Characteristics Estimation of the Scintillation Detector for Decommissioning Monitoring in the High Radiation Dose Area

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1. Introduction

It's necessary to measure the contamination for planning of high-level radioactivity facilities to be decommissioned such as hot-cells or glove-boxes used for nuclear spent fuels. These facilities are very high radiation level, it is difficult to approach. So, it is preferable to separate a photomultiplier tube (PMT) from the scintillation detector using optical fiber.

In this study scintillation detector was prepared using a transparent epoxy resin and organic scintillator. In order to evaluate in the high radiation dose, the scintillation detector was irradiated with high-level gamma-ray, and then the optical properties were tested.

For remote measurement the optical fiber was used. The scintillation light is transmitted through an optical fiber to the PMT that is placed in an electronic instrument outside the high-level radiation area.

2. Methods and Results

2.1 Scintillation Detector Preparation

An organic scintillation detector was prepared using a transparent epoxy resin (Kukdo Chemical Co., LTD, Korea). In this study, the epoxy resin YD-128 which was the Bisphenol A type epoxy was used as an epoxy resin and D-230 as a curing agent. The used organic scintillator was 2,5-diphenyloxazde (PPO) as a first solute and 1,4-bis[5-phenyl-2-oxazol]benzene (POPOP) as a second solute which was a wave shifter.

The organic scintillator was mixed with optically transparent epoxy resin until the organic scintillator powder was completely wet and uniformly distributed throughout the liquid. The mixture was then poured into a polyethylene mold and cure into a bulk type.

2.2 Radiation Hardness of the scintillation detector

The scintillation detector for high-level radiation measurement has to have the radiation hardness. The epoxy and plastic scintillation detector was irradiated with high dose gamma-ray. The used plastic scintillator was a commercially available BC-408 (Bicron).

When the scintillation detectors were irradiated with high dose, the color was changed like Fig. 1. The epoxy base scintillation detector was changed to dark brown with dose increase. But the BC-408 was changed to light yellow green.

Fig. 1. The color change of the scintillation detector after high dose gamma-ray irradiation (up : epoxy base scintillator, down : plastic scintillator).

The optical property is the important property of the scintillator. In this study the transmittance was measured before and after irradiation. The transmittance of the epoxy base detector was rapidly decreased in the short wavelength region. But the BC-408 was increased through all over the wavelength.

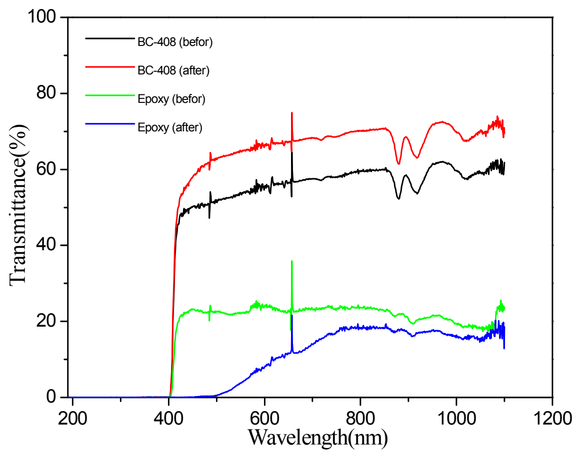

Fig. 2. Optical transmittance of the scintillation detector before and after gamma-ray irradiation.

2.3 Signal Transmission

The optical fiber was widely used in the radiation detection for long distance signal transmission [1-5]. The optical fiber is one of the most promising candidates for signal transmission because it has ideal properties such as broad bandwidth, low attenuation, light weight, and being free from sensitivity to electromagnetic interferences.

The optical fiber was inserted into the epoxy base scintillation detector. The aluminum housing for the scintillator and PMT was manufactured like as Fig. 3. The diameter and length of the optical fiber were 1200, 1500 μm and 2, 5 m, respectively. The used PMT was head-on type H5211A (Hamamatsu inc., Japan), which was connected with optical fiber using SMA connector.

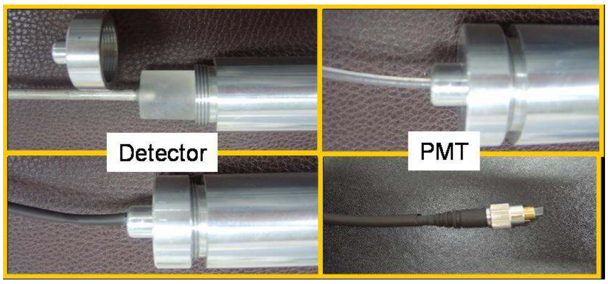

Fig. 3. The scintillation detector and PMT connected with optical fiber.

2.4 Radiation Measurement

In order to test the radiation detection ability, the scintillator was inserted into the counting chamber and the PMT was located in the chamber outside. For radiation test, the aluminum housing for the sensor and PMT was also manufactured and tested using a Cs-137 gamma-ray.

Using the scintillator detector, the gamma-ray spectrum was measured according to the diameter change of the optical fiber. With the diameter change, the pulse height spectrum was not largely changed, but efficiency of the radiation increased with the diameter increase. Also, the pulse height spectrum for the length of the optical fibers was measured. In this case, there were no significant differences at spectrum shape and total counts with the length of the optical fiber. The results show that there was large change for the diameter of the optical fiber, but no change for the length. Therefore, there is little attenuation of the light through the optical fiber, so it can transfer the signal for long distance.

3. Conclusions

The epoxy base scintillation detector applicable to high-level radiation area was prepared and tested. The scintillator was manufactured as bulk type which was hardened with a transparent epoxy resin with organic scintillator. It can transmit the radiation signal for long distance using the optical fiber.

The transmittance and color change before and after irradiation was large in the epoxy base detector. The epoxy base scintillator was not appropriate for high-level radiation measurement. There was no significant change in the BC-408.

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