Upgraded heating device for Ge detector annealing

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The Clover Ge detectors that are used for verification of the particle identification at BigRIPS separator are susceptible to radiation damage by neutron exposure.[1] It is well known that the neutron damage degrades the energy resolution of Ge detectors, and that the degraded energy resolution can be restored by annealing process at the Ge crystal temperature of ∼100°C and for the process time of ∼100 hours. To carry out the annealing process in our facility, the annealing system had been prepared by ourselves.[2]

Though the heating device for our ORTEC Clover Ge detectors (AMETEK, Inc.) had also been prepared, the Ge crystal temperature had been limited to the maximum of 80°C, and due to that, the annealing time took a few tens of days.[2] This was because the heat had been found to damage the vacuum sealer of the LN_2 dewar. The heating device had a copper heating rod that had a heat source at one end. The other end was inserted into the LN_2 inlet and conducted the heat to the bottom of the inner wall of the LN_2 dewar. The vacuum sealer damaged by the heat was located in the middle of the narrow duct of the LN_2 inlet.

Thus, we have redesigned the heating device for ORTEC Clover Ge detectors to realize faster annealing at the Ge crystal temperature of ∼100°C. The arrangement of the improved heating device is illustrated in Fig. 1. To prevent the vacuum sealer of the LN_2 inlet duct from heat damage, we prepared a small cartridge heater (CH1-650; TRUSCO NAKAYAMA Corp.) that is thin enough to insert through the inlet duct to the bottom of the LN_2 dewar. To ensure the heat conduction to the bottom part of the inner wall, the heater was covered with a copper cap that has 10 mm outer diameter. The temperature of the heater is measured by a thermocouple sensor and adjusted by the temperature controller (TC10EM; M-Systems Co., Ltd.). The temperature of the Ge crystal is monitored by the built-in Pt500 thermo-sensor.

We have performed the annealing test of the ORTEC Clover Ge detector #3 by using the improved heating device. During the annealing test, the detector vacuum port was connected to the vacuum pumping system[2] and the pumping was kept working. We adjusted the heater temperature so that the Ge crystal temperature reached to the objective equilibrium temperature of ∼100°C. As a result, we found that the equilibrium Ge crystal temperature of 104°C is obtained when the setting temperature of the heater (SP value) is 270°C (Fig. 2). Note that the true temperature of the heater is approximately the SP value plus the room temperature because no cold junction sensor is used for the thermocouple sensor. After the 100 hours' annealing

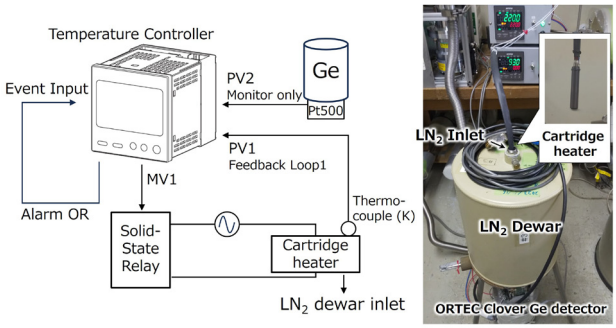

Fig. 1. Arrangement of the improved heating device for ORTEC Clover Ge detectors.

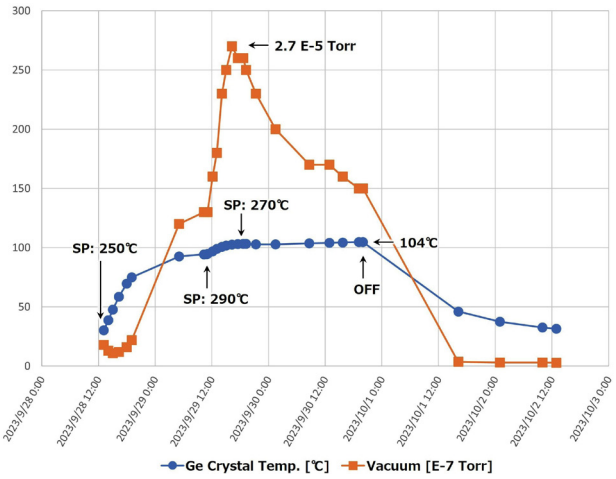

Fig. 2. Result of the annealing test of the ORTEC Clover Ge detector #3. Ge crystal temperature of 104°C was retained.

test, we confirmed that the good vacuum of the detector container is retained. Furthermore, we were able to improve the energy resolution of the ORTEC Clover Ge detector #3 to 3.2 keV–4.2 keV for 1.3 MeV gamma rays, that was 4.0 keV–6.1 keV before the annealing test.

We succeeded in upgrading the heating device for Ge detector annealing and improving the energy resolution of the ORTEC Clover Ge detector. However, we could not recover the original energy resolution of the Ge detectors yet. As mentioned in the previous report,[2] we may have to investigate the electronics component to achieve that. We will pursue further improvement of the maintenance environment for Ge detectors so that much stable operation can be realized.

References

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