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Investigation of lanthanide-doped APLF scintillators for neutron detection

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Investigating the fusion plasma is necessary to control the fusion process and to understand the plasma dynamics. Down-scattered (DS) neutrons detection is much suitable for measurement of the areal-density. We have demonstrated that lanthanide-doped $20\text{Al}(\text{PO}_3)_3\text{-}80\text{LiF}$ (APLF) has excellent characteristics as DS neutron scintillators. In this paper, the properties of lanthanide-doped APLF scintillators for neutron detection was investigated.

Required temporal resolution of scintillators for DS neutron detection is less than 10 ns. The temporal resolution depends on fluorescence wavelength of luminescence center ion. Different lanthanide-doped APLF samples were prepared by melt-quench method for evaluation. Time-resolved spectroscopy using vacuum ultraviolet laser was used to assess the fluorescence decay times of each sample. Among all samples, the Nd-doped has the fastest time of 6.6 ns. When compared to the fluorescence decay time of a standard scintillator, GS2 with 38.1 ns, the lanthanide doped APLFs.

The fluorescence decay time of a Pr-doped APLF was also evaluated using different radioactive sources. The Pr-doped APLF exhibits fast fluorescence lifetime compared to GS2 by one order of magnitude regardless of the excitation source.

We have studied the potential of lanthanide-doped APLF as scintillators for neutron detection. Lanthanide-doped APLFs have faster fluorescence decay time compared to GS2. Nd-doped APLF exhibits the fastest decay time of 6.6 ns. The fluorescence of the Pr-doped and GS2 using three different radiation sources were also compared. Though the light output of the doped APLF is lower, the fluorescence intensity can still be detected. Lanthanide-doped APLFs can be better alternatives to conventional scintillators for neutron detection. Further developments on lanthanide-doped APLF based neutron scintillators are highly anticipated.

In addition, this Pr-doped APLF scintillator was applied to development of a multichannel low-energy neutron spectrometer, and was actually used to detect DS neutrons in the recent fusion experiment using GEKKO XII. As a result, DS neutrons were successfully detected. We are confident that our scintillator will be a powerful tool of fusion experiment.

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