Al/Au/n-Si/Al Surface Barrier Detector

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Charged-particle detectors are required to be operated sometimes in ambient light for applications like alpha counting and range finding. Detectors like Al/p-Si surface barrier with aluminium on the front side are found quite suitable. Gold/n-Si surface barrier detectors are not usable because of their excessive background photo current. These detectors, we fabricate for use in nuclear experiments, were given an aluminium coating on their gold side for use in room light.

Gold on n-type silicon (Au/n-Si) surface barrier detectors were fabricated by following the usual procedure [1]. High-puriy 5-10 kΩ-cm n-type ~1 mm thick Si wafers (<111>) were lapped, chemically polished, dried and fixed on glass-epoxy mount. Two-component epoxy resin (Bisphenol-A epoxy + aliphatic or cyclophatic amine hardener) was used for fixing as well as protecting the junction edge. Thin coatings (~50 μgm/cm2) of gold and aluminium were thermally evaporated to prepare the rectifying contact on the front and the near-ohmic contact on the back side respectively. The Au/n-Si/Al surface barrier diodes were characterized for their electrical properties and performance as alpha detectors. Detectors showing good energy resolution (~50 KeV) were selected and provided with another thin reflecting coat of aluminium on their front sides (Fig.1).

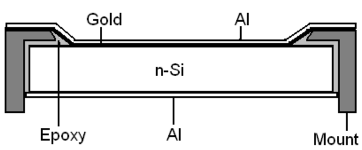

Fig. 1 Al/Au/n-Si/Al Detector Structure

The effect of the additional coat of alumunium was assessed by evaluating the performance of the fabricated Al/Au/n-Si/Al device as charged-particle detector. I-V characteristics were monitored over a period of time (Fig. 2). Detector leakage was found falling closer to earlier figures (measured before depositing the additional Al coat) with time. It took about 10 days to observe stability in leakage. This leakage behaviour is likely to be related to the gold/aluminium interfacial structure that stabilizes by forming intermetallic compounds [2].

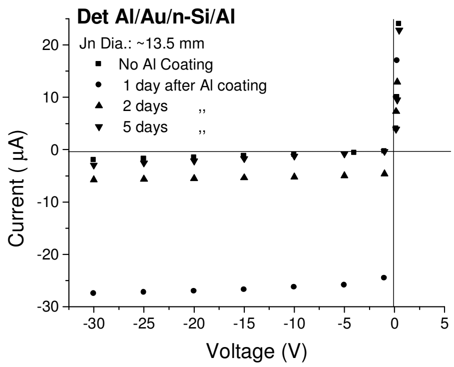

Fig. 2 Current-Voltage characteristics of a surface barrier detector before and after Al deposition.

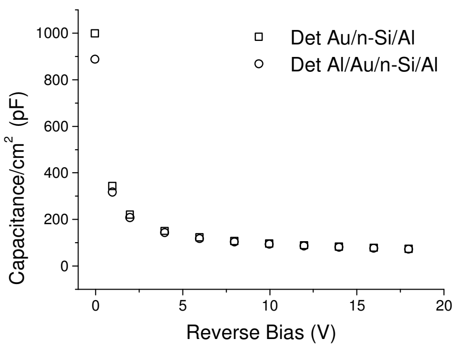

Fig. 3 Capacitance-Voltage characteristics.

It was found from the capacitance-voltage characteristics (Fig.3) that the dependence of depletion layer width on bias voltage was more or less identical for both the detector structures (Au/n-Si/Al and Al/Au/n-Si/Al).

Detectors were tested for their optimum energy resolution inside a vacuum chamber in dark. Alpha response of a ~140 mm^2 area detector to Am/Pu source is produced in Fig.4. Its energy resolution (60 KeV for 5.48 MeV) remained nearly the same after depositing the additional Al layer.

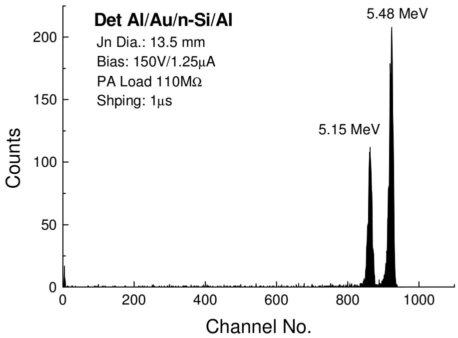

Fig.4 Alpha spectra for dual source (^{141}Am and ^{239}Pu).

Detectors were also tested in ambient (room) light. The increase in leakage current was seen to be less than 2%. Detector noise or biasing behaviour was not affected. Energy spectra for partial deposition of alpha energy in air were recorded with the ~13.5 mm diameter detector mentioned earlier (fig.4). The 8 mm diameter Am/Pu dual source was placed at distances of 10, 20 and 30 mm. Broadening of the Am/Pu peaks (Fig.5) was attributed to the spread of particle energy loss in air.

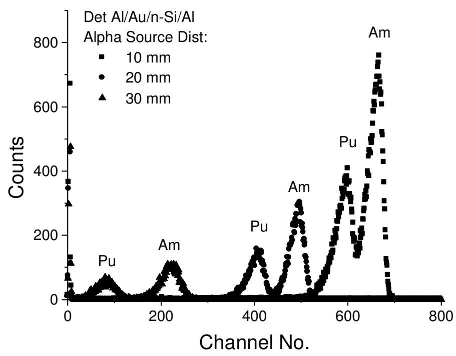

Fig.5 Alpha spectra recorded in room light.

Au/n-Si type of surface barrier detectors were given a thin (~50 $\mu g/cm^2$) aluminium coating and used for recording alpha energy spectra in ambient light. Electrical characteristics and energy resolution of the detectors were not affected by the additional Al thin film. However, the additional Al layer increased the thickness of the dead layer that affect the minimum particle energy one can measure. We are to reduce the dead layer thickness, but see that detector performance in ambient light is not adversely affected.

References

[1] R. Chaudhry and H.V. Hegde, BARC Report 650, 1972.
[2] S.U. Campisano, et al, Philosophical Magazine, 1975, 31:4, 903-917.