§31. Characterization of Er_2O_3 Coating Materials by Irradiation Induced Luminescence

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The purpose of the present study is to investigate a characterization method for Er_2O_3 ceramic materials, which has been developed for suppression of MHD pressure drop in the liquid Li cooled fusion blanket, by irradiation induced luminescence measurements[1)] and understand physical mechanisms to explain a relation between a luminescence property and crystal property. In our precious studies, it has been found that luminescence intensities of Er_2O_3 materials weakened in the range of 640-690 nm by irradiation damages. Oxide samples simulating irradiation damages in an Er_2O_3 crystal have been synthesized and changes in the transition spectra have been examined. Physical mechanisms of the change in the spectra have been studied by comparing with spectra obtained by electronic state calculations.

Oxides with the C-type rare-earth structure have been selected as host materials for simulating irradiation damages in an Er_2O_3 crystal. The oxides materials have a similar structure as Er_2O_3 and form all proportional solid solution with Er. A local structure around Er is considered to be strained with the Er concentration. Influences of the strain on the energy levels have been examined.

The selected host materials were Y_2O_3 (a=10.605 Å), In_2O_3 (a=10.118Å) and Sc_2O_3 (a=9.842Å). Samples containing Er_2O_3 with the concentrations of 3, 10, 30, 50, 70 mol.% have been synthesized by the solid-state reaction. A lattice strain and change in an Er-O intreionic distance induced by the Er_2O_3 addition are considered to be small in the Y_2O_3 host, since the difference in the lattice constant is small (~0.53%). In the case of In_2O_3 and Sc_2O_3 hosts, the lattice constants are smaller than Er_2O_3 by ~4.1% and ~6.7 %, respectively. It is expected that the larger larger lattice strain could be induced by the Er_2O_3 addition than the Y_2O_3 case. Results of Rietveld analyses also support the above consideration.

Excitation and absorption spectra of the samples have been measured. Changes in the transition energies to the three levels of $^4I_{2/9}$, $^4F_{9/2}$ and $^4S_{3/2}$, which relate to a luminescence process by a cross relaxation (Fig. 1), have been compared among the samples with the different host materials. Almost no change has been observed in the peak position of the absorption spectrum for the Y_2O_3 host. This indicates that the change in the energy levels due to the Er_2O_3 addition is considered to be significantly small. In the case of the Sc_2O_3 host, the peaks widely distributed in the absorption spectra by the addition of a low concentration of Er_2O_3 (Fig. 2). The Er_2O_3 addition to a host with a smaller lattice constant could shorten the Er-O interionic distance and enhance the interaction of the ions. It is considered that this induced larger splits in the energy levels and widely distributed spectra. It is possible that these splits in the energy levels due to a change in the Er-O interionic distance suppress the probability of the cross relaxation process and weaken the luminescence intensity.

The characterization method with optical methodology on the present study to explain the relation between luminescence properties and crystal properties will be extended to other oxide, carbide, nitride and hydride materials studied in the fusion blanket development.

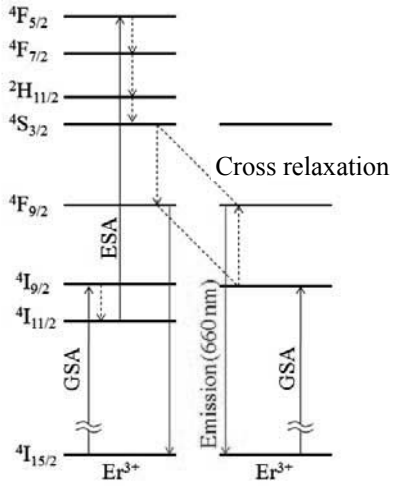

Fig. 1 Luminescence process by cross relaxation (800 nm laser excitation)*

* N. Jaba *et al*., J. Phys.: Condens. Matter, 12 (2000) 4523-4534.

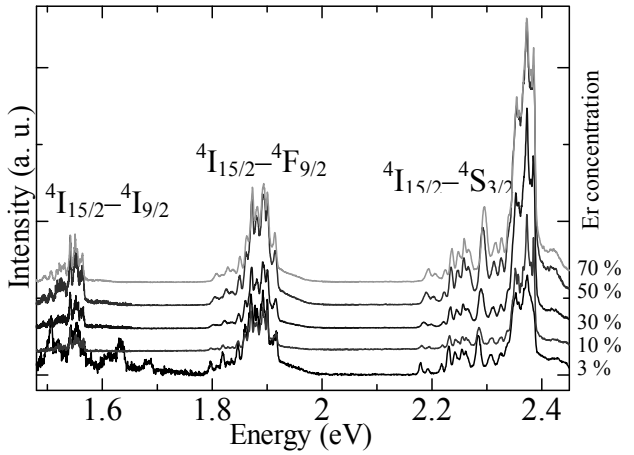

Fig. 2 Excitation spectrum (3 %) and absorption spectra (10-70 %) in Sc_2O_3 host.

1) Tanaka, T., Yoshino, M., Hishinuma, Y., Zhang, D., Kada, W., Sato, F., Iida, T., Nagasaki, T., and Muroga, T.; "Characterization of Er_2O_3 ceramic coatings by luminescence measurements", Journal of Nuclear Materials, in press.