Title

HIGH VOLTAGE OPERATION OF LITHIUM-DRIFTED SILICON DETECTORS USING A SHELF STRUCTURE

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Publication Date

1967-05-01

UCRL-17557

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May 1967

Berkeley, California

DISCLAIMER

Su[redacted]ed to Gatlinburg Conference
On [redacted] Conductor Detectors and
Assoc[redacted] Circuits, May, 1967

UCRL-17557
Preprint

UNIVERSITY OF CALIFORNIA

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AEC Contract No. W-7405-eng-48

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FOREWARD

This is one of a series of papers presented at the Gatlinburg Conference on Semi-Conductor Detectors and Associated Circuits (May, 1967). Taken together, the papers represent a general summary of some of the recent advances in this area at LRL, Berkeley.

HIGH VOLTAGE OPERATION OF LITHIUM-DRIFTED SILICON DETECTORS USING A SHELF STRUCTURE*

By: F. S. Goulding and R. P. Lothrop

As shown by Llacer [1,2], the turnup in leakage current and noise with increasing voltage in lithium-drifted detectors can usually be attributed to breakdown effects at the junction of the n-type surface channel and the bulk p-type material (see Fig. 1). In his second paper Llacer points out that the breakdown voltage depends on the type of structure used as well as the precise surface conditions. Structures in which the bulk electric field tends to deplete the surface channel can be expected to give better high voltage performance.

Measurements on surface channels made in our laboratory confirmed the major points of Llacer's model and suggested the possibility of using the shelf structure shown in Fig. 2 to increase the breakdown voltage of lithium-drifted silicon detectors and to make surface treatment less critical. The basic process is similar to that described earlier[3,4] except for the second step shown in Fig. 2. After the lithium diffusion over the complete front face of the wafer, a short drift is carried out to produce a 1/2mm drifted region (N.B. 1/2mm may not be the optimum depth but is quoted here for the purpose of illustration). The mesa structure normally used in our planar detectors is now etched, removing all lithium-diffused material in the shelf region but not removing the intrinsic shelf region itself. Drifting is then continued through the whole wafer as in our earlier process.

The effect of the shelf is shown in Fig. 3. Due to the high electric field existing across the shelf region (as much as 50,000 V/cm) the surface channel is pinched off and no voltage appears at the junction between the surface channel and p-region at X. Surface potential measurements on a typical detector produce the results shown in Fig. 3b. Fig. 4 shows the leakage current-voltage characteristic of one of these detectors. While the leakage current of this particular detector is somewhat high, there is no sign of turn-up in leakage current up to 3KV applied voltage. This compares with about 500V in similar units not having the shelf structure.

*This work was carried out as part of the program of the Nuclear Chemistry Instrumentation Group of the Lawrence Radiation Laboratory supported by AEC Contract No. W-7405-eng-48.

We also note that none of the low frequency noise which is characteristic of surface breakdown is observed in this unit.

Several shelf-structure units do show leakage current turn-up and breakdown noise in the 2 to 5KV applied voltage range. We have no explanation for this behaviour at the present time.

References

1) J. Llacer, IEEE Trans. Nucl. Sci. NS-11, No. 3 (1964) 221.

2) J. Llacer, IEEE Trans. Nucl. Sci. NS-13, No. 1 (1965) 93.

3) F. S. Goulding and W. L. Hansen, IEEE Trans. Nucl. Sci. NS-11. No. 3 (1964) 286.

4) R. P. Lothrop and H. Smith, UCRL-16190, June 11, 1965, Lithium-Drifted Silicon Detector Production Process.

Figures

1) Illustrating Source of Voltage Breakdown

2) Showing Construction of Shelf Structure

3a) Structure Geometry

3b) Surface Potential Distribution

4) Typical Leakage Current-Voltage Curve

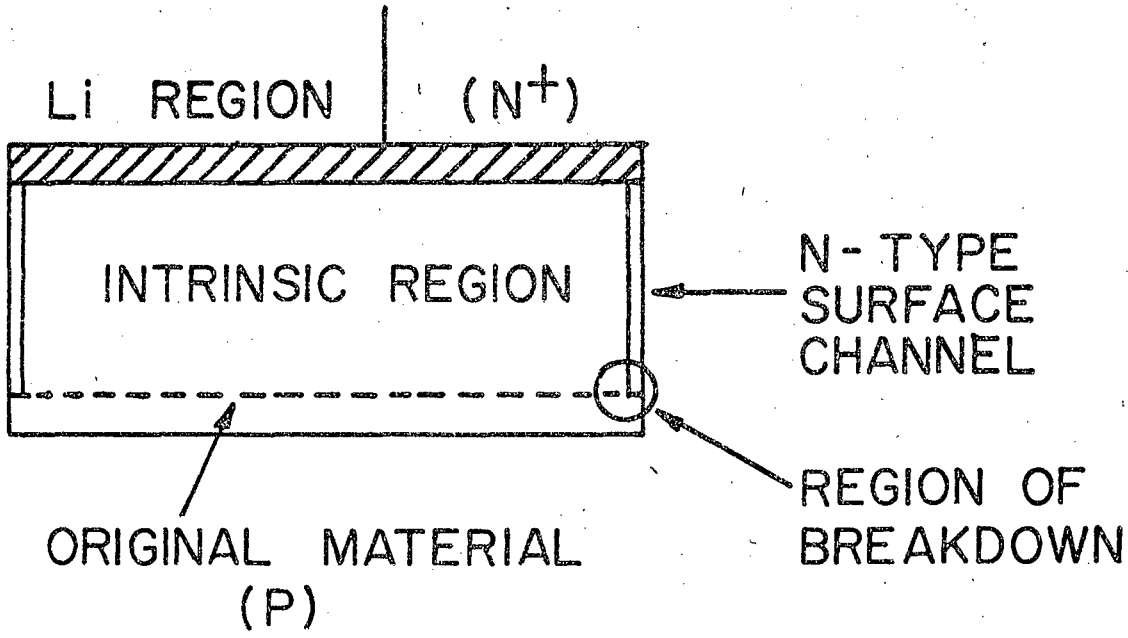

FIG I: ILLUSTRATING SOURCE OF VOLTAGE BREAKDOWN

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Fig. 1.

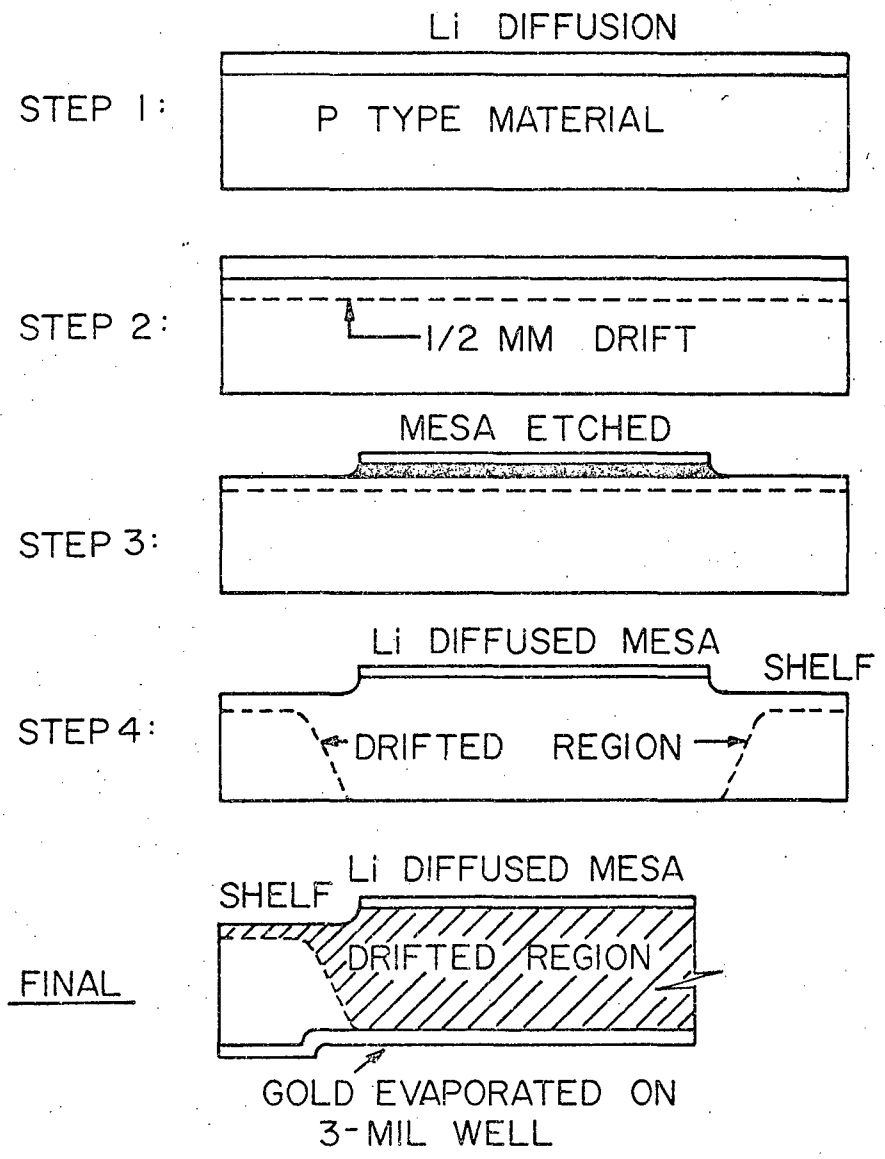

FIG 2: SHOWING CONSTRUCTION OF SHELF STRUCTURE

XBL 674-1433

Fig. 2.

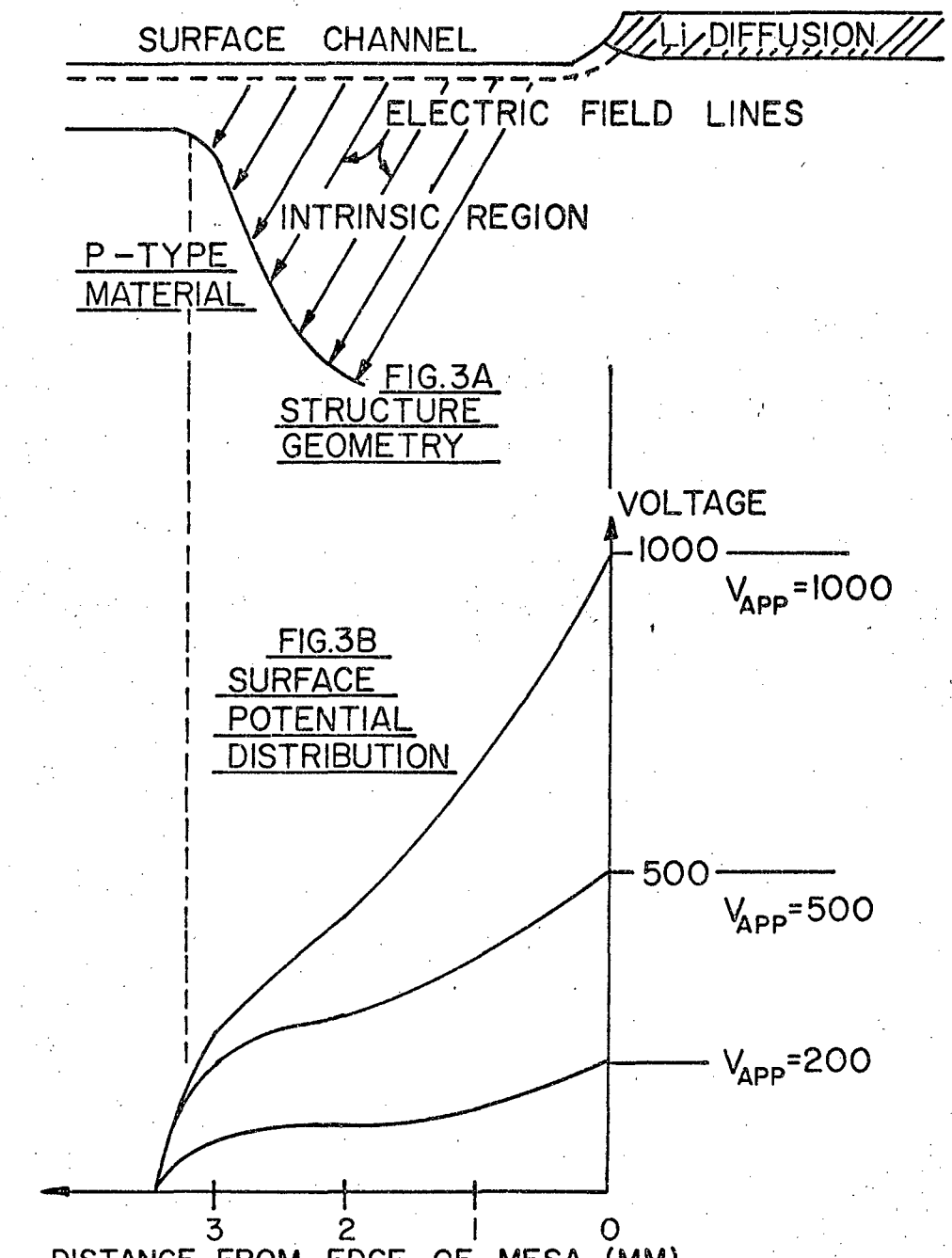

FIG.3: ILLUSTRATING DEPLETION OF SURFACE AT SHELF

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Fig. 3.

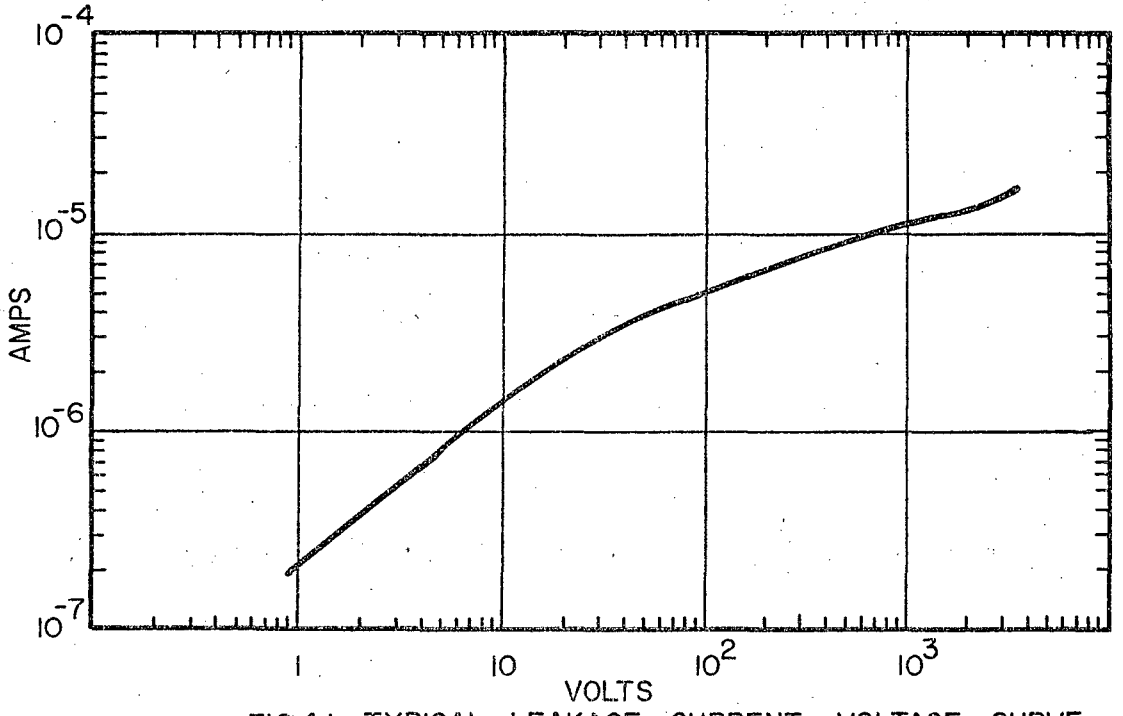

FIG.4: TYPICAL LEAKAGE CURRENT – VOLTAGE CURVE

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Fig. 4.