Department of Applied Nuclear Technology

Key words Radiation measurement, inverse problem, radiation behavior analysis, environment radioactivity, response function, uncertainty, Monte-Carlo simulation

Doctor of Engineering / Professor

Hiroshi Nishizawa

Education

Department of Nuclear Engineering, Faculty of Engineering, Osaka University,
Department of Nuclear Engineering, Master's Program, Graduate School of Engineering, Osaka University

Professional Background

Head Researcher, Sensing systems Development Department of Industrial Electronics & Systems Laboratory, Sensor Information Processing Department of Advanced Technology R&D Center, Mitsubishi Electric Corp. / The 42nd Environment Minister's Award (2015)

Consultations, Lectures, and Collaborative Research Themes

Radiation measurement, Improvement of radiation detectors or measurement methods, Radiation behavior analysis, Research and implementation of unfolding method

e-mail address

nishizawa@fukui-ut.ac.jp

Main research themes and their characteristics

「Improvement of Radiation Measurement Performance Using Unfolding Method」

After the Fukushima Daiichi Nuclear Power Plant accident, it has become more important remarkably to measure the specific radioactivity of substances such as foodstuff precisely in short time. Although a conventional germanium semiconductor detector has excellent energy resolution, it requires a liquid nitrogen coolant system and its sensitivity is not sufficient to measure in short time, and furthermore it is often expensive. On the other hand, a NaI(Tl) scintillator, that is not expensive, has an advantage that it is suitable for mobile and flexible use in the fields because of no coolant system. However, its energy resolution is not sufficient to determine the amount of radioactivity. In order to improve the energy analysis ability of a NaI(Tl) scintillator, we have applied an unfolding method to realize the measurement system with both high precision and low cost.

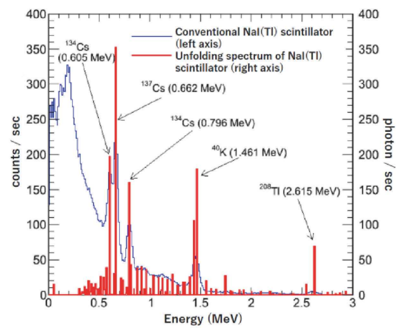

Fig.1 Unfolding spectrum of NaI(Tl) scintillator

The principle of unfolding method itself had been established in partial fields. However, its energy analysis width was too wide to distinguish each radioisotope, so that our development subjects are to establish the high accurate response function with narrow energy width and to clarify the uncertainty of unfolding in order to realize the measurement system. To obtain a high-precise response function, we have developed a combination simulation method of radiation and optics, which consists of Monte-Carlo electron and gamma transport code and optical ray-trace simulation. To evaluate uncertainty, we investigated the influence of each variable factor that affects the measurement results by intentionally noise-superimposed simulation and repeated measurements. Consequently, we have achieved the practical realization of measurement system for foodstuff, airborne particle monitor and water monitor using unfolding method.

「Stacked Cd(Zn)Te Detector to Improve the Sensitivity in High Energy Regions」

The sensitivity in high energy region of room-temperature operated Cd(Zn)Te semiconductor detector is not enough due to the low mobility life-time product of charge carriers and the difficulty to enlarge crystal volume. When the incident γ-ray energy is less than a few hundred keV, it has good energy resolution and high sensitivity because the photon interaction occurs so near to collecting electrode that the charge collection efficiency is high. However, when the incident γ-ray energy is over a few hundred keV and the photon interaction occurs at random locations in the detector, the charge collection efficiency becomes low because of hole trapping phenomena. Therefore the accurate γ-ray energy can not be measured and it becomes difficult to distinguish the full energy peaks.

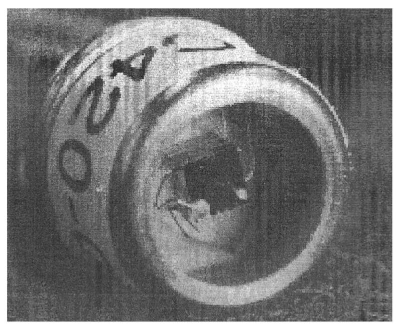
Fig.2 Prototype of stacked CdTe semiconductor detector

In order to satisfy both the improvement of the charge collection efficiency and the large detector volume, we proposed the stack structure of thin Cd(Zn)Te elements. We established the new simulation method of Cd(Zn)Te detector response to design the detector geometry and operation conditions. This was based on Monte-Carlo electron and gamma transport code embedded the charge carrier trapping phenomena to obtain the accurate response function of Cd(Zn)Te detector. Using this design method, the experimental results of the prototype indicated that the sensitivity could be improved as simulated.

Major academic publications

H.Nishizawa, H.Hayashi, T.Azuma, Y.Watanabe and T.Kin, Radioactivity Measurement System Using a Sodium Iodide Scintillator Applying an Unfolding Processing Method, Jpn. J. Health Phys., 49(1), 45-47 (2014)

H.Nishizawa, H.Inujima, T.Usami, H.Fujiwara and H.Nakamura, Response calculation of a stacked CdZnTe detector for ^{16}N γ-ray measurement, Nuclear Instruments and Methods in Physics Research A 463, 268-274 (2001)