Progress on Ce:$Li_6Y(BO_3)_3$ single crystals toward thermal neutron detection

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The development of efficient, low-cost, and stable solid-state materials for portable thermal neutron detection is highly expected in order to substitute the currently used ^3He and BF_3 tank detectors. A few Li-based glasses and halide compounds have emerged as candidates, but all of them present critical drawbacks for their practical implementations. Ce:$Li_6Y(BO_3)_3$ (LYBO) is a priori a very promising oxide candidate that, however, has been disregarded so far due to its disappointingly low light yield, caused by a poor crystalline and optical quality.

Recently, we found that for compounds with a low melting point like LYBO (T_m = 865°C), doping with CeF_3 instead of the commonly used CeO_2 and carrying out the growth under non-oxidizing atmosphere leads to the successful incorporation of Ce^{3+} activators.[1] As can be seen in the transmittance spectrum of Fig. 1(a), the Ce:LYBO crystal exhibits the characteristic Ce^{3+} absorption bands without any trace of Ce^{4+}. On the other hand, we found that the presence of scattering centers is closely related with the slight incongruent nature of LYBO.[2] All as-grown crystals show a high scattering center density, leading to a bright scattering path of a laser pointer beam, as shown in Fig. 1(b). These scattering centers can be drastically reduced via annealing at a temperature close to the melting point, so that the scattering path becomes almost invisible. By the combination of the above strategies, namely the efficient Ce^{3+} doping and the drastic reduction of scattering centers, the light yield of LYBO was systematically improved by 600% to a value of ~4400 ph/n (Fig. 1(c)), thus becoming comparable to reference Li-glass GS20. At the same time, the afterglow was reduced by 2 orders of magnitude to a low level of 0.02% @ 50 ms. Consequently, this work demonstrates for the first time the actual potential of Ce:LYBO for thermal neutron scintillation.

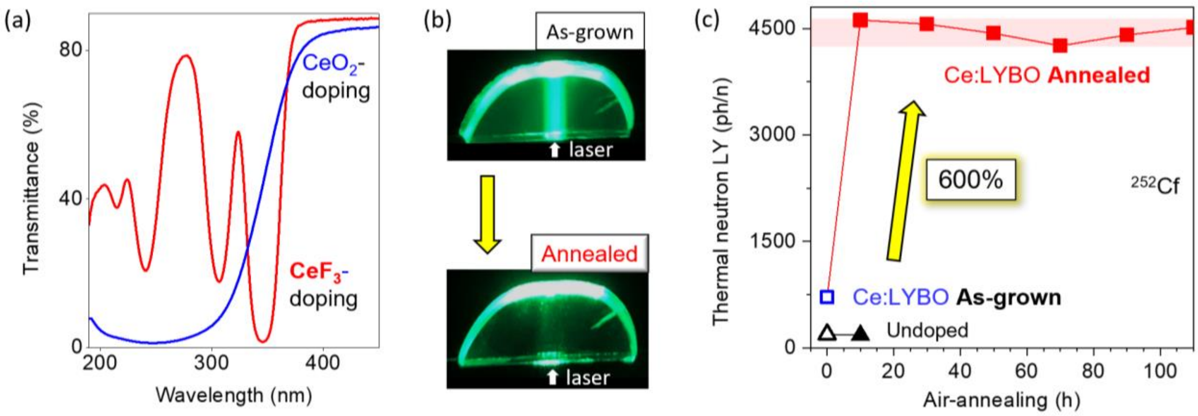

Fig. 1. (a) Ce^{3+} activation in Ce:LYBO crystals. (b) Drastic reduction of scattering centers. (c) 600% increase of thermal neutron light yield.

Reference

[1] D. Yuan, et al., *Jpn. J. Appl. Phys.*, 62, 010614 (2023).

[2] D. Yuan, et al., *J. Solid State Chem.*, 300, 122286 (2021).