fast neutron radiation monitor using polycrystal composite stilbene

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1. Introduction

Organic single crystal stilbene has the best spectrometry characteristics and light yield in comparison with plastics and liquids and has been widely used as neutron detectors or monitors due to their fast timing response and good pulse shape discrimination (PSD) properties in neutron/gamma mixed fields such as a particle accelerator, a generation IV nuclear reactor, a nuclear fusion reactor, and so on. However, single stilbene crystals are so difficult to obtain in large size that greater than 60-80 mm in diameter, and are also vulnerable to damage from thermal and mechanical shocks that its extensive use are limited[1]. Recently, polycrystal composite stilbene based on grains of stilbene crystals have been developed in several Research Institute [2]-[3] and it is manufactured in large size for neutron detection. We have investigated its characteristics, especially capability of neutron /gamma discrimination.

2. Methods and Results

The neutron-gamma discrimination tests using Φ2” x 1cm polycrystal stilbene scintillator have been performed by ^{252}Cf neutron radiation source and compared with the Φ2” x 2” BC-501A liquid scintillation. The ‘Composite stilbene scintillator’ is manufactured with stilbene crystal grains into organosilicone base. The method of preparation of the composite stilbene scintillator as the detector of fast neutrons included the following steps. First, a single stilbene crystal was grown by Bridgeman-Stockbarger method [4]. Then, we obtained the stilbene crystal grains of this grown crystal by grinding at a low temperature with liquid nitrogen and choice of the stilbene crystal grain from 0.5 to 4.5 mm. After above performance, these crystal grains stayed in dark place at least 24 hours to stabilize. Second, we prepared the light guide hosing which determine the size and shape. Prepared hosing container size equalizes the composite stilbene scintillator. And we mixed the crystal grains and the organosilicone base, sylgard-527 component A and B. Then, the composition was located in the hosing container.

Signal processing and experiment

For measuring fast neutron spectra on a gamma ray background, specially designed electronics is necessary. The signals of neutron and gamma-ray are discriminated by using pulse shape discrimination circuit which implemented into Flash Analog-to-Digital Convertor (FADC). FADC used a discrimination method based on the difference in scintillation pulse shaping time when signal processing. Figure 1 shows the pulse shape of neutron and gamma signals of 252cf neutron source which is output of FADC followed by PMT and preamp.

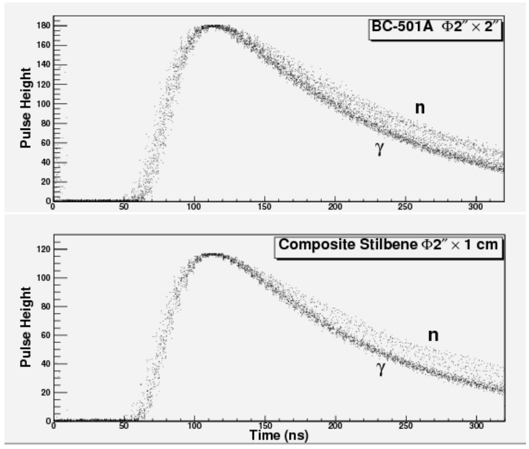

Fig. 1 FADC pulse shape of 252cf with BC-501A and polycrystal composite stilbene

A ^{252}Cf neutron radiation source was used for n-γ separation experiments of a Φ 2” x 1 cm composite stilbene scintillation detector. These scintillators were attached with a 2 inches RCA 8575 photomultifier tube (PMT). And scintillators were coupled onto PMT’s window with optical grease, BC-630.

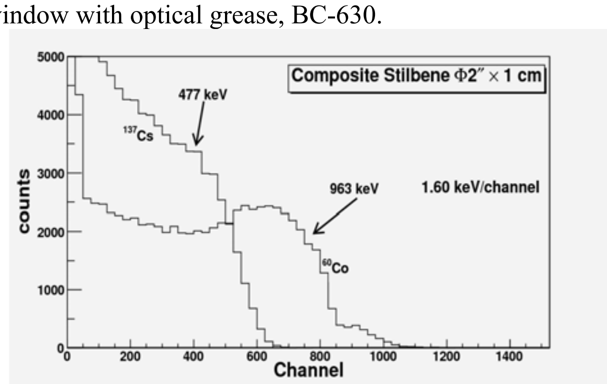

Fig. 2 gamma spectrum with composite stilbene

Figure 2 shows the gamma spectra of composite stilbene with 137Cs and 60Co. The arrow is Compton edge of each of radioactive source and used for energy calibration.

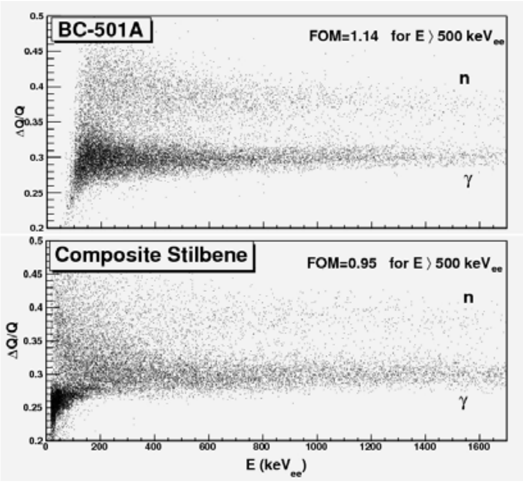

Fig. 3 neutron/gamma seperation plot with 252cf

Fig.3 shows the neutron and gamma discrimination of BC-501A and composite stilbene with 2 dimensional scattered plot of ratio of partial to total charge and energy of electron equivalent energy. The n-γ separation capability of Φ2" x 1cm composite stilbene was estimated to be 83% relative to the Φ2" x 2" BC-501A.

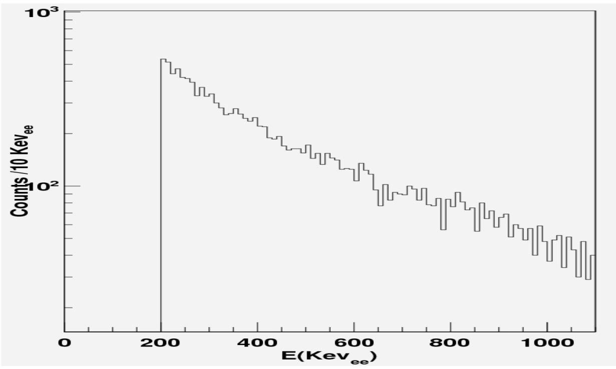

Fig. 4 proton recoil spectrum of composite stilbene using 252cf

Finally, we obtained recoil proton spectra with composite stilbene scintillator irradiated by ^{52}Cf, as shown in Fig.4.

3. Conclusions

Composite stilbene scintillators based on grains of single crystals were manufactured and compared with BC-501A Liquid scintillator. The composite stilbene scintillators can be manufactured large area scintillators such as liquid and plastic scintillators and have advantages that they can be used without special housing, and do not have any toxic. The result showed that the performance of n-γ separation of Φ2" x 1cm composite stilbene scintillator have 83% relative to Φ2" x 2" BC-501A. We have a plan to perform mono-energetic neutron measurements for estimation of neutron detection efficiency and feasibility study for fast neutron radiation monitoring.

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