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STUDY OF CHARACTERISTICS OF COLUMN-TYPE NON-POWER DETECTORS FOR MEASUREMENT OF GAMMA-RAY DOSE

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Introduction

Irradiation by gamma rays can produce a charge deposition near the interface of materials of different atomic number (Z). The deposition of charge can cause high induced voltages if one of the materials is an insulator. This effect can be in the kilovolt range under conditions using the better insulators. For example, irradiation of a plate of a low-Z insulator which is much thinner than the absorption length of gamma rays but thicker than the maximum range of the electrons produced within it by gamma rays will produce a current of photo- and Compton electrons which runs in the direction of the incident radiation beam. When a perturbating layer of higher-Z material is placed perpendicular to the beam, within the insulator, a space charge will be produced on both sides of the higher-Z layer within the insulator. The accumulation of space charge near the perturbating layer continues with increasing dose until limited by radiation-induced conductivity or breakdown of the insulator. The phenomena and regulations of charge deposition in higher atomic number materials placed within an insulator and irradiated were studied by S.Kronenberg[1], Jin Shengren[2-6] and others[7-14]. Some characteristics of plate-type non-power detectors with different structures were studied[2-6]. The results indicated that the application of plate-type non-power detectors, even with different structures, was limited. In this paper, the characteristics of column-type non-power detectors, with different structures, are further studied and compared with the characteristics of plate-type non-power detectors with different structures.

Experiments and Measurements

The structure of a column-type non-power detector is shown in Fig.1. The column-type non-power detector consists of: a) an internal electrode of a higher-Z material such as Aluminium; b) a dielectric such as polyester film; c) a conducting layer such as Carbon which forms a capacitor together with the internal electrode and the dielectric; d) an induction body of a low-Z material such as polythene which produces photo- and Compton electrons when irradiated; e) an outer shell which is connected to the conducting layer; and f) a measuring hole which is as small as possible.

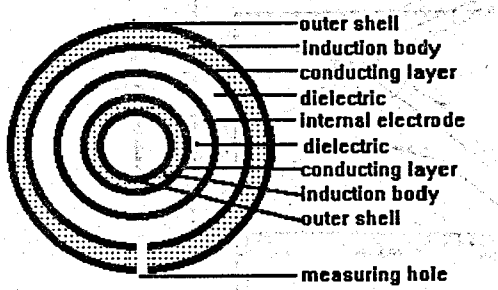

Figure 1 The structure of a column-type non-power detector.

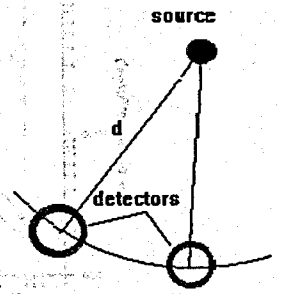

Figure 2 The plane schematic of the experiment.

The gamma ray source used for the measurements is a vertically-placed column-type ^{60}Co source with an irradiation rate of 0.1432 ($C.kg^{-1}.s^{-1}$). The plane schematic of the experiments is illustrated in Fig.2. Charge densities per unit area ($Coulomb/cm^2$) induced in the internal electrode by gamma rays were measured with a high input-resistance electrometer (FJ-256, made in China). Time was less than 1 minute from the stop of irradiation to the start of measurements with the electrometer. The measurement uncertainty is much less than $\pm 10\%$, consisting of inherent detector errors and errors of the measuring system.

Results and Discussions

Column-type non-power detectors with different diameters were simultaneously irradiated. The internal electrode diameters of the column-type non-power detectors were 1.4 cm, 4.1 cm and 6.1 cm, respectively. The detectors were placed 0.3 m from the source, where the dose rate was 1.99 (Gy/s). The charge densities per unit area induced in the internal electrodes by ^{60}Co gamma rays of different doses were measured with

the electrometer. The results of the measurements are shown in Fig.3. It can be seen from Fig.3 and compared with Fig.4 that positive charges are also deposited in the insulated internal electrodes of column-type non-power detectors, though the shape and structure of these detectors are different. The charge densities deposited in the internal electrodes of column-type non-power detectors are also nonlinear with respect to irradiation dose, and all of them decrease after tending towards saturation. The order of saturation dose corresponding to the saturation charge densities of different detectors is S-type > U-type > I-type and ϕ6.3 cm > ϕ4.1 cm > ϕ1.4 cm. The larger the diameter of a column-type non-power detector, the larger the value of the saturation dose, and the more linearly the charge density deposited in the internal electrode of a detector changes with irradiation dose.

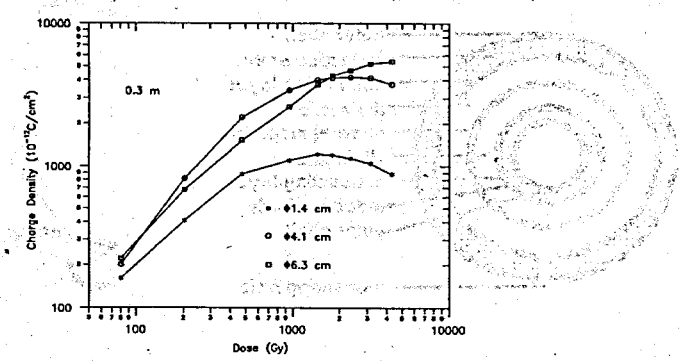

Figure 3 Charge density induced in plate-type detectors.

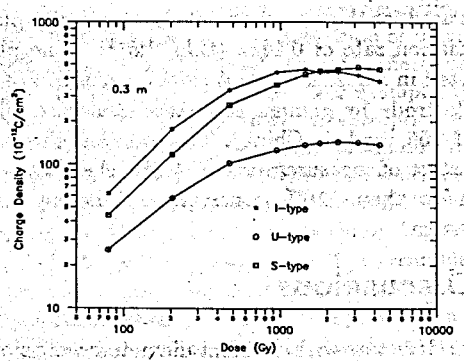

Figure 4 Charge density induced in column-type detectors.

A column-type non-power detector with a diameter of 4.1 cm was placed 0.3 m, 1.1 m, 2.0 m and 2.8 m, respectively, from the ^{60}Co gamma ray source and irradiated at

the same dose each time. The charge densities per unit area induced in the internal electrode at different distances from the source were measured with an electrometer as a function of irradiation dose. The results, which appear in Fig.5, show that the charge densities deposited in the internal electrode are obviously different, because of the different distances between the detector and the source, though the irradiation doses were the same. The saturation doses are definitely dependent on the distance between the detector and the source. The farther the detector is from the source, the more parallel the gamma rays from ^{60}Co point source are, the more linearly the charge density deposited in the internal electrode changes with irradiation dose.

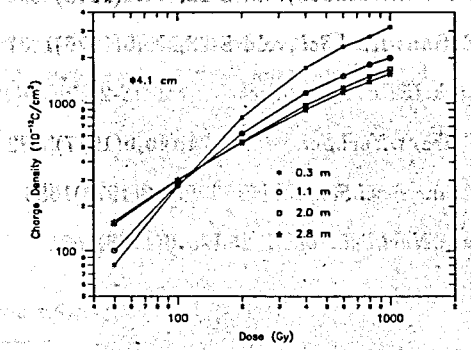

Figure 5 The charge density of the column-type non-power detector at different distance from the source.

Conclusion

The charge densities deposited in the internal electrodes of column-type non-power detectors with different diameters are nonlinear as a function of irradiation dose, and decrease after tending towards saturation, as do plate-type non-power detectors. In the case of a ^{60}Co gamma ray point source, the charge densities deposited in the internal electrodes of detectors are dependent on the distance between the detector and the source, and the diameter of the column-type non-power detector.

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