§10. *In-situ* Optical Measurements of Decrystallization Induced by Ion Bombardment on Er_2O_3

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i) Introduction Optical methods are potentially useful for characterization of radiation-induced defects in ceramics blanket materials. Feasibility studies of the optical methods are undertaken for *in-situ* characterization of the radiation-induced defects in Er_2O_3 by ion bombardment. The characterization is important for qualification of Er_2O_3 coatings as electric insulation of Li/V-alloy blanket systems and as hydrogen permeation barriers.

A potentially useful luminescence band in $640-690$ nm is identified as $4f^{11}$ $^4F_{9/2}-^4I_{15/2}$ transition of Er^{3+} at C_2 cation sites. It has been demonstrated that ion bombardment on a plasma splay coating sample [1)] and a sintered bulk sample [2)] quenches preferentially the luminescence band.

ii) Modeling of luminescence quenching due to decrystallization by Ar^+ ion bombardment For a given local displacement per ion (Φ), a displacement per atom (dpa: C) at a depth (x) and an ion fluence (f) is written as,

$$C(x;f) = \frac{1}{Y}\int_0^{\gamma} \Phi(x-\gamma')d\gamma' \quad (x \geq \gamma), \qquad (1)$$

where $\gamma = f \times Y/n$ is a surface erosion depth, and Y and n are a sputtering yield and an atomic number density of the target, respectively. Fractional number of emitters, *i. e.* Er^{3+} cations, may be depopulated by an amount of $\alpha \times C$, where α is a fraction of the dpa which contributes to depopulate the emitters. The depopulation of the emitting cations can be ascribed to decrystallization of the target. Figure 1 shows a measurement of luminescence quenching with Ar^+ (33 keV) ion fluences and fitting curves using the dpa given by Eq. 1. The local displacement per ion for Er_2O_3 was calculated by using the TRIM code. The fitting is significantly sensitive to sputtering yield data used in the dpa calculation.

iii) Luminescence quenching by H^+ ion bombardment Figure 2 shows ion-induced luminescence spectra and its quenching with H^+ (34 keV) ion fluences. Intensity of the luminescence band at $640-690$ nm preferentially decreases as the ion fluence increases. The relative intensity decreases rapidly until the ion fluence attains to 2×10^{21} /m^2. At larger ion fluences, however, the relative intensity appears to have a finite value independent on the ion fluence. During the H^+ ion bombardment, not only decrystallization but also recovery may take place in the target at a finite temperature. In steady states, the luminescence intensity reaches at a value determined by rates of displacements and recombinations which may depend on temperature, projectile ion species and kinetic energies. This issue will be addressed in future studies.

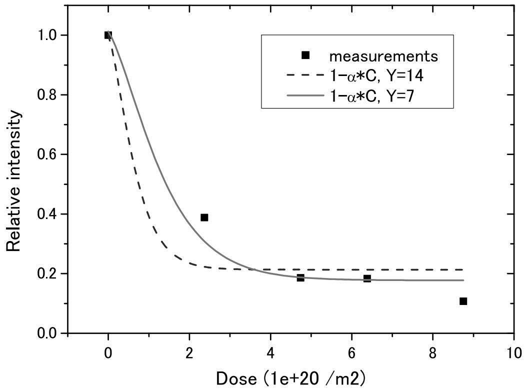

Fig. 1: Luminescence quenching with Ar^+ (33 keV) ion fluences on a sintered Er_2O_3 sample [3)].

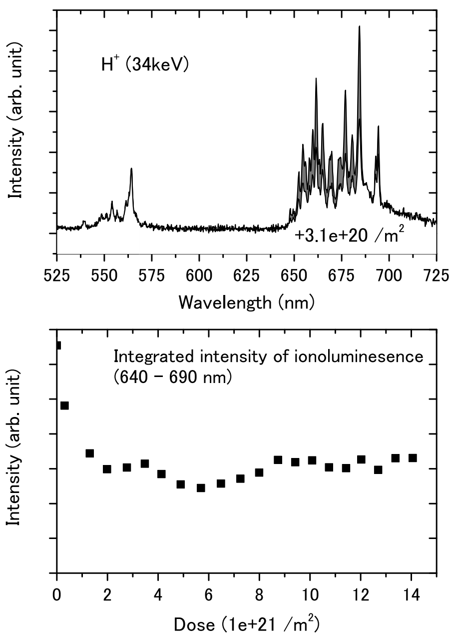

Fig. 2: Ion-induced luminescence spectra and its quenching with H^+ (34 keV) ion fluences on a sintered Er_2O_3 sample [4)].

1) T. Tanaka *et al.*, J. Nucl. Mater. (2011) vol.417 794.

2) D. Kato *et al.*, Plasma Fusion Res. (2012) vol.7 2405043.

3) D. Kato *et al.*, presented at the 9th joint meeting on Nucl. Fusion Energy, Jun. 28-29, 2012, Kobe, Japan.

4) D. Kato *et al.*, presented at the 29th JSPF annual meeting, Nov. 27-30, 2012, Kasuga, Japan.