$Y(Ta_{1-x}Nb_x)O_4$ single-crystal scintillators

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Abstract

Environmental-friendly alternatives to the commercial scintillator $CdWO_4$, which contains the toxic element Cd, are highly desired. As potential candidates, in this work the scintillation characteristics of single-crystals of the rare-earth tantalate family $Y(Ta_{1-x}Nb_x)O_4$ are studied. Bulk single-crystals of the Fergusonite structure are grown by the floating-zone (FZ) method covering the whole solid-solution range from $YTaO_4$ to $YNbO_4$. Figure 1(a) shows the stable melt growth of crystals by the FZ. Due to phase transitions upon cooling, transparent single-crystal areas are obtained only partially, as the one seen in the inset. Both $YTaO_4$ and $YNbO_4$ exhibit a unique broad X-ray luminescence centered at 339 and 407 nm, respectively. Mixed crystals (up to 2% Nb partial substitution) exhibit both emissions with different ratios depending on composition. The X-ray luminescence spectra are shown in Fig. 1(b). The highest radioluminescence (15900 ph/MeV) and the lowest afterglow (0.008% @ 40 ms) are found for the $YTaO_4$ crystal. These two characteristics are comparable to those of $CdWO_4$. However, the emission shift from UV to visible by Nb-substitution is preferable for Si-photodiode detection, as in the case of $CdWO_4$. The optimum Nb concentration for maximum X-ray detection performance is discussed considering the absorption cross-sections, and the emission and detector efficiencies.

Keywords: Tantalates, Single-crystal, Scintillator

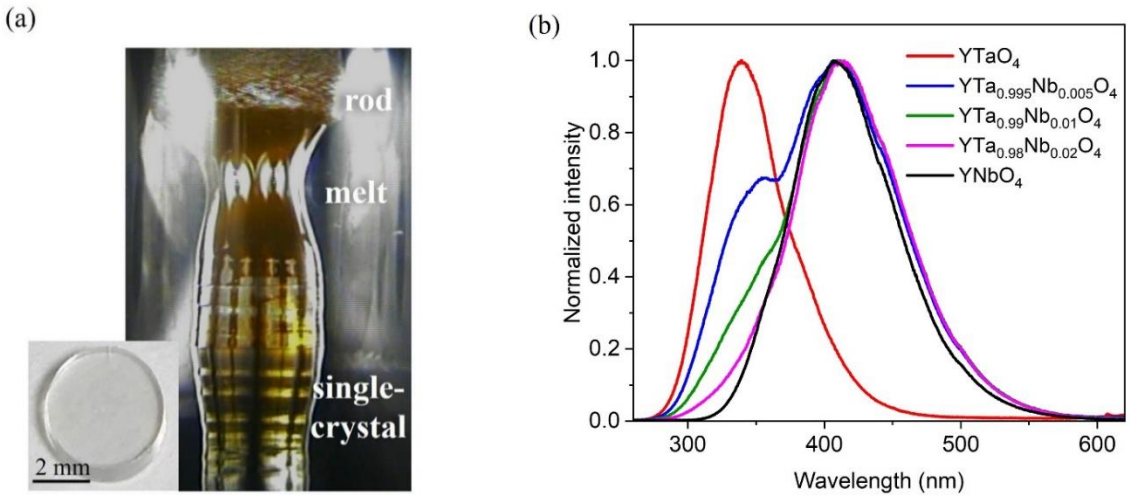

Fig. 1 (a) Photographs of a $YTaO_4$ crystal growing by the FZ and a transparent both-sides polished plate of 1mm in thickness, (b) X-ray luminescence spectra of $Y(Ta_{1-x}Nb_x)O_4$ single-crystals with Nb-substitutions of 0, 0.5, 1, 2, and 100%.