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Bridgman growth and luminescence properties of dysprosium doped lead potassium niobate crystal

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Abstract

Dy-doped lead potassium niobate ($Pb_2KNb_5O_{15}$, PKN) single crystal was grown by the modified vertical Bridgman method through spontaneous nucleation. The crystal was brownish, transparent and inclusion free. Five excitation peaks of Dy^{3+} ions were clearly seen from near ultraviolet region to blue range. It was unique that the excitation peaks in blue range were more intense, especially the one centered at 455nm. The emission bands consisted of blue, yellow and red emissions, which were at about 487 nm, 573 nm and 662 nm respectively. The CIE chromaticity diagram of PKN:Dy indicated that white light and yellow light could be emitted when the crystal was excited under near ultraviolet light and blue light, respectively. Thus PKN:Dy crystal is a candidate material whose emitting light could be tunable through changing the excited light wavelength.

Keywords

A1.Doping; A2.Bridgman technique; B1.Niobates

1. Introduction

Light emitting diodes (LEDs) has attracted significant attention in recent years due to the advantages of long lifetime, saving energy, high efficiency, reliability, and its environmental-friendly characteristics [1,2]. The commercial LEDs are assembled by combining a chip with different color-emitting phosphors, which are usually embedded in epoxy resins. This structure cause many drawbacks, such as the poor heat resistance of the epoxy resins, the refractive index mismatch between the phosphors and the epoxy results in light scattering. Compared with phosphors, single crystals possess good anti-light irradiation, as well as good thermal, mechanical, and chemical stability. The rigid cyclic symmetric structure of single crystals results in the high luminous efficiency of active ions. It is helpful for LEDs to obtain high stability, long lifetime, high luminous efficiency, and good color [3,4].

The crystals with the structure of tetragonal tungsten bronzes (TTBs) are one type of ferroelectric materials, which have potential applications in dielectric, piezoelectric, ferroelectric, and optical devices[5-8].As a member of TTB oxides, lead potassium niobate ($Pb_2KNb_5O_{15}$, PKN)is one well-known compound, which was first synthesized as a solid solution of$PbNb_2O_6$in 1960[9].In the past more than 50 years, PKN single crystal have been mainly studied on its piezoelectric, ferroelectric–ferroelastic coupling, surface-acoustic-wave, thermal expansion, and optical characteristics[10-14]. However, rare reports focus on exploring its luminescence performances. It was reported that the spectroscopic and luminescence properties of RE ions were strongly influenced by the presence of highly polarizable Pb^{2+} ions due to the strong and direct nature of