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Luminescence and structural properties of Fe³⁺ doped ZnAl₂O₄: the influence of charge imbalance

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Introduction

Keeping in mind that the unit cell of spinal ZnAl₂O₄ is made of tetrahedral and octahedral sites, of which upon doping shows different characteristics. Zn²⁺ occupies the tetrahedral sites, while Al³⁺ occupies the octahedral sites. When doped with Fe³⁺, ZnAl₂O₄ is characterized by two broad emissions with maxima around 485 and 730 nm [1]. To maintain electrical neutrality, charge balancing should be taking into consideration when doping ZnAl₂O₄, since charge imbalance can lead to charge defects within the material, which can create non-radiative luminescence centers in the material. We have prepared sets of ZnAl₂O₄ doped Fe³⁺ phosphors. To investigate the effect of charge imbalance on the luminescence properties of the phosphors, Fe³⁺ was used to substitute Zn²⁺ in one instance and Al³⁺ in another instance. The site occupancy of the Fe³⁺ ion was investigated.

Results

The two sets of phosphors are represented by the general formula ZnAl_(2-x)Fe_x⁽³⁺⁾O₄ (Fe³⁺ substituting Al³⁺) and Zn_(1-x)Fe_x⁽³⁺⁾Al₂O₄ (Fe³⁺ substituting Zn²⁺). The structure, morphology and the elemental compositions of the phosphors were determined using X-ray diffraction, field emission scanning electron spectroscopy and energy dispersive X-ray spectroscopy, respectively. The elemental composition, chemical and electronic states of the phosphors were analyzed using X-ray photoelectron spectroscopy. Both photoluminescence (PL), and cathodoluminescence properties of the phosphors were also studied. The luminescence studies showed that the ZnAl_(2-x)Fe_x⁽³⁺⁾O₄ phosphors have superior luminescence than the Zn_(1-x)Fe_x⁽³⁺⁾Al₂O₄ phosphors, as expected. The band gaps of the phosphors were determined from the diffuse reflectance data.

1. Reference [1] N. Pathak, S.K. Gupta, K. Sanyal, M. Kumar, R.M. Kadama and V. Natarajan. Dalton Trans. 43 (2014) 9313.

Apply to be considered for a student award (Yes / No)?

Yes

Level for award (Hons, MSc, PhD, N/A)?

N/A

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