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Permalink
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Publication Date
1962-12-04
University of California

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UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Berkeley, California
Contract No. W-7405-eng-48

COMPENSATED-SURFACE OXIDE-PASSIVATED SILICON JUNCTION RADIATION DETECTORS
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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 guardring 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.

\(^{*}\) Work done under the auspices of the U. S. Atomic Energy Commission.


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 (> 2000Ω 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 Bi₂₃ vapor with dry N₂ 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-SiO₂ interface. The structure shown in Fig. 1 is now etched in the front face (piccin is used as a mask) and phosphorus is diffused at 900°C for 30 min through the oxide mask. The phosphorus source is PBr₃ at room temperature, with dry N₂ mixed with a trace of O₂ 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.