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Development of the EJ-440/BC-408 Phoswich Detector for Monitoring the Decommissioning Wastes Contamination

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1. Introduction

During the decommissioning of the nuclear facilities, such as KRR 1&2 and uranium conversion facility, a great quantity of waste are generated, the exact contamination level measurement is required for safety management.

In this study a phoswich detector for simultaneous counting of alpha and beta ray in a decommissioning waste was developed. The phoswich detector is convenient for measuring alpha- and beta-ray using only a single detector, composed of a thin ZnS(Ag) and a plastic scintillator[1-5].

The overall counting results reveal that the developed phoswich detector is efficient for simultaneous counting of alpha and beta ray.

2. Methods and Results

2.1. Phoswich detector

The combination of two dissimilar scintillators optically coupled to a single PM tube is often called a phoswich (or phosphor sandwich) detector. The scintillators are chosen to have different decay times so that the shape of the output pulse from the PM tube is dependent on the relative contribution of scintillation light from the two scintillators[6].

A characteristic of the phoswich detectors used is shown in table 1. For a alpha counting, ZnS(Ag) scintillator sheet is used, which was EJ-440 manufactured by Eljen Technology. It consists of a very uniform deposit of silver activated zinc sulfide phosphors applied to on side of clear polyester plastic sheet. And the BC-408 plastic scintillator was used for beta-ray counting, which was manufactured by Saint-Gobain Crystals.

Table 1. Characteristic of the phoswich detectors used

	BC-408	EJ-440
Base material	PVT	ZnS(Ag)
Density	1.32 g/cc	10 mg/cm^2
Light Output (% Anthracene)	64	300
Refractive Index	1.58	-
Decay Time (ns)	2.1	200
Wavelength of Max. Emission (nm)	425	450

2.2. Zero crossing method of pulse shape discrimination (PSD)

The zero crossing method of pulse shape discrimination has used widely in the phoswich detectors. The main advantage of this method is its suitability for use over a large dynamic range of pulse amplitude (variation greater than 100:1). Measurement of the zero crossing time of the bipolar pulse then determines the particle type. An idealized distribution of zero crossing times for hypothetical particle types ‘a’ and ‘b’ is shown in Fig. 1.

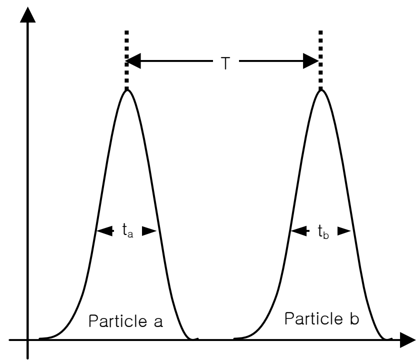

Figure 1. Idealized zero crossing time distribution for particle ‘a’ and ‘b’.

The distribution of zero crossing times can be used to determine a PSD figure of merit M. With reference to fig. 1.

$$M_{a,b} = T / (t_a + t_b)$$

where T is the separation between the time peaks and t_a and t_b are the respective FWHM of the zero crossing time distributions.

2.3. The measurement of pulse-height and pulse-shape distributions

Fig. 2 shows the pulse height spectrum of alpha-rays from Am-241 source and beta-rays from a Sr/Y-90 source, obtained by EJ-440/BC-408 phoswich detectors. Beta-ray events were observed in the low energy range, while alpha-rays were observed simultaneously in the higher channels. In the pulse height distribution, alpha- and beta-ray are overlap in the low energy regions. Each radiation must be discriminated in a phoswich detector to allow simultaneous measurement of different type radiations using single-detector system. Pulse-shape distributions were measured with a technique of pulse-shape discrimination to examine the degree of resolution between alpha- and beta-rays, which is represent in a figure of merit.

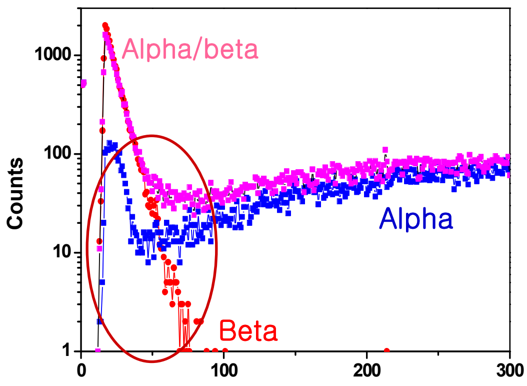

Figure 2. Pulse-height distribution of alpha- and beta-rays measured with EJ-440/BC-408 phoswich detector.

The pulse-shape distribution spectrum for alpha and beta rays was measured as fig. 3. The figure of merit of the EJ-440/BC-408 phoswich detectors was 0.5.

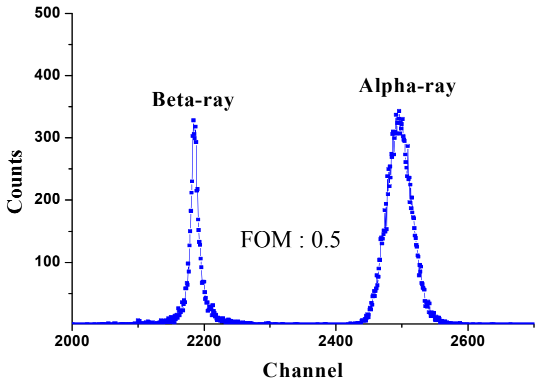

Figure 3. Pulse-shape distribution of alpha- and beta-rays measured with EJ-440/BC-408 phoswich detector.

The distance between a BC-408 and a EJ-440 is one of the important factors for selecting the size of a phoswich detector. The count rates as a function of the distance between two scintillators was measured from 0 to 4 cm. The maximum count rate for alpha rays was observed when the distance was 2 cm.

3. Conclusion

A EJ-440/BC-408 phoswich detector for simultaneous counting of alpha- and beta-rays was developed. This detector will be available not only for direct counting of the internal pipes such as decommissioning site but also for a narrow and isolated space such as glove box and hot-cell in a nuclear fuel cycle facility.

This work is now in process. In near future, the phoswich detector to be developed will be tested in the decommissioning works of the Korean Research Reactor KRR-1&2 and uranium conversion facility.

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