



Temperature-dependent luminescence emission of YNbO₄ and YNbO₄:Bi phosphor powders

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Introduction

Self-activated phosphors that contain metal-oxides groups with the closed-shell transition metal ions, such as NbO₄³⁻, WO₄³⁻, MoO₄³⁻, VO₄³⁻, have attracted great attention for display and lighting applications. Luminescence phenomenon in these tetrahedral groups originates from one electron charge transfer from oxygen to the empty d orbital of the central metal ion. Yttrium niobate (YNbO₄) belongs to this group of phosphors, and is generally used in X-ray intensifying screens. It exhibits intense blue light emission at around 410 nm under X-ray and UV excitation^{1,2}. Introducing Bi³⁺ into YNbO₄ is causing red-shift of luminescence emission because 6s electron of Bi³⁺ is transferred to d orbital of Nb⁵⁺, enabling metal-to-metal charge transfer and forming a new low-lying emitting state³. This emission appears as a wide band in the 400–600 nm range and the maximum at ~450 nm. YNbO₄:Bi was firstly proposed as a good candidate for use in field emission displays³. Recently, Bi³⁺ is being added to YNbO₄ matrix as a co-dopant and a sensitizer, in order to transfer energy to other rare earth ions and tune the absorption/emission in white light emitting diodes (w-LEDs)⁴ and solar cells^{5,6}.

Yttrium niobate is usually synthesized by a solid state reaction method, where precursors are ball milled for tens of hours^{7,8}. Here we prepared the single-phase pure and Bi³⁺-doped YNbO₄ phosphor powders, using fast and energetically efficient mechanochemical method followed by annealing. The precursors were firstly mixed in a ball-mill at 100 rpm for 3h, then pre-calcinated at 800°C for 2h, ball-milled again, and finally annealed at 1200°C for 2h.

The crystalline structure of the samples is confirmed by XRD measurements. The crystallite size of ~300 nm for both samples was estimated from Rietveld refinement. Optical characterization was performed using diffuse reflectance and photoluminescence spectroscopy. We measured excitation spectra at room temperature and emission spectra in the different temperature ranges (293–403 K for pure and 293–533 K for Bi³⁺-doped sample). Both samples exhibit intense emission and both mechanisms are discussed. Luminescence emission quenching temperatures were also determined.

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