capsules with three sets of Ge-doped fibre material and TLD-100 located unconnectedly a rock-hard phantom. The electron and photon irradiated with 6 $x10^6$ eV and 6x 10^6V respectively. The size of all fibre was 5 $\pm$ 1 mm with approximately weight 0.20 $\pm$ 0.02 mg. This length was sufficient to accomdate the planchet during the readout process. The quantity of all fibre measured using an automatic device. The beam size was 10^2 mm x 10^2 mm and situated at SSD of 1000 mm and applicator of size 10^2 mm x 10^2 mm. The LINAC apparatus transported dose rate 200 MU/min. The TL yield was analyzed by a reader (Harshaw 3500) at UTM, Malaysia.

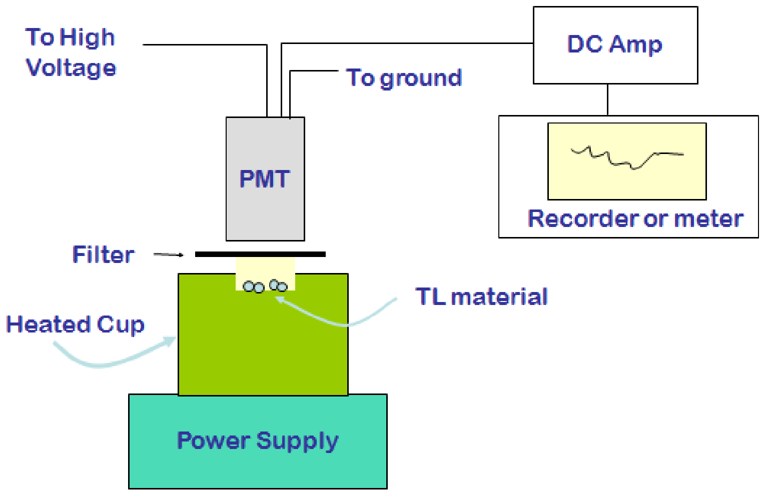

Fig. 1. A schematic diagram of a TLD reader

4. RESULTS AND DISCUSSION

The details comparative effect of radiation on Germanium incapacitated Optical fibres and commercially available TLD-100 are explained in this section. Fig. 2 and Fig. 3 show a relative scheme of TL intensity for photon and electron exposed on TLD-100 dosimeters and Germanium-doped optical fibers. The intensity was normalized and indicated as a role dependent on dose. On behalf of specific doses, individual materials were treated with photons and electrons. The energy of photon and electrons were 6MV and 6 MeV respectively. All data point was subtracted the background and represents an average of 3 separate fiber. The analyses of data and error indicate the mean error. Apparently from the graph, we have confirmed that TL-dose be contingent linearly. The TL response is higher for electron than those of photon irradiation. We found the Photon irradiation on the Germanium-doped fibers and TLD-100 is lesser than those of electron irradiation about 0.77 times. Therefore the linear energy transfer (LET) of the photons in the doped fibers were observed weaker than associated to electrons irradiation.

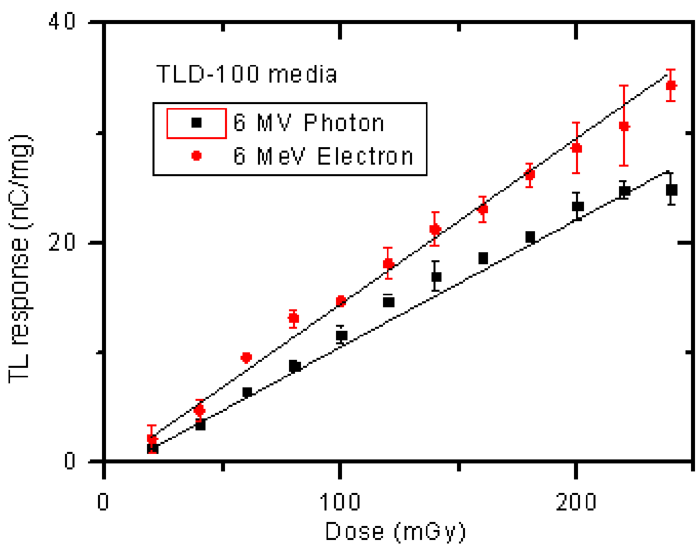

Fig. 2. Dose response linarity of TLD-100 media

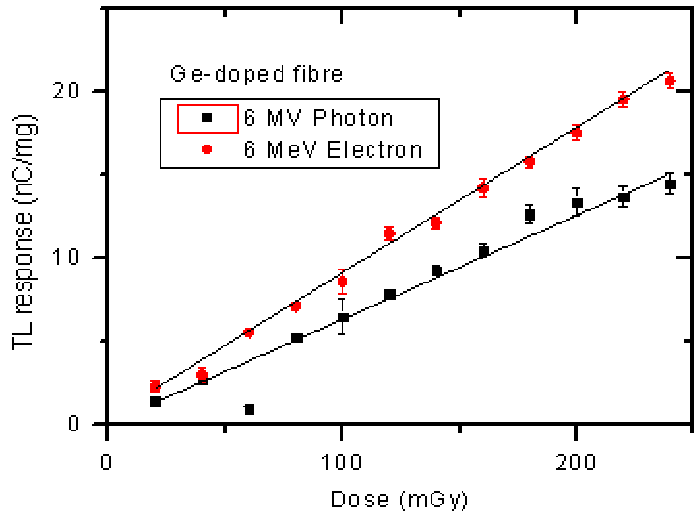

Fig. 3. Dose response linarity of Germinium-doped Sio_2 fibre

It is shown that the signal of both kinds of materials display worthy linearity for the doses 20 – 240 mGy. It means the dose is higher, the TL yield (nC/mg) is higher or vise-versa for both materials. Therefore each dosimeter is dependent on the dose. Actually, when the optical fiber or TLD-100 is treated, electrons are produced and stuck in the substances. These traps are delivered by lattice imperfections and they are deep enough to prevent the outflow of electrons for a lengthy time at room temperature. On heating, the stuck electrons are free and recombine at luminescence centers for the discharge of light. The yield of the sunny was found to be comparative to the asorbed dose [5]. TL yield is related to the dose because a TL response is proportional to the intensity of light. But the response on Ge-doped fibres of photons and electrons irradiation was found 0.59 times than those of TLD-100 media.

The effect of both types of irradiation on Ge-doped optical fibers is presented in Fig. 4. The ratio of TL yield in 6 mega volt photon and 6 MeV electron as a function of dose are displayed in this diagram. Each data point for a step of 20 mGy dose represents the ratio of the average reading. From the figure the yield ratio as a role of dose is not linear. The respose for electrons are greater than that for photon irradiations. The average ratio of photon compared to electron irradiation on Ge-doped fibers was found 0.77 times.

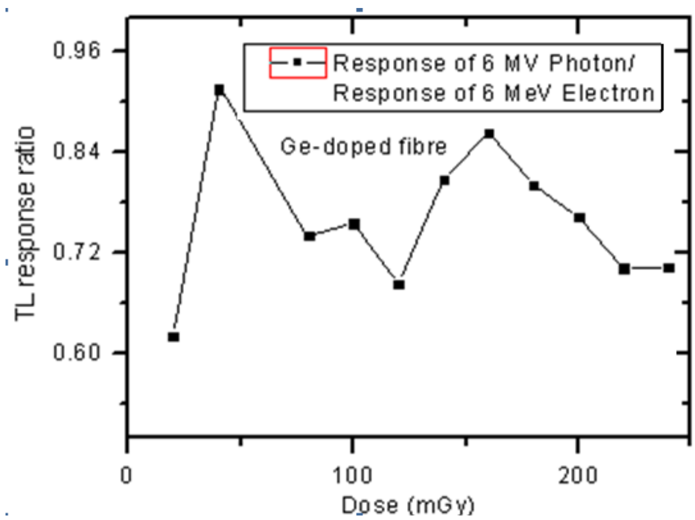

Fig. 4. The TL yield ratio of Germanium-doped SiO_2 fibre

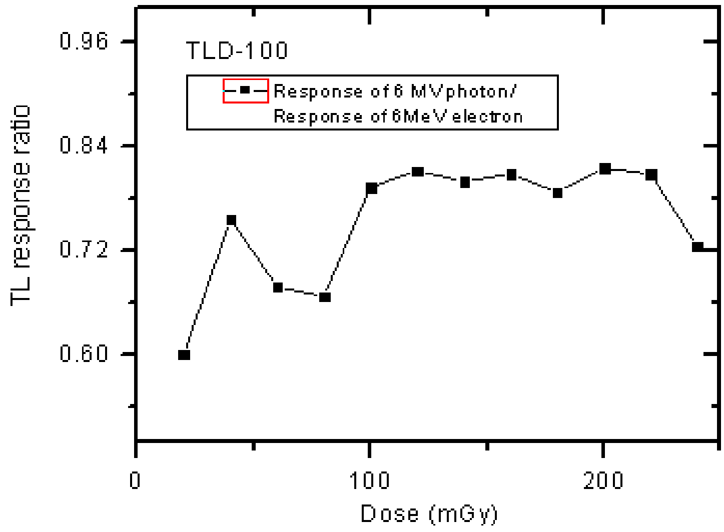

Fig. 5. The TL yield ratio of TLD-100

Fig. 5 shows the ratio of TL yield obtained for photon and electrons irradiation for TLD-100. The similar results at lower doses (< 100 mGy) observed according to Fig. 4. But ratio of TL response for dose (> 100 mGy) is almost constant and the average respose for electrons irradiation are stronger compared to photon irradiation by a factor of 1.3. But the average yield on Ge-doped fibres of photons and electrons irradiation was found 0.59 times than those of TLD-100 media.

5. CONCLUSIONS

Using $6x10^6$ V photons and $6x10^6$ eV electrons, the TL-intensity dependence on dose were observed linearly from the dose range 20 to 240.0 mGy for Ge- doped media and TLD-100. The average photon yield of Ge-doped media and TLD-100 was found 0.77 times in electron irradiation. The average yield 1.7 times higher in TLD-100 than Ge-doped media. The Ge-doped fibres give valuable information as new dosimeter according to the linearity and sensitive response that can be used by clinical linear accelerators.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country of Malaysia. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the author. The authors thank En Izwan Che Pi (Hospital Sultan Ismail, Johor Barhu) for help in performing the irradiations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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