Optimization of epoxy passivation process to fabricate silicon radiation detectors

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Introduction

Passivation of surface using two-component epoxy at room temperature is followed to fabricate silicon surface-barrier type of detectors. Proper curing of the epoxy resin using the right amount of amine-based hardener is crucial to minimize moisture intake and hence obtain stable detector performance. A simple experiment was conducted to test hardening and water intake of the cured epoxy by varying the resin to hardener ratio. The data obtained helped us to fix the proper resin to hardener ratio and fabricate charged-particle detectors with lower leakages and better stability.

Experimental

The epoxy curing experiment was carried out by using Ciba CY 230 epoxy resin and amine-based Epoxylite C323 hardener. Epoxy resin to hardener ratio, by volume, was varied from 2:1 to 16:1. The resin and hardener were mixed well, using wooden stick, on a glass plate and then placed on polythene to cure at 60-80 ^{o}C (under an infrared lamp) for 4 hrs. Polythene helped to detach the hardened epoxy samples easily. The cured samples were transparent and clear. Their hardness, as tested by pressing and bending, was found increasing with the decrease of the amine content up to the resin to hardener ratio of 14:1. The samples of 8 - 14:1 ratios were as hard as Perspex. With further decrease of the amine component (16:1), the sample became soft.

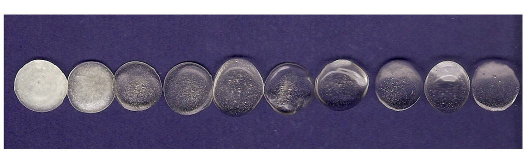

Fig.1 Epoxy samples: cured with resin to hardener ratios of 2, 3, 4, 5, 6, 8, 10, 12, 14 and 16:1 (left to right).

Sorption of water was carried out by dipping the cured epoxy samples in water at room temperature for a month. After the water intake, samples with resin to hardener ratio of 4:1, 3:1 and 2:1 turned progressively whitish with increase of the amine component (see Fig.1). The whitish colour is attributed to blushing of the excess amine in the samples [1]. The water intake started dropping with increase of the epoxy component up to the resin to hardener ratio of 8:1 and then remained more or less the same, 2 ±0.5% (see Fig.2). Epoxy cured with equivalent –NH to equivalent epoxy ratio of 0.5 to 1.2 was reported to show water intake independent of the amine content [2].

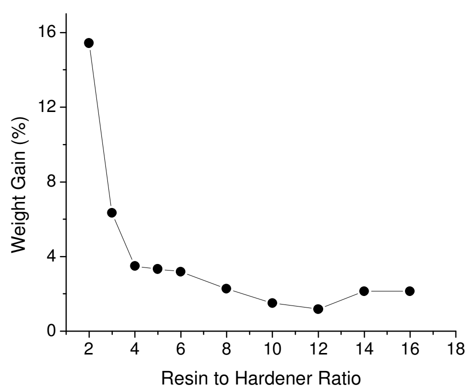

Fig.2 Water intake of epoxy samples.

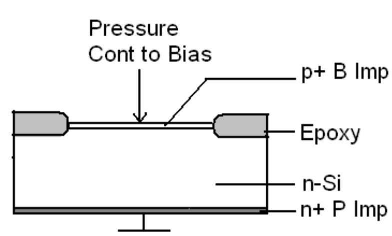

Fig.3. Epoxy passivation test structure

In order to see the effect of moisture intake, ion-implanted p^+/n-Si/n^+ mesa diodes of fixed junction area (see Fig.3) were epoxy passivated with resin to hardener ratios of 4, 8 and 12:1. The passivated diodes were tested for their leakage characteristics in vacuum ($\leq 10^{-1}$ torr) and air (see Fig. 4). In the case of the 4:1 epoxy, the leakage was greatly affected due to the intake of moisture. In the other two cases, the leakages were low and least affected.

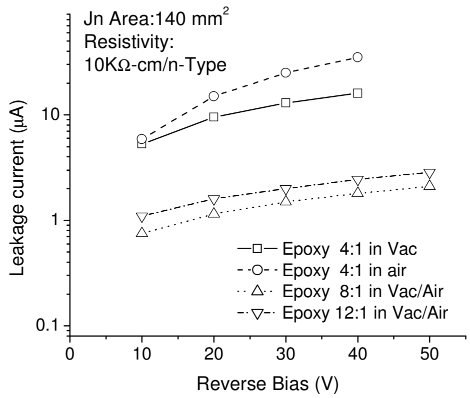

Fig.4 Leakage characteristics of diodes passivated with epoxy.

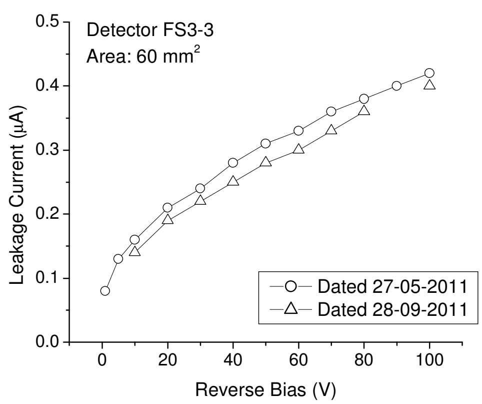

Fig. 5 Leakage characteristics a Si surface barrier diode.

Au/n-Si/Al type of surface barrier detectors for charged-particles [3] was fabricated by passivating the surface with epoxy which was cured with resin to hardener ratio of 10:1.

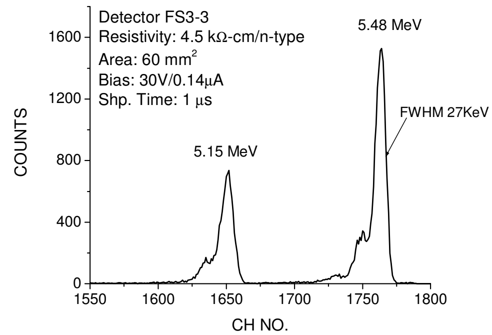

Fig. 6 Am-Pu alpha spectrum.

Detectors were fabricated with high breakdown voltages (>100V). Their leakage characteristics were found quite stable for more than 3 months (see Fig.5). 50 mm^2-area detectors with energy resolution of ~30keV for 5.48 MeV α (see Fig.6) could be fabricated.

Conclusion

Epoxy passivation process was optimized by fixing the resin to hardener ratio that minimized the moisture intake. It was possible to fabricate epoxy passivated Si detectors with useful and stable characteristics.

Acknowledgement

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References

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