Bias Gamma-ray Detector for Irradiation Test

Chul-Yong, Lee *, Kee-Nam Choo, Sung-Woo Yang
Korea Atomic Energy Research Institute 111 Daedeok-daero, 989beon-gil, Yuseong-gu, Daejeon 34057, Korea
**Corresponding author : lcy@kaeri.re.kr*

1. Introduction

A Self Powered Gamma Detector(SPGD) is a gamma-ray detector for reactor irradiation test and in-core radiation measurement. This basic principle of a SPGD measures current by allowing electrons to be emitted by the Compton effect and electrons to reach the collector via the insulator when gamma-ray are absorbed into the emitter. In order to measure the nA current according to the gamma-ray signal, the electron generated in the emitter must reach the collect, but some electrons are absorbed or extinguished. However, applying bias power from the outside to form a strong electric filed between the emitter and the collector can reduce the number of electrons that are extinguished before the collector reached [1].

This study is about the development of the bias gamma-ray detector for an irradiation test. In this paper, we refer to development for a bias gamma-ray detector and experiment.

2. Design of Bias Gamma-ray Detector

Bias gamma-ray detector for a reactor use should use MI (Mineral Insulator) cable and detector type is a small metal tube. Fig. 1 shows the design of bias gamma-ray detector. The sensor element used as a detector's emitter is pure Pb plate and a detector's collector is Al Plate with surface-insulated. We applied the laser micro welding technology for stainless outer tube and MI cable sealing. In addition, the detector tube is sealed after filled with helium gas. The out tube diameter is ø15.8mm and MI cable of ø1mm is used. The size of the Pb emitter plate is 2.0x50.0x2.0mm and used high pure grade Pb. Fig. 2 shows current measurement principle of bias gamma-ray detector. The - electrode of detector connects to the Pb emitter and + electrode connects the collector plate from MI cable. Thus electrons generated in the emitter by gamma-ray reach the collector plate by a strong bias filed. Here, the bias power is connected between the emitter and the collector, so insulation is very important if the electrical shot does not occur. To this end, the hard anodizing is performed on the surface of the collector plate and insulates such as Teflon film can be used.

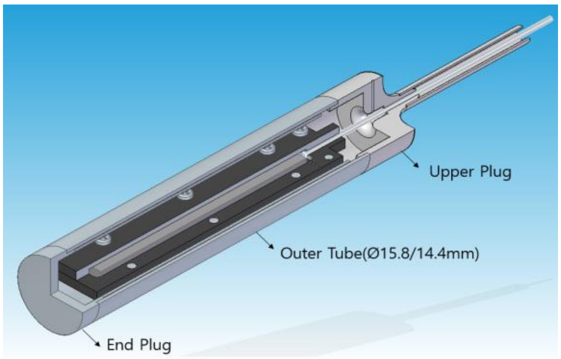

Fig. 1. Design of bias gamma-ray detector

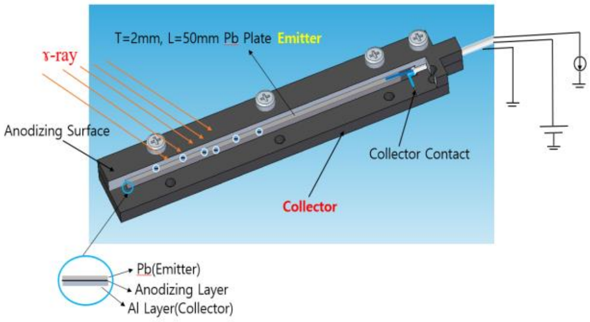

Fig. 2. Current measurement principle of bias gamma-ray detector

3. Response Experiment of Bias Gamma-ray Detector

A response experiment of bias gamma-ray detector was conducted on low-level test facility in Jeongeup (Republic of KOREA).

Fig. 3 shows gamma irradiation test by ^{60}Co source. The nA current output was measured from the ^{60}Co source according to the distance of the detector (3/5/10/15/20 Gy/h). The two bias gamma-ray detectors were fabricated for the test. The MI cable length of detector is about 15m and an extended triaxal cable need for the test. The current measurement was performed using 5 chnnel picoammeter under development such as figure 4. Applied bias voltage is 50V and input current of 0-2,000nA convert to 0-5V output voltage.

Fig. 3. Bias Gamma-ray Detector (left) and Gamma-ray irradiation test (right)

Fig. 4. Picoammeter for nA current measurement

4. Results

Fig. 5 show the measurement results of bias gamma-ray detector. The two detectors can be confirmed to change linearly according to the irradiation dose rate (3/5/10/15/20 Gy/h). The sensitivity of the detector is 13x10^{-14} A/(Gy/h.g) from the test results. This sensitivity value is much larger the Thermocoax's SPGD (2x10^{-14} A/(Gy/h)) and the JAEA's SPGD (0.8x10^{-14} A/(Gy/h.g)) [2].

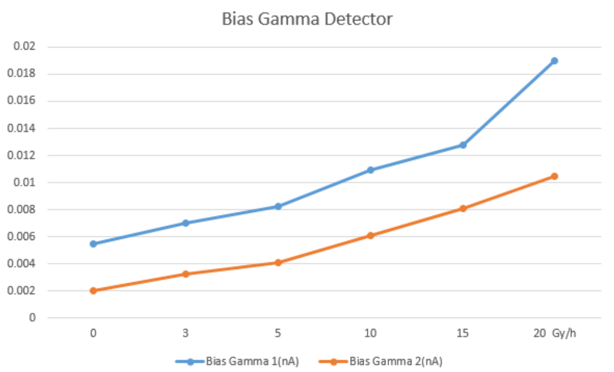

Fig. 5. Current measurement of bias gamma-ray detector.

5. Conclusions

To improve the disadvantages of low output current of SPGD, a bias gamma-ray detector was developed. The development detector was fabricated by using high purity Pb plate as an emitter and by assembling the collector plate with the surface insulated by micro screw. The sensitivity of the bias gamma-ray detector was significantly improved as confirmed in the low-level gamma irradiation test.

We will carry out high-level gamma irradiation test and neutron field test later

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2. T. Takeuchi, et al., "Development of self-powered gamma detector", Jur. Nu. Sci and Tec. Vol 51, No. 7-8, 2014.