§73. Measurement of Tritium Distribution in Matter by Means of A Combined Technique of An Imaging Plate and Thin Absorbers

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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[1,2]. In this study, a combined technique of an imaging plate (IP) and thin absorbers was applied to tritium in nickel and vanadium 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 keV. With this technique, photostimulated luminescence (PSL) decay curves are obtained by changing absorber's thickness.

Tritium was introduced into sheet type specimens (1.5 x 1.5 x 0.05 cm^3) of nickel by gas absorption method at 673 K on 24 Dec 2010. Specimens were loaded with deuterium containing 17% tritium. For vanadium specimen (4.8 x 1.0 x 0.05 cm^3), tritium was introduced at 673 K on 27 May 2008. The tritium concentration in the specimen was controlled to be 1.0 appm; the total concentration of tritium and deuterium was 200 appm. Then all specimens were kept at room temperature. Tritium distribution was measured twice, 20 and 388 days after tritium loading for the nickel specimen and 3.5 years for the vanadium specimen, respectively by the combined technique of a BAS-MS type-IP (Fujifilm Co., Ltd.) and absorbers. The 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.

PSL decay curves are expressed as a function of the effective thickness for three absorbers. The effective thickness, $\mu \cdot t$, which normalizes the thickness of each absorber by $1/\mu$, was obtained by the following equation:

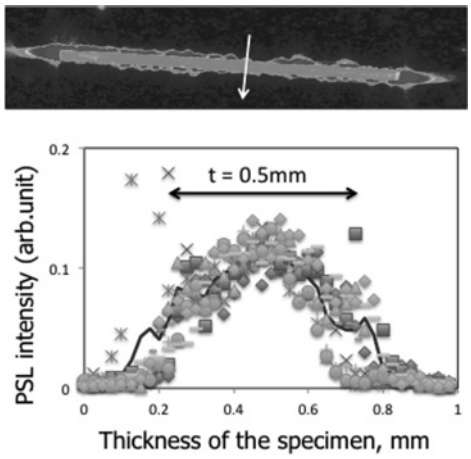
$$\mu \cdot t = (\mu/\rho) \cdot \rho \cdot t \qquad (1)$$

where μ/ρ is the mass attenuation coefficient (cm^2/g) at K or L-edge X-ray absorption for copper and aluminum absorbers and gold absorber, respectively, ρ density (g/cm^3), and t the thickness of absorbers (cm).

For the nickel specimen taken at 20 days after loading, PSL decay curves pattern for copper and aluminum absorbers were similar, while that for gold was quite different from others. However, PSL decay curves taken at 388 days showed no differences in the PSL decay curves pattern for three absorbers and these curves became close and similar to the curve for the gold absorber at 20 days. The same technique was applied to tritium in the vanadium specimen and PSL decay curves were obtained, expressing the same pattern with those in the nickel specimen for three absorbers at 388 days.

In Fig.1(a) and (b), cross section images and depth profiles are shown, exhibiting tritium distributions in the nickel and vanadium specimen, respectively. Through the cross section, no significant inclination of tritium concentration was observed in both images and depth profiles. These observations for two specimens indicate that uniform tritium distribution in the specimen provides the similar single PSL decay curves pattern for the copper or aluminum and gold absorber. This technique can be used usefully to observe tritium depth distribution in matter nondestructively.

(a)



(b)

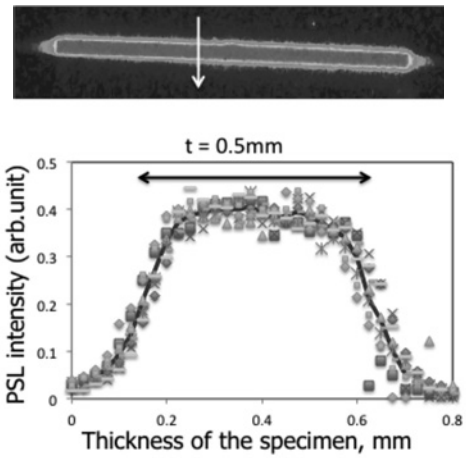


Fig. 1. Autoradiography cross section images and depth profiles for the nickel (a) and vanadium (b) specimen, respectively.

1) Ohuchi-Yoshida, H. *et al*., Fus. Eng. Des. **87** (2012) 423.
2) Ohuchi, H., *et al*., Fus. Sci. Technol. **60** (2011) 944.