HPGe and clover gamma ray detector maintenance

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Introduction

High purity germanium (HPGE) detectors [1] are used for gamma ray spectroscopy. At Inter University Accelerator Center (IUAC), New Delhi, both single crystal HPGe detectors and composite detectors like Clovers are used for nuclear structure studies. The germanium detectors have very high resolution (~ 1.5-2keV @ 1 MeV γ-peak) and thus employ very sensitive and low noise electronics in the preamplifier circuits. In order to minimize the leakage current in the crystal and the input stage of preamplifier, the crystals are cooled using LN_2. Thus there is electronic circuitry to sense LN_2 temperature and shut down the detector in case of improper cooling. Further the detectors also suffer from radiation damage due to exposure to neutrons at the time of experiments. In this abstract we describe below the procedures taken by us to service some of our detectors. We describe in detail the problems encountered and the results after servicing.

Diagnosis & solutions

1. No output from preamp:

Some of the detectors were not showing any output signal after connecting the test signal of the detectors to a pulsar. For the diagnosis of the above problem, preamplifier of the corresponding detector was opened and it was found that the isolation capacitor (68μF, 35V) of 12V supply had shorted. After that we have replaced it with a working isolation capacitor and detector was start giving the proper signal.

2. Problem due to leakage current:

During the servicing of detectors, it was found the some of the detectors were showing high leakage current. The high leakage current is due to the improper functioning of FET. Due to which the detectors were not taking bias after a certain volt. After a certain volt, the leakage LED was started to glow and the signal was ended. To overcome this problem, first the evacuation and annealing of the detectors were done but it was not successful. Finally, the bad FET was replaced by opening the FET assembly towards the crystal side and replacing it with the new one. This resolves the problem and the detector behavior was normal.

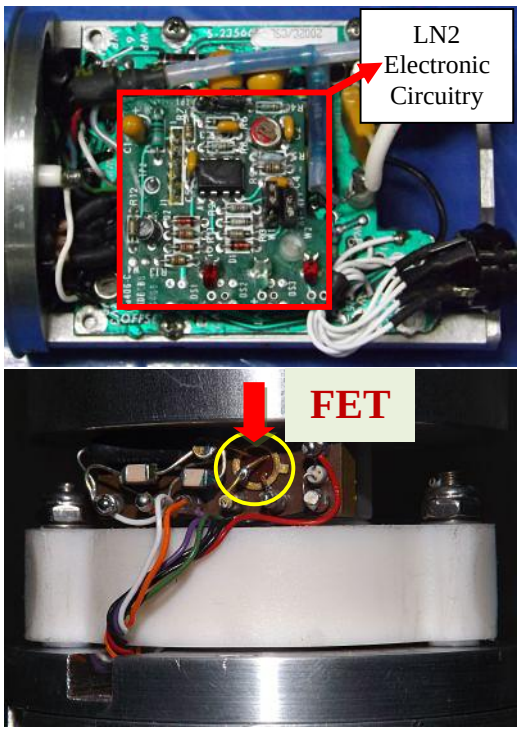

Fig.1. The above figure shows the preamp card and the lower figure shows the inside view with FET assembly

3. Dewar evacuation and annealing.

The LN_2 filling of Dewar of the detectors at a proper time and the holding capacity of Dewar for LN2 is very important in the case of Germanium detectors. It was found that the Dewar of some of the detectors was taking longer time to fill and also there was condensation on aluminum cap towards crystal side. To overcome the above problem, first the detector was warmed at room temperature and then it was evacuated up to a pressure $\sim 10^{-6}$ mbar. It was also annealed during evacuation process to save the time. It takes 2-3 days for the simultaneous evacuation and annealing.

4. Tailing in peak.

One of the reasons of tailing in peak is the neutron damage of crystals. In this type of tailing, a peak at higher energy shows tailing to the lower energy side (left side). To overcome this problem, the detector was annealed and evacuated by wrapping heating tape around the aluminum cap of the crystal side at a temperature ~ 85 ºC and pressure up to $\sim 10^{-5} - 10^{-6}$ mbar for 2-3 days.

5. Clicking sound with bias.

A clicking sound was coming from the inside of the detector just after giving a certain bias voltage. The reason of this clicking sound is an electric short between the legs of the capacitor, mounted on preamplifier card. For the diagnosis of this problem, the detector was placed in the dark room to see any electric shorts. To overcome this problem, insulation glue was put in between the capacitor legs. After this, the detector was taking the recommended bias voltage with no clicking sound.

Conclusion

The diagnosis of some technical problems found in the germanium detectors at IUAC and their solutions has been discussed in the present paper. We have discussed the problems related to FET, bias voltage, tailing in the peaks due to neutron damage, LN_2 filling and their corresponding solutions in this paper. The repaired germanium detectors has been successfully used in the recent lifetime measurement experiment in GDA beam line at IUAC and all the detectors gave the excellent performance during the experiment.

Acknowledgement

The authors are grateful to the IUAC for providing the financial support for purchasing the necessary electronic components required for detector servicing.

References

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