ICFRM2007/60  
**Effect of 14-MeV Neutrons on Strontium-aluminate-based Long-lasting Phosphor**


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Long-lasting phosphor (LLP) emits photons for a long period after the cessation of irradiation without any further external excitations; LLP exhibits not only long-lasting emission but also a strong fluorescence. LLP is a good candidate as a measurement tool for detecting the radiation intensities of strong electromagnetic fields in ITER-like fusion reactors, because conventional electrical detectors are influenced by the disturbances from electromagnetic forces. In this paper, we examine the fluorescence and long-lasting emission properties of two types of strontium-aluminate-based LLPs-SrAl$_2$O$_4$:Eu$^{2+}$,Dy$^{3+}$ and Sr$_4$Al$_{14}$O$_{25}$:Eu$^{2+}$,Dy$^{3+}$-subjected to 14-MeV neutron irradiation.  

14-MeV neutron irradiation was performed at the fusion neutronics source located at the Japan Atomic Energy Agency. The flux was in the range of $10^{10}$ to $10^{13}$ n/m$^2$s, and the associated electronic excitation dose rate was less than 5.0 mGy/s. The luminescence generated from the LLPs under neutron irradiation and after the cessation of irradiation was measured with an optical detector equipped with optical fibers.

The fluorescent spectra of LLPs have characteristic peaks due to their dopants, namely, Eu$^{2+}$ and Dy$^{3+}$. The fluorescent intensity of SrAl$_2$O$_4$:Eu$^{2+}$,Dy$^{3+}$ decreased as the irradiation fluence increased, although the intensity of Sr$_4$Al$_{14}$O$_{25}$:Eu$^{2+}$,Dy$^{3+}$ exhibits a good radiation resistance with regard to neutrons with slight changes in the increasing irradiation fluence up to $10^{19}$ n/m$^2$. Long-lasting emissions were exhibited after the cessation of neutron irradiation, and the emission spectra have a peak only due to Eu$^{2+}$; the peak due to Dy$^{3+}$ shows an immediate end. The decay time of the long-lasting emission for the 14-MeV neutron irradiation is greater than that for UV irradiation. The decay time of the LLPs is mainly attributed to the energy levels of the hole-trap centers. It is considered that the material structure of LLPs is modified by the displacement effects of the neutrons; the changes in the energy levels result in an increase in the decay time. Further, it is found that there is an optimum neutron fluence to obtain the largest decay time; in this experiment, SrAl$_2$O$_4$:Eu$^{2+}$,Dy$^{3+}$ and Sr$_4$Al$_{14}$O$_{25}$:Eu$^{2+}$,Dy$^{3+}$ have the largest decay time when the neutron fluences are $5.12 \times 10^{18}$ and $7.58 \times 10^{18}$ n/m$^2$, respectively.

Number of words in abstract: 343

Keywords:  
Technical area: B2. Functional materials Diagnostic materials  
Special session: Not specified  
Presentation: No preference  
Special equipment: No special equipment