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COMPENSATED-SURFACE OXIDE-PASSIVATED SILICON JUNCTION RADIATION DETECTORS

Berkeley, California

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COMPENSATED-SURFACE OXIDE-PASSIVATED SILICON JUNCTION RADIATION DETECTORS

William L. Hansen, Frederick S. Goulding and Robert P. Lothrop

December 4, 1962

Compensated-Surface Oxide-Passivated Silicon Junction Radiation Detectors*

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It has been evident for some time that extended use of silicon junction radiation detectors depends upon development of a successful technique for junction edge protection. Epoxy resins[1] have been employed with some success in surface-barrier detectors, and silicone resins, waxes, and other protective materials have all been employed with varying degrees of success. The guard-ring structure was devised at this laboratory to reduce the effect of the exposed junction edge on leakage and noise characteristics of the diode.[2]

The success of oxide passivation in conventional transistors and diodes suggested that this technique might prove useful in edge-protecting diffused radiation-detector junctions. Anticipated use of the technique for this purpose has been mentioned briefly in several papers,[3,4] but early results were disappointing because of the effect of donor states at the Si-SiO_2 interface. In n-on-p detectors, the n type surface channel caused high leakage current, while in p-on-n detectors it caused low breakdown voltage.

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* Work done under the auspices of the U. S. Atomic Energy Commission.

1. R. J. Fox and C. J. Borkowski, IRE Trans. Nucl. Sci. 9, 213 (1962).
2. F. S. Goulding and W. L. Hansen, Nucl. Instr. Methods 12, 249 (1961).
3. J. W. T. Dabbs and F. J. Walter, Eds., Semiconductor Nuclear Particle Detectors, National Academy of Sciences-National Research Council Pub. 871, 1961.
4. W. M. Gibson and T. C. Madden, Bull. Am. Phys. Soc. 7, No. 8, 558 (1962).

In the work reported here diffusion of an acceptor impurity into the Si surface prior to oxidation is used to compensate for the donors introduced by the oxide growth. Conditions have been established for adequate control of the degree of compensation, and it has been demonstrated that good detectors can be made by this process using high-resistivity silicon ($>2000\Omega$ cm). Resolution of the α-particle spectrum is typically 17 keV for 1-cm-diam. detectors made by this process and initial indications are that these detectors are much less sensitive to ambient conditions than were earlier types of detector.

These detectors are manufactured from thin wafers of p type high-resistivity silicon. A boron diffusion for 3 hours at 1000° C using BI_3 vapor with dry N_2 carrier gas produces a p^+ back contact, the boron-diffused layer on the front being removed by etching. A gallium diffusion at 900° C for 1 hour is then employed to produce a shallow p^+ layer with very low hole concentration. The sheet resistance of this p^+ layer is about 3400Ω/square. The wafer is then oxidized in steam at 1000° C for 2 hours. The gallium is partially gettered by the oxide growth and, if the amount of oxidation is correct, the gallium acceptor centers remaining in the silicon just compensate the donor states which occur at the Si-SiO_2 interface. The structure shown in Fig. 1 is now etched in the front face (picein is used as a mask) and phosphorus is diffused at 900° C for 30 min through the oxide mask. The phosphorus source is PBr_3 at room temperature, with dry N_2 mixed with a trace of O_2 as a carrier. The oxygen inhibits bromine etching of the silicon. The oxide is then etched off the back of the wafer to permit electrical connection to the boron-diffused layer, and connections are made as shown in Fig. 1. The detector is then operated as a guard-ring detector.

FIGURE LEGEND

Fig. 1. Oxide passivated guard-ring detector.

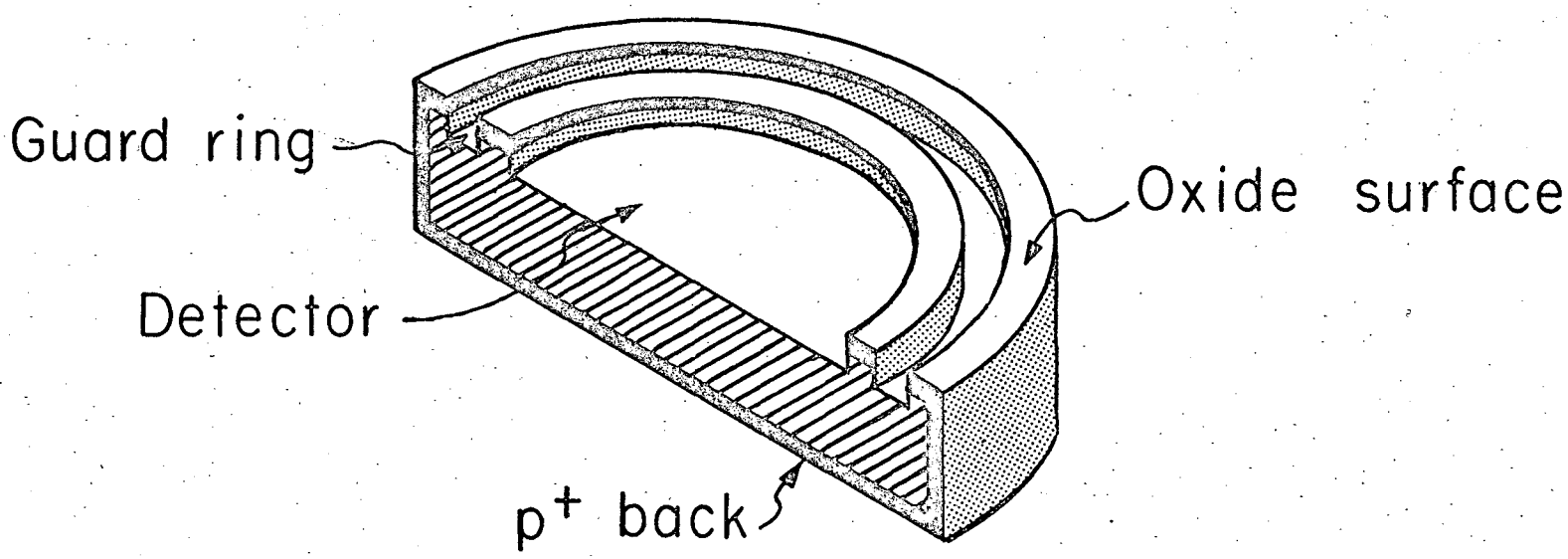
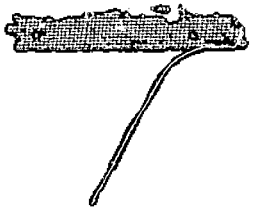


Fig. 1.

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