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Author
Raju, M.R.

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M. R. Raju

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LAWRENCE RADIATION LABORATORY
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1. Introduction

Use of miniature silicon diodes (MC 170, MC 459, MC 488B, etc., Microsemiconductor Corporation, 11250 Playa Court, Culver City, California), manufactured for electronic circuit applications, as dosimeters for heavy charged particles has been reported (Koehler 1967, Raju 1966). The diodes are operated in short-circuit mode because of relative freedom from temperature effects and no need of bias supply. In addition, the response is proportional to the dose rate over a very wide range of dose rates. The depth-dose distribution of 50-MeV protons and 910-MeV α particles measured with these diodes shows no saturation effects at the Bragg peak position. The depth-dose distribution of ^{60}Co γ rays and 8-MeV electrons as measured by these diodes agrees well with results from the ionization chamber. The sensitivity of these diodes is limited to about 10 rads/min because of their small size.

Trump and Pinkerton (1967) have also shown the use of the diodes for automatic isodose meter, and their results show excellent agreement with ion chambers for the depth-dose distribution of ^{60}Co γ rays, 6 and 20-MeV electrons.

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*Guest scientist from the Southwest Center for Advanced Studies, Dallas, Texas.

The purpose of this note is to provide some information of interest in the use of these diodes as radiation dosimeters.

2. Radiation Damage

The sensitivity of these diodes does not change when they are exposed to a total dose of (a) 2 megarads of 50-kVP x-rays at a dose rate of 2500 R/min, (b) 0.2 megarad of 250-kVP x-rays at a dose rate of 1500 R/min, or 0.5 megarad of ^{60}Co at a dose rate of 3000 R/min. However, when they are exposed to beams of either heavy charged particles or high-energy electrons, the sensitivity is reduced by a factor of about 2 for a dose of a megarad or so. Hence the diode can be used as a dosimeter for conventional radiation such as 250-kVP x-rays and ^{137}Cs and ^{60}Co γ rays, without a significant problem caused by radiation damage. For use with intense beams of high-energy electrons and heavy charged particles, however, it can be exposed to a high dose, of the order of a megarad, with these radiations and thus it can be used as a dosimeter, since further small exposure does not significantly change its sensitivity.

3. Dose-Rate Effects

The response is found to be independent of dose rate up to an investigated dose rate of 5000 R/min (Raju 1966). The dose rate region is extended beyond 1 megarad/min by using 8-MeV electrons from a linac. The diode is first preexposed to a dose of 10 megarads. Its current output as a function of dose rate is shown in fig. 1. Saturation effects are seen at 30 000 rad/min. A bias of a few volts is adequate for the charge collection up to a dose rate of 1 megarad/min. Further increase in voltage do not seem to help any further. The saturation at 1 megarad/min is probably due to radiation damage. The increase in current at lower dose rates when external bias is applied is due to the increase in leakage current. At higher dose rates, at which the leakage current is negligible when compared with radiation-induced current, the response of the biased diode follows that of an unbiased one.

4. Temperature effects

The diode is exposed to a constant dose rate and its current is measured when the temperature is varied over a range of 5 to 60° C. The average temperature coefficient is found to be +0.4% per 1° C.

5. Directional response

The sensitivity of the diode is found to change with the angle of its orientation when exposed to 250-kVP x-rays. Depending on the type of diode used, the difference in sensitivity between minimum and maximum response is as much as 2 to 3 times. However, when the diode is exposed to high-energy electrons or high-energy heavy charged particles, the sensitivity is found to be independent of the angle of orientation of the diode.

6. Energy response

The sensitivity of the diode is about the same for ^{60}Co γ rays, 8-MeV electrons, and x-rays, and this is in agreement with the results of Trump and Pinkerton (1967). For low-energy x-rays, however, the sensitivity is higher because of a higher absorption coefficient for silicon. For example, the sensitivity of the diode is found to be about 2.5 times as high for 250-kVP x-rays as for ^{60}Co γ rays for a given exposure.

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Caption

Fig. 1. Current output as a function of dose rate.

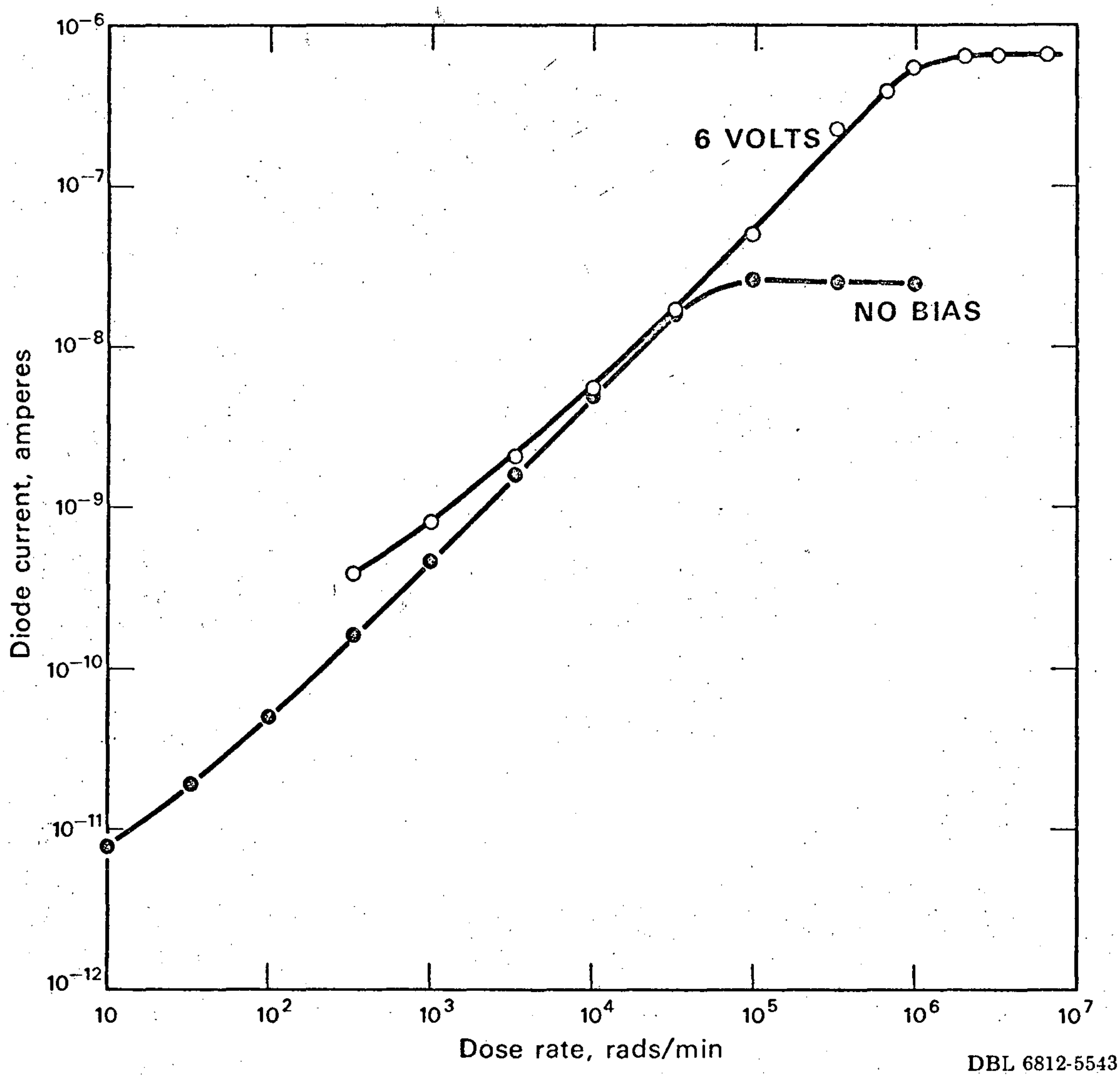

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Fig. 1. Current output as a function of dose rate.

TECHNICAL INFORMATION DIVISION
LAWRENCE RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720