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# Direct Conversion Of Ionizing Radiation Into Electrical Energy Using PIN Diodes

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The energy that comes from the source of ionizing radiation is enormous and quite unused. Using energy from ionizing radiation is a novel concept, while so far in the literature (to the best of our knowledge), only beta radiation has been treated as a possible source of energy (Quenon 2021). This paper focuses on utilizing gamma radiation energy using the Cobalt-60 radiation source. Direct conversion of radiation into electrical energy is possible using pn or pin junction-based semiconductor structures. When high-energy photons hit a semiconductor structure, a built-in electric field of pn junction can separate the generated electron-hole pairs before they recombine, creating the potential difference at the component electrodes. The PIN diodes used in this paper were made in planar technology, with three different active area surfaces: 0.8, 5 and 80 $mm^2$, at the Center of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia. The experiment was conducted in controlled laboratory conditions at the Department of Radiation and Environmental Protection at the Vinča Institute of Nuclear Sciences, Belgrade, Serbia. The range of gamma radiation dose rates for which the PIN diodes have been tested is from 1 $\mu$Gy/h to 10 Gy/h under controlled conditions at room temperature. It is necessary for the diode to operate in a photovoltaic mode to act as a current source in an electrical circuit. Therefore, during irradiation, the characteristics of diodes: short-circuit current and open-circuit voltage were measured as the most important parameters of the current source. The lowest detected dose rate value of the PIN diode with the largest active area (80 $mm^2$) was 5 mGy/h, while diodes with middle (5 $mm^2$) and the smallest active area (0.8 $mm^2$) were 100 mGy/h. The short-circuit current values of PIN diodes for all active area dimensions have a linear dependence with a given dose rate range. By calculating the short-circuit current density, we obtain that diodes with different active areas have almost the same dependence on the dose rate. This result indicates that the current generated under the ionizing radiation directly depends on the size of the active region of the PIN diode. On the other hand, open-circuit voltage values do not have a linear dependence on the dose rate, even the diode with the smallest active area (0.8 $mm^2$) has higher values than the diode with the middle active area (5 $mm^2$). For the highest dose rate (10 Gy/h), the short-circuit current value of the PIN diode with the largest active area is 37 nA, and the open-circuit voltage is 118 mV, which can enable power supply of the low power electric circuits by connecting diodes in series and parallel. The research should continue in order to develop a self-powered circuit that will monitor radioactive sources and their environment.

**References**

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