

§69. Non-destructive Measurement of Tritium by Bremsstrahlung X-rays Using an Imaging Plate

Ohuchi-Yoshida, H. (Pharm. Sci., Tohoku Univ.),
Hatano, Y. (Hydrogen Isotope Res. Center, Toyama Univ.),
Kawano, T.

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^{1,2)}. An IP made of europium-doped BaFBr(I), a photostimulated luminescence (PSL) material, is a two-dimensional radiation sensor. In this study, a combined technique of an imaging plate (IP) and thin absorbers was applied to tritium in nickel specimens using copper, aluminum, and gold foil as the absorber. Copper and aluminum foil are used as a K-edge filter with X-ray absorption at 9.0 keV and 1.56 keV, respectively. Gold has L-edges X-ray absorption at around 13 keV¹⁾.

Tritium was introduced into sheet type specimens (1.5 x 1.5 x 0.05 cm³) of nickel by gas absorption method at 673 K. The initial distribution of tritium in the nickel specimen was examined by γ -ray induced X-ray spectroscopy (BIXS) under Ar atmosphere. Tritium distribution was measured twice, 20 and 388 days after tritium loading by the combined technique of a BAS-MS type-IP (Fujifilm Co., Ltd.) and absorbers. The BAS-MS type-IP has a high sensitivity to photons. It can detect bremsstrahlung X-rays, but not the beta particles emitted from tritium because of its 9- μ m-thick polyethyleneterephthalate protective film. The BAS-MS type-IP was irradiated with bremsstrahlung X-rays by placing the specimen directly on the IP or with inserting absorbers for 1 h. A model FLA7000 IP reader (Fujifilm Co., Ltd.) was used to read out the IP image.

X-ray spectrum from the nickel specimen containing tritium showed a sharp intense peak of Ar K X-rays at around 3 keV and another smaller sharp peak at 7.48 keV, which can be assigned to Ni K X-rays. The spectrum indicates that tritium is concentrated in the surface regions. Fig 1 shows PSL decay curves as a function of the number of electrons for three absorbers taken at 20 days after loading. PSL decay curves for copper and aluminum absorbers (shown as \diamond , \triangle , respectively) are similar, while that for gold (shown as \square) is quite different from others. PSL decay curve consists of two components, with fast and slow rates of decay, and they can be expressed in the following equation¹⁾,

$$f(x) = a \cdot e^{-\mu_1 x} + b \cdot e^{-\mu_2 x} \quad (1)$$

where a and b are the relative ratio of two components, μ_1 and μ_2 penetrating coefficient of each component, and x is

the thickness of the absorber. Two components of PSL decay curves for copper and gold absorber are shown as solid lines in Fig.1. The same measurements were repeated at 388 days after loading. PSL decay curves are shown in Fig.2, expressing no differences in the PSL decay curves for three absorbers. The ratio, a , the component with fast rate of decay for the copper absorber at 388 days was determined as 0.72, which became smaller than that at 20 days (determined as 0.975), indicating PSL derived from the lower energy range decreased with time, while PSL decay curves for the gold absorber does not change with time.

Cross section images and depth profiles were taken by autoradiography to obtain tritium distributions in the nickel specimen. No significant inclination of tritium concentration was observed in both images and depth profiles. From these results, it was considered that the same PSL decay curves pattern for the copper or aluminum and gold absorber indicates uniform tritium distribution in the specimen.

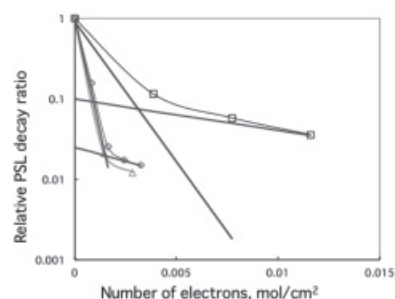


Fig. 1. PSL decay curves as a function of the number of electrons for three absorbers taken at 20 days after loading.

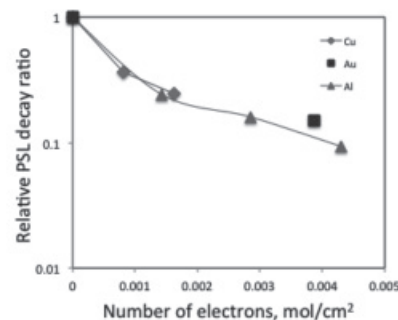


Fig. 2. PSL decay curves as a function of the number of electrons for three absorbers taken at 388 days after loading.

- 1) Ohuchi-Yoshida, H. *et al.*, Fus. Eng. Des. in press.
- 2) Ohuchi, H., *et al.*, Fus. Sci. Technol. **60** (2011) 944.