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F. S. Goulding and R. P. Lothrop
May 1967
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F. S. Goulding and R. P. Lothrop

May 1967
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.
SOME OBSERVATIONS OF RADIATION DAMAGE IN LITHIUM-DRIFTED SILICON DETECTORS IN
NUCLEAR REACTION EXPERIMENTS *

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

During several years of using large quantities of lithium-drifted silicon
detectors we have observed many examples of radiation damage. As our observations
seem to supplement, and to some extent differ from those reported elsewhere
(e.g. Ref. 1), this brief note seems worthy of presentation at this meeting.

Our observations can be summarized as follows:

1) In nearly all cases the damage is distributed over the entire area of
the detector. Except where a detector has been accidentally moved through the
direct particle beam, no image of the collimator is seen. These results point
very clearly to fast neutrons as the major source of damage.

2) The effect of the irradiation is delayed. In general no damage effects
are observed during the course of an experiment (i.e. 1 to 3 days), but the effects
appear over a period of several days to weeks depending on the degree of damage
sustained.

3) The result of the damage is to convert the intrinsic (or nearly intrinsic)
material toward its original p-type. Experimentally one observes this as an increase
in the voltage required to deplete the whole sensitive region. This voltage increases
over a period of weeks following the irradiation and may eventually exceed the voltage
limit set by surface breakdown. If the detector is operated at a voltage below the
punch-through value, the thick dead layer within the gold entry window causes severe
degradation in resolution.

4) If the detector output is used for timing purposes, the onset of damage
may appear as a change in timing (due to reduced electric field in the back region
of the detector) long before the appearance of a window.


*This work was carried out as part of the program of the Nuclear Chemistry Instru-
mentation Group of the Lawrence Radiation Laboratory supported by AEC Contract
5) These consequences of damage appear before any other apparent effects—such as severe leakage current or surface noise.

6) We have had no success with re-drifting lithium in these detectors. This result may well depend upon the degree of damage.

It is tempting to suggest that our results are explainable in terms of lithium precipitation at damage sites. However, no effort has been made by us to study this process in any detail. (Perhaps some graduate student might think this a worthy subject for a Ph.D. thesis).

We hope that these observations impress experimenters with the importance of reducing the fast neutron dose at any detector used in a nuclear reaction experiment. The use of a beam collimator near the target is to be avoided where possible—the final collimator should be well back in the beam pipe. It is also desirable to move the Faraday cup well back from the scattering chamber. While this may require an extra quadrupole magnet between scattering chamber and Faraday cup, the cost may well be less than that of detectors. As a further precaution, care must be taken to reduce unnecessary neutron production such as can arise from beam spill onto the target frame. Finally, where their thickness is adequate, diffused rather than lithium-drift detectors should be used. Diffused detectors continue to operate after receiving total doses about $10^3$ times bigger than the amount required to kill lithium-drifted silicon detectors.
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