§68. Non-Destructive Measurement of Tritium by Bremsstrahlung X-rays Using An Imaging Plate

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Non-destructive and quantitative measurements of the amount of tritium retained on/in plasma-facing materials (PFMs) of magnetic fusion devices are of great importance to control of fuel particles and ensure safety for maintenance work in the fusion systems. We have been developing an approach to detect tritium using the bremsstrahlung induced by beta rays with an imaging plate (IP) in order to detect tritium in regions deeper than the escape depth of beta-rays[1]. An IP made of europium-doped BaFBr(I), a photostimulated luminescence (PSL) material, is a two-dimensional radiation sensor. IP's sensitivity greatly depends on the X-ray energy, because the photostimulable phosphor is composed of elements having relatively high atomic numbers. PSL intensity increases as the X-ray energy becomes higher in the energy range of 0 to 18.6 keV (the maximum energy of tritium beta-rays)[1]. It means that PSL responses are affected by energy spectrum variation in the IP technique utilizing the bremsstrahlung X-ray. The energy of the bremsstrahlung can be any energy from zero to the energy of the incident particle, and the energy spectrum varies depending on the atomic number and thickness of the target (or absorbing) material. To quantify the amount of tritium in deeper regions by the IP technique, the tritium depth profile is required.

In this study, a method to obtain tritium depth profiles with the combined technique of the IP and thin absorbers has been developed. We used different metal absorbers such as copper and gold foil. Copper foil can be used as K-edge filter with x-ray absorption at 9.0 keV. Gold has L-edges x-ray absorption around 13 keV. The PSL decay curves were obtained by exposing the IP sheet to a tritium source, which is a small borosilicate glass tube filled with pure tritium gas of 50 MBq, with varying the thickness of each foil. The PSL values were normalized to that obtained without foil. Then we covered the tritium source with nickel foil sheet in the thickness range 5 to 35 μm, simulating migrating tritium in nickel and the PSL decay curves were obtained in the same manner.

The PSL decay curve for each absorber, so obtained, seems to consist of two components having each penetrating coefficient, and can be expressed as a following equation,

$$f(x) = a \cdot e^{-\mu 1 x} + b \cdot e^{-\mu 2 x} \qquad (1)$$

where a and b are the relative ratio of two components, μ_1, μ_2 penetrating coefficient of each component, and x the thickness of absorber. It was found that each penetrating coefficient takes constant value for each absorber and it is independent of absorber thickness. The relative ratios of two components vary depending on the nickel thickness. The relationship of the relative ratio of two components when copper foil was used as the absorber is shown as a function of the nickel thickness (0 ~35 μm) in Fig.1. The same relationship when gold foil was used as the absorber is shown in Fig.2. These results indicate that there is a relationship between the ratio of two components and the depth at which tritium migrates in nickel. These results indicate that tritium depth profiles can be obtained with the combined technique of the IP and thin absorbers. In a further experiment, we'll apply this relationship to the measurement of a nickel sample containing tritium.

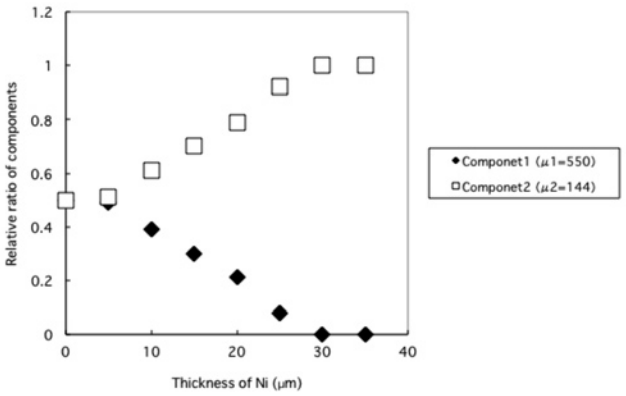

Fig. 1. Relationship of the relative ratio of two components as a function of the nickel thickness (0 ~35 μm) when copper foil was used as the absorber.

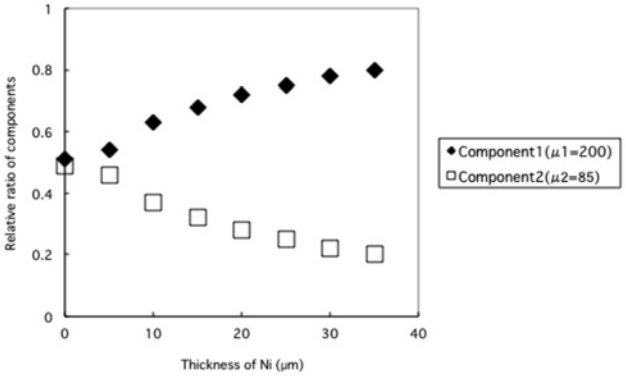

Fig. 2. Relationship of the relative ratio of two components as a function of the nickel thickness (0 ~35 μm) when gold foil was used as the absorber.

1) Ohuchi, H., Hatano, Y.,: *Radiochimica Acta*, in print.