§9. 14MeV Neutron Detection System Utilizing Radioluminescence and Optical Fiber

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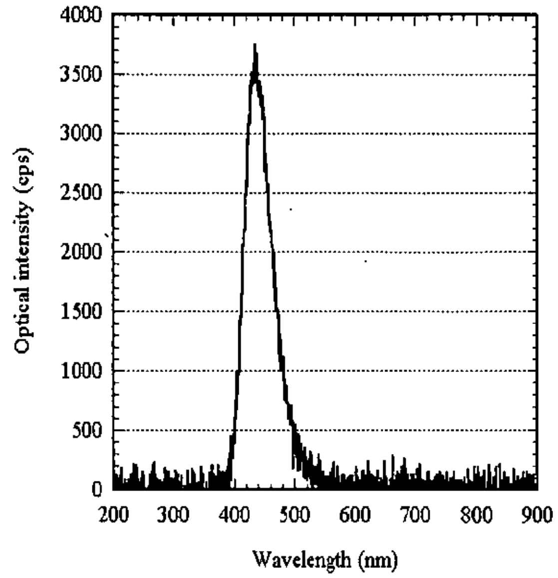
A possibility of applying a compact optical system to diagnostics of high energy neutrons from a fusion nuclear fusion reaction has been studied, utilizing radiation resistant optical fibers and radioluminescent (radiation-induced luminescent) materials sensitive to a fast neutron. Several materials, which were expected to radiate luminescence, were attached at an end of a synthesized fused silica (SiO_2) made radiation resistant optical fiber whose core-diameter was 0.2mm and were exposed to high energy neutrons generated by the deuterium-tritium (D-T) reaction in the Fast Neutron Source (FNS) of Japan Atomic Energy Research Establishment (JAERI) in Tokai, and to gamma-rays from cobalt-60 sources in the JAERI-Takasaki, at room temperature. The fast neutron flux was in the range of 10^{11-12}n/m^{2}s in the FNS and the gamma-ray dose rate was about 5Gy/s for the water in JAERI-Takasaki gamma-ray facility. An optical signal was guided through a 30 m long radiation resistant optical fiber, which was developed in the ITER-EDA (ITER Engineering Design Activity) framework for the purpose of applying optical fibers to in-vessel components in the ITER, to a measuring instrument composed of an optical grating and a CCD, the PMA-11 made by Hamaphoto Co. Ltd. Silver activated zinc sulfide (ZnS-Ag), copper activated zinc sulfide (ZnS-Cu), and a strontium aluminate doped with europium and dysprosium ($Sr_zAl_xO_y$-EuDy), were found to be radioluminescent, being sensitive to high energy neutrons with a peak position at 450nm, 570nm, and 500nm, respectively, having a half width of 75-150nm. Figure 1 shows a luminescent spectrum from the ZnS-Ag under a fast neutron flux of about 10^{12}n/m^{2}s. The ZnS-Ag had the strongest luminescence among three but its intensity decreased with the increase of neutron fluence, in the meantime, the other two, the ZnS-Cu and the $Sr_zAl_xO_y$-EuDy had relatively weak luminescent intensity but their peak intensity did not change substantially with the fast neutron fluence up to 10^{20}n/m^2. Changes of the luminescent peak intensities are shown in Fig 2 as a function of irradiation time. For a high sensitivity, the ZnS-Ag is the best among three, but for a long-term stability and being free from frequent re-calibration or replacement, the ZnS- Cu and the $SrAl_2O_4$-EuDy are preferable. Behaviors of radioluminescence were different in between the fast neutrons and the gamma-rays, indicating that the discrimination of the neutrons from the gamma-rays is possible. The present results clearly shows that a simple fast-neutron-detection system can be composed for a burning plasma machine.



Fgure 1 Radioluminescent spectrum from ZnS-Ag under 14MeV fusion neutron irradiation in FNS.

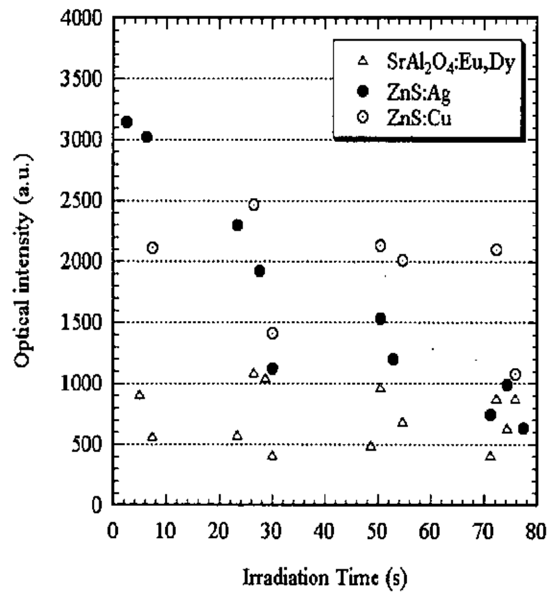


Figure 2 Change of optical intensity of radioluminescence by 14MeV neutron in the course of irradiation. 14MeV neutron flux is about 10^{11-12}n/m^{2}s in FNS of JAERI