§12. Irradiation Effects on Reactor Relevant Material Surfaces by Slow Highly Charged Ion Beam

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Much attention has been paid to Er_2O_3 thin film fabricated by Metal Organic Chemical Vapor Deposition (MOCVD) for the coating material of a thermonuclear reactor blanket. It is known that the luminescence of Er_2O_3 provides information on its crystallinity. We observed luminescence of Er_2O_3 thin film during the irradiation with highly charged ions (HCIs) produced by an electron beam ion source (EBIS) as a function of charge state and kinetic energy of incident Ar ions.

We used Kobe EBIS installed at the Kobe University for the production of HCIs. The Kobe EBIS is designed for the application of ion beam processing of materials so that it is constructed and operated easily without demanding expertise of EBIS using a separate, commercially available super-conducting magnet. Maximum designed values of electron beam energy and electron current are 40 keV and 300 mA, respectively. For the present experiment, the acceleration potential of HCIs extracted from the Kobe EBIS is 3kV, and beam current is in the range of 100 pA. Fig. 1A shows the experimental setup for the observation of luminescence. Fig. 1B is the example of luminescence image with an exposure time of 2 min. for the same area as Fig. 1A.

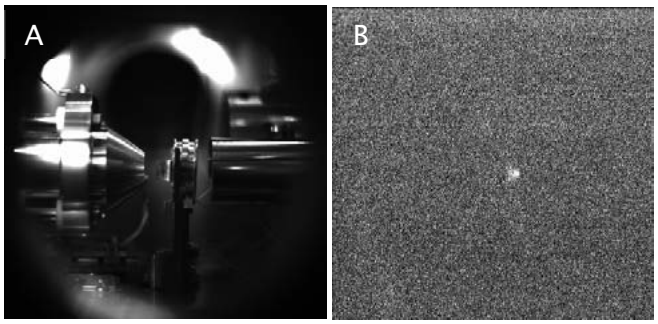

Fig. 1. CCD camera images of experimental setup and luminescence during the irradiation.

We found that the luminescence intensity rises non-linearly as the charge state increases (Fig. 2) while the intensity is independent of kinetic energy (Fig. 3). The luminescence intensity was measured over two kinds of wavelength ranges; one is the entire range of effective sensitivity of the CCD camera (400-1100 nm) and the other is the range of luminescence bands of Er_2O_3 [1] using an optical filter transparent over the 607-680 nm range. The present results demonstrates that the luminescence of Er_2O_3 thin film arises from the potential energy of highly charged ions rather than the kinetic energy of incident HCIs.

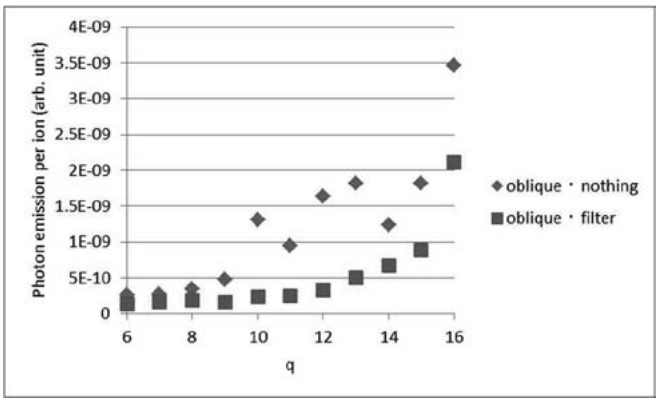

Fig. 2. Charge state dependence of luminescence intensity.

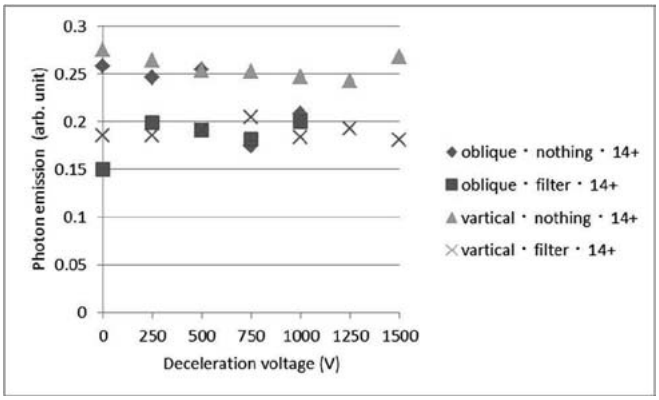

Fig. 3. Deceleration voltage dependence of luminescence intensity.

1) Kato, D. et al：Plasma and Fusion Research, 7 (2012) 2405043.