IX—17

5 - POINTS DOSEMONITOR UTILIZING SEMICONDUCTOR DETECTOR

Mitsuaki Kitamura and Tokuzo Komai
Radiation Apparatus Plant, Shimadzu Seisakusho Ltd., Kyoto

Abstract

The semiconductor as a radiation detector is much more advantageous than the ionization chamber in the fact that it is extremely small in design, rigid in structure, and requiring no high tension power source. The 5-points dosemonitor is employed silicon diodes as the detector. The dosemonitor can directly measure the dose of rectal wall and bladder wall in the treatment of cervix cancer. The detector consists of five semiconductors set in line by same intervals.

1. Composition of 5-points dosemonitor

The detector illustrated in Fig. 1 is an integrated body of five semiconductors arranged at equal intervals, measuring about 5 mm in diameter. The outputs of each detector are respectively integrated and displayed in the digital panel meter located on the control panel, and, at the same time, the dose rate is changed over for each channel to be exhibited in the meter.

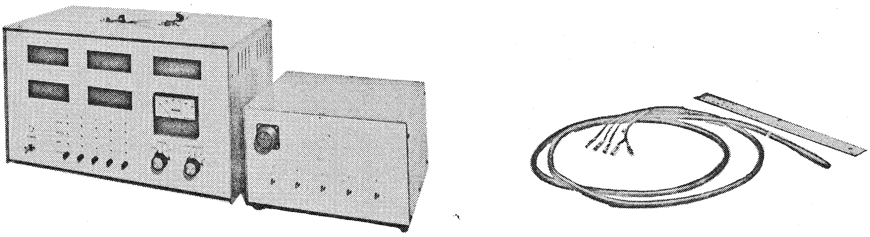

Fig. 1 Appearance of 5-points dosemonitor

2. Performance of semiconductor radiation detector

When a voltage of V is applied to the p-n junction of semiconductor from outside, a current of Ii will flow, which can be expressed as:

$$I_i = K \{\exp(eV/kT) - 1)\} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

The value of K is the saturated current flowing when a sufficiently large reverse voltage is applied to the p-n junction and determined by the characteristics of a specific semiconductor; k is the Boltzmann's constant; and T is an absolute temperature.

Meanwhile, the current Ir produced at the semiconductor by radiation is:

$$I_r = eR(L_P + L_n + D) \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

In which, R is the carrier produced per cm^2/sec when radioactive rays are radiated and is proportional to the radiation dose rate; Lp is the diffusion length of electrons in the P-type range; Ln is the diffusion length of positive holes in the n-type range; and D is the width of depreciation layer.

Since $L_n \gg L_p$, $L_n \gg D$, it follows that:

$$I_r \cong eRL_n \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

From equations (1) and (3), the output current I obtained as the radiation detector will be:

$$I = I_i - I_r.$$

Hence,

$$I \cong K\{\exp(eV/kT) - 1)\} - eRLn \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

From this equation, it is found that the output current I of semiconductor detector is expressed in the function of temperature T and has temperature dependency. When a measuring method that can make $V = 0$ is used, the relation will become

$$I = -eRLn$$

and it is possible to obtain an output current proportional to dose rate, irrespective of temperature.

Figure 2 illustrates this measuring circuit and the temperature curve of the 5-point dosemonitor is plotted in Fig. 3.

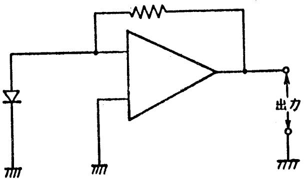

Fig. 2 Measuring circuit.

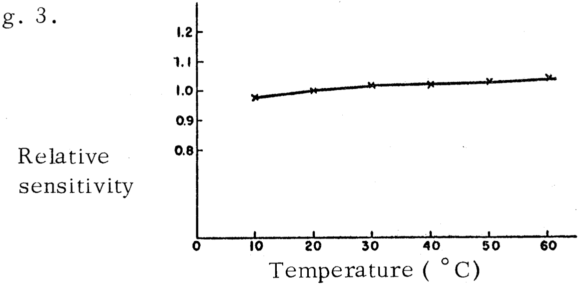

Fig. 3 Temperature curve.

Another problem related to this semiconductor detector is the deterioration due to radiation. The deterioration of 5-points dosemonitor due to Co^{60} -γ rays is a sensitivity change of less than 3 %, in the range of up to 1.4×10^6 (rad), which is sufficiently at a practical level.

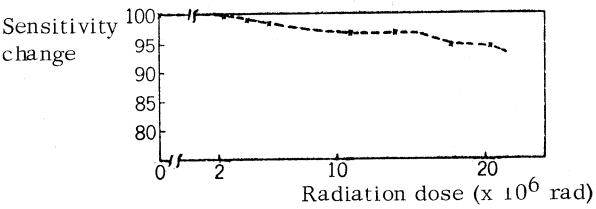

Fig. 4 Deterioration curve.

3. Conclusion

By designing the outside diameter of detector in 5 mmϕ , it becomes possible to measure the dose rate of bladder wall. It is very effective in the clinical service, together with the measurement of dose rate in the rectum. The 5-points dosemonitor can be applied not only in the measurement of intracavitary dose rate as mentioned above, but in labor saving of measurement of dose rate distribution and other uses.