

Relative Thermoluminescence Response of TLD-100, TLD-200 and Ge-doped Optical Fiber to 8.05 keV X-ray

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ABSTRACT The responses of three types of thermoluminescence dosimeters (TLDs), namely the TLD-100, TLD-200 and Ge-doped optical fiber to soft X-ray with photon energy of 8.05 keV were measured. The X-ray source used is the vacuum spark plasma which is capable of producing intense copper K_{α} line radiation at energy of 8.05 keV. The output dosage of the vacuum spark X-ray source is measured by a calibrated ion chamber and it is found to increase with operating voltage. The TL sensitivities of TLD-100, TLD-200 and Ge-doped optical fiber are determined and results are normalized to their responses to ⁶⁰Co gamma rays. The TL sensitivities are found to be 1.2 for TLD-100, 29.0 for TLD-200 and 13.8 for Ge-doped Optical Fiber.

ABSTRAK Ransangan oleh sinar-X lembut bertenaga foton 8.05 keV ke atas tiga jenis dosimeter thermoluminesens (TLD) iaitu TLD-100, TLD-200 dan gentian optik dop-Ge telah diukur. Punca sinar-X berkeamatan tinggi dari plasma pencucuh vakum yang berupaya menghasilkan sinaran garis K_{α} bertenaga 8.05 keV diguna. Dos keluaran punca sinar-X plasma pencucuh vakum diukur dengan kebuk pengionan terkalibrasi dan didapati dosnya bertambah dengan pertambahan voltan operasi. Kepekaan TL bagi TLD-100, TLD-200 dan gentian optik dop-Ge diukur dan nilainya dinormalkan kepada ransangan oleh sinar gamma dari Co-60. Kepekaan TL didapati ialah 1.2 untuk TLD-100, 29.0 untuk TLD-200 dan 13.8 untuk gentian optik dop-Ge.

(TLD, vacuum spark, Soft X-ray)

INTRODUCTION

Thermoluminescence dosimeters (TLDs) are relative dosimeters that have to be calibrated against a standard dosimeter such as ion chamber. Most TLDs responses are energy dependent especially at low energy [1, 2]. Thermoluminescence (TL) sensitivity or efficiency is defined as the amount of TL signal produced per unit mass by a dose unit of interest in comparison to that produced by a reference radiation. Various measurements of the TL responses of commercially available TLD-100 and TLD-200 to X-rays with respect to ⁶⁰Co gamma ray exist in the literature, most of them getting different values. In our case, we are looking at the responses of TLD-100, TLD-200

and Ge-doped optical fiber to low energy X-rays from a vacuum spark plasma source. We have studied the TL properties of Ge-doped optical fiber and have used it as dosimeter for high energy (MeV) photon therapy [3]. As far as we know, this is the first time that the response of the Ge-doped optical fiber to low X-ray energy is determined.

EXPERIMENTAL PROCEDURES

TLD-100 and TLD-200 in the form of chips (3.2 mm x 3.2 mm x 0.89 mm) supplied by Harshaw/Bicron are used in the study. The chips are annealed for 24 hours at 400°C and then cooled to room temperature before being used. The Ge-doped fiber of length about 2.0 cm is first

stripped of its outer coating before being annealed in the same condition as the other dosimeters. The annealed detectors are stored in the dark and irradiated within 24 hours after annealing. TL reading was performed as soon as possible after irradiation using a Harshaw model

3500 reader, in a nitrogen atmosphere, at a constant heating rate of $5\text{ }^{\circ}\text{C}\text{s}^{-1}$, integrating from temperature of 50°C to 400°C . Figure 1 shows the calibration curve of the fibre exposed to known dose of radiation from Co-60.

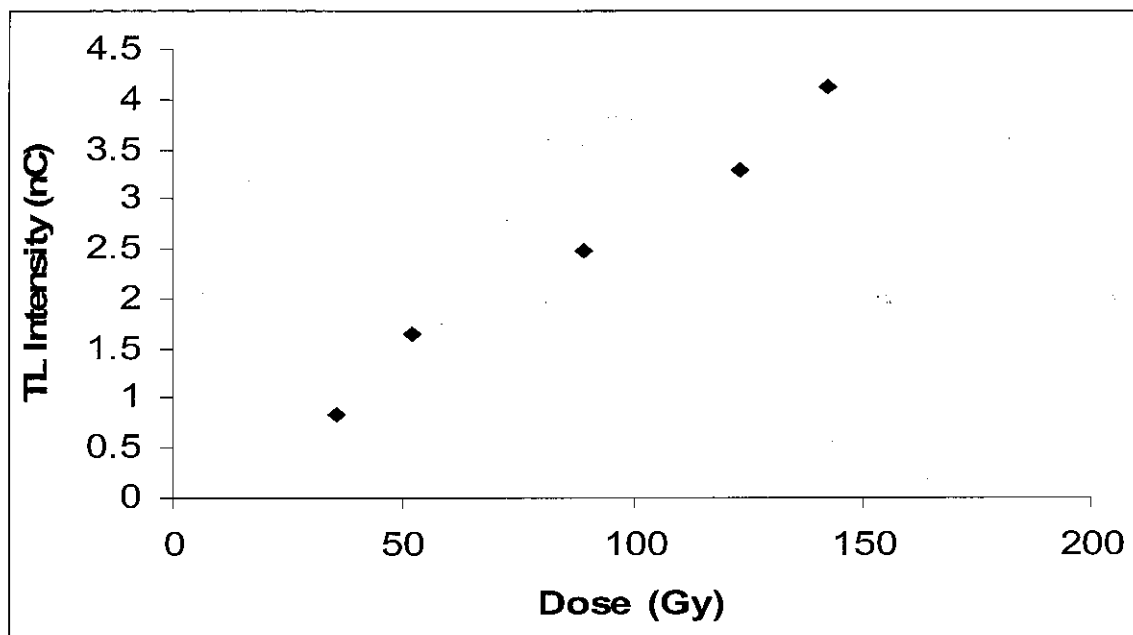


Figure 1. Calibration curve of Ge-doped optical fibre obtained by exposing to known dose of Co-60

The low energy X-ray can be obtained by using a vacuum spark device operated with copper anode and discharge voltages of 5, 10, 15 and 20 kV [4]. The X-ray dose is determined using a calibrated ion chamber (type TM23344-0929); attached to UNIDOS monitor supplied by PTW-Freiburg and is averaged over 10 shots for each discharge voltage. The TL sensitivity is normalized to that of ^{60}Co gamma rays.

As the TL response of TL dosimeter is energy dependence, this study provides the correction factor when the fiber is used as TL dosimeter in measuring dose from low energy X-ray devices.

RESULTS AND DISCUSSION

When operated with copper anode, the X-ray emission spectrum obtained from the vacuum spark discharge is dominated by the characteristic copper K_{α} lines with energy of about 8 keV as shown in Figure 2. The X-ray dose is found to be increasing with operating voltage as shown in Figure 3. Figure 4 show the responses of TLD-100, TLD-200 and Ge-doped optical fiber as a function of vacuum spark discharge voltage. All the detectors show an increase in response as the X-ray intensity increases with discharge voltage.

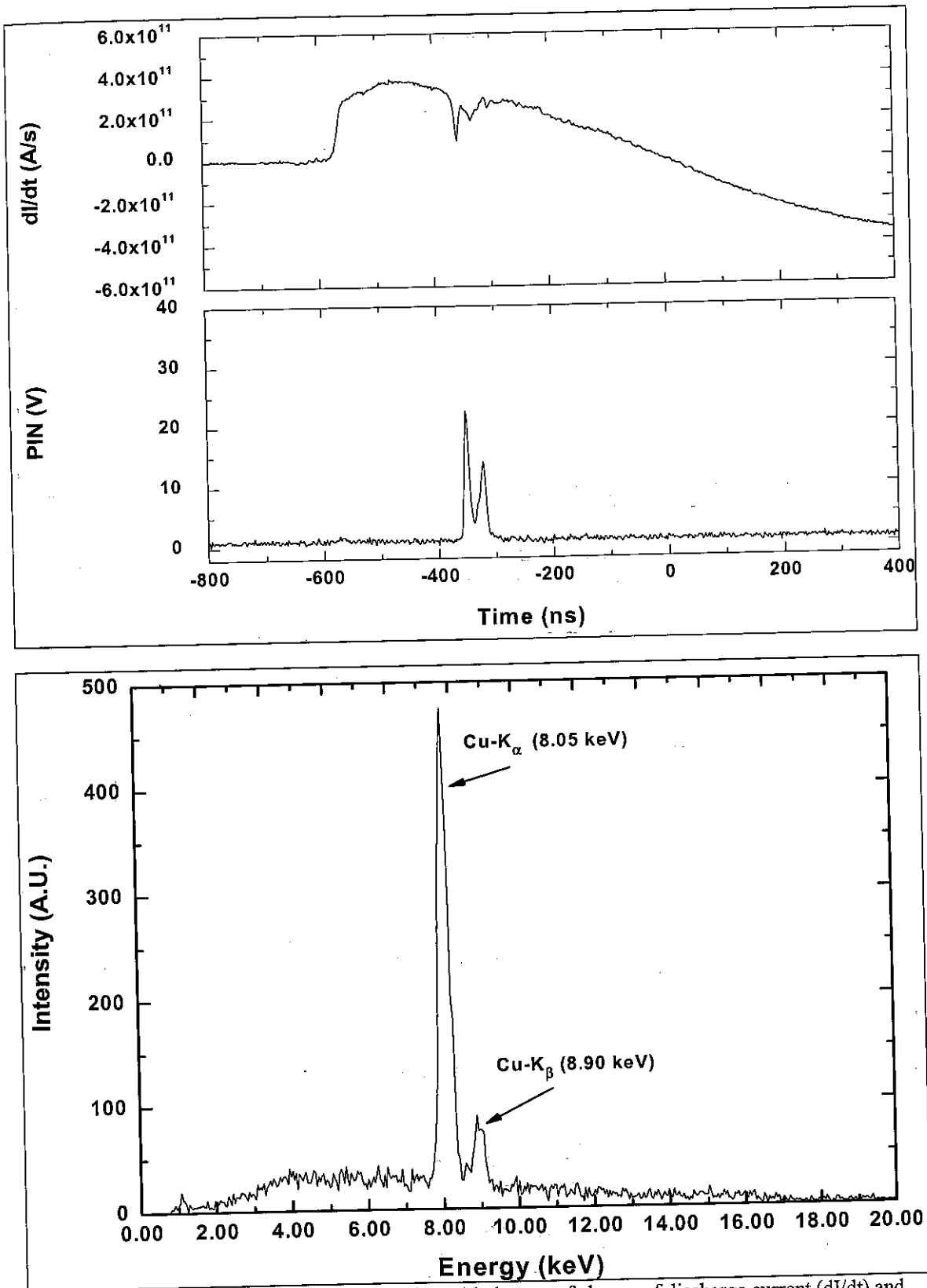


Figure 2. The X-ray spectrum shown together with the rate of change of discharge current (dI/dt) and the PIN diode signal of the X-ray emitted from vacuum spark plasma device using copper anode at 20 kV discharge voltage

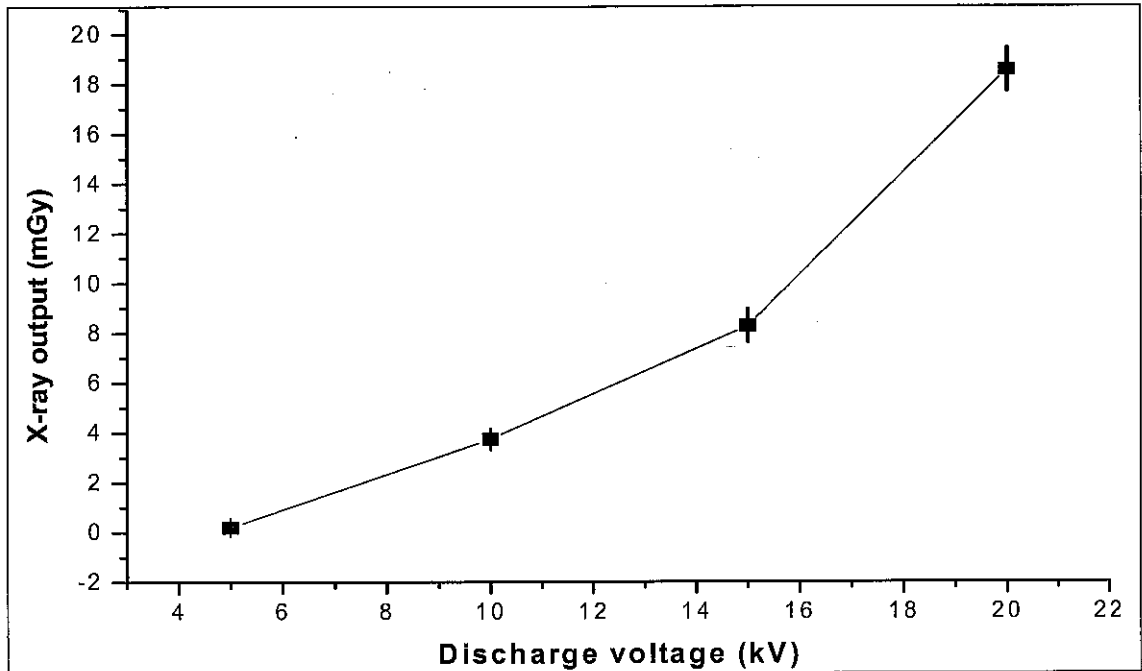


Figure 3. The output dose (mGy) from vacuum spark device as a function of operating voltage (kV) measured by calibrated ion chamber

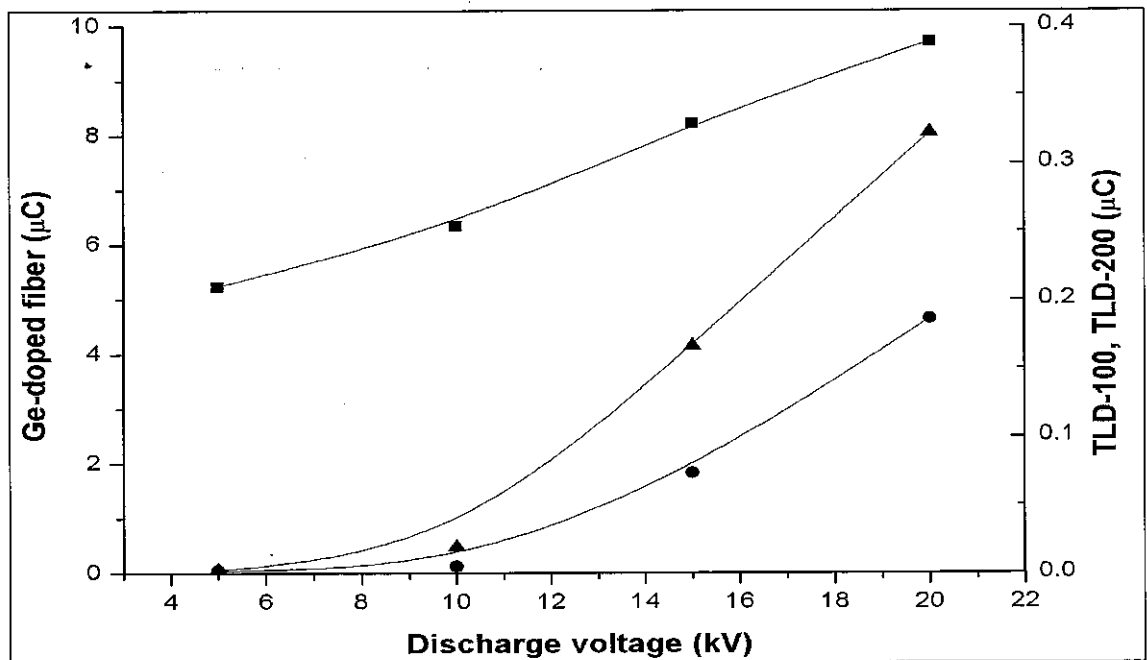


Figure 4. The TL responses in μC , averaged over 10 shots, as a function of vacuum spark discharge voltage (kV) as measured by TLD-100 (\bullet), TLD-200 (\blacktriangle) and Ge-doped fiber (\blacksquare)

The TL sensitivity of each detector is measured by normalizing its response at 8.05 keV to its response at 1.25 MeV gamma radiation from ^{60}Co . TLD-200 is the most sensitive detector with a sensitivity factor of about 29 compared to TLD-

100 whose sensitivity factor is only about 1.2. The sensitivity of Ge-doped fiber is about 13.8.

CONCLUSION

The relative responses of three types of thermoluminescence dosimeter to X-ray photons at 8.05 keV have been measured and compared. It was found that TLD-200 has the best sensitivity of about 29, followed by the Ge-doped fiber which is 13.8. The TLD-100 is the least sensitive to the low energy photons, with a sensitivity of as low as 1.2.

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