Development of flexible and thin gamma/beta probe system for measurement of dose distribution

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In this study, we fabricated the flexible and thin gamma/beta probe system (GBPS) to measure the dose distribution of the gamma and beta radioisotopes. To evaluate the performance of the GBPS, we measured the Cs-137 with 5 μCi and Sr-90 with 1 μCi according to the location of the radioisotopes in a confined space. As the experimental results, the GBPS shows that it can be performed to get the distributions of gamma/beta radioisotopes. Based on the results of this study, it is expected that a flexible and compact GBPS can be contributed to nuclear safety technologies with advantages of dose information monitoring in. nuclear waste disposal site.

I. INTRODUCTION

In the near future, many countries will face a significant increase in radioactive waste from nuclear power plant and it's decommissioning [1]. The contamination level of radioactive waste must be assessed before deciding on its free release or reuse. Therefore, it will become more important to measure the dose distributions of radioactive wastes with a detector very fast and exactly. Moreover, it is very difficult to measure dose distributions of radioactive waste in local confined spaces, such as the insides of pipes [2]. In this study, we developed a flexible and thin gamma/beta probe system (GBPS) to measure the dose distribution of gamma/beta radioisotope, based on a disc-type scintillator and flexible image guide with 1m of length and 2 mm of diameter. GBPS consists of a fiber-optic taper, an image intensifier, and a complementary metal-oxide semiconductor (CMOS) camera. The image guide is a bundle of thousands of individual optical fibers that transfers optical spatial properties from one end of the bundle to the other [3]. Therefore, it is possible to perform the GBPS for measuring the dose distributions of radioactive materials remotely in confined spaces. We determined the thickness of the disc type of inorganic scintillator considering the high signal to noise ratio (SNR) and spatial resolution on dose distribution using the GBPS.

Finally, the experimental results verified that the proposed GBPS can be used to analyze location and intensity of radioisotopes by measuring their gamma/beta images even when radioisotopes are located in a confined place.

II. MATERAILS AND METHOD

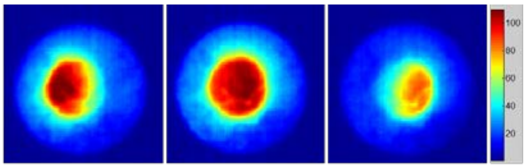
To fabricate the GBPS, disc-type cerium-doped lutetium yttrium orthosilicate (LYSO:Ce) inorganic scintillator with a diameter of 2 mm were used. The image guide (MCL-2000-2.4, Industrial Optics) coupled with LYSO:Ce disc consists of about 13,000 single fibers whose diameter is 8.7 μm and the total outer diameter is 2 mm. The optical resolution and the numerical aperture (NA) are 57.4 lp/mm and 0.63, respectively. When the sensing probe of GBPS approaches to radioisotope, the scintillating image informing dose distribution are generated from the LYSO:Ce disc. And this image is transmitted through the image guide, fiber-optic taper and the image intensifier. Finally, the intensified scintillating image of radioisotope is measured by a CMOS camera module. And then we can verify the location and intensity of radioisotope from the RGB scale scintillating images after doing simple image processing using MATLAB code.

III. RESULTS

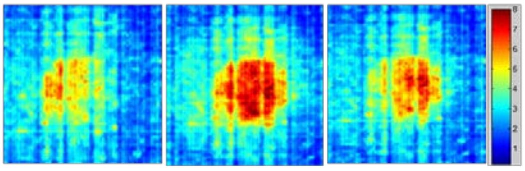
Fig.1 shows the dose distribution of the radioisotope measured with the GBPS according to the location of the radioisotope. As shown in Fig. 1, we could confirm the dose distribution changes according to the positional movement of both the beta and gamma source. In addition, even if the channel of the GBPS increases, the images of the each channels can be obtained simultaneously under the assumption that the proximal end of the probe can be connected to the input window of the image intensifier. Therefore, GBPS shows that many radioactive wastes can be measured simultaneously and remotely in hazardous and confined nuclear environments.

IV. CONCLUSION

In this study, we developed the GBPS that can obtain both gamma and beta image of radioisotopes in a confined space. As experimental results, the GBPS shows that it can be performed to get both the location and the intensity of radioactive isotope. Based on results of this study, it is expected that a flexible and compact GBPS can be contributed to nuclear safety technologies in radioactive waste disposal facility with advantages of dose information monitoring in a confined space.



Gamma-ray (Cs-137 5 μCi)



Beta-ray (Sr-90 1 μCi)

Fig.1. Dose distribution according to the location of the radioisotope.

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