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Site occupancy and phonon sideband of trivalent europium doped calcium aluminosilicate phosphors

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ABSTRACT

A series of Eu^{3+} doped $Ca_2Al_2SiO_7$ were synthesized by the solid-state reaction method. Structural and luminescent properties of the obtained samples were investigated through X-ray diffraction, Raman and luminescence spectra. The luminescent characteristic of the $^5D_0 \rightarrow {^7F_{0,1}}$ transitions from emission spectra of Eu^{3+} ions showed that the Eu^{3+} ions occupy at two different sites in $Ca_2Al_2SiO_7$ lattice. The $Ca_2Al_2SiO_7$:Eu^{3+} red phosphors have three phonon sidebands with energies ~673 cm^{-1}, 848 cm^{-1} and 1443 cm^{-1} which have been determined via the excitation spectra of Eu^{3+} ions in $Ca_2Al_2SiO_7$ materials. These obtained phonon energies coincided with the vibrational energies observed from Raman spectra. The multiphonon relaxation rates for the excited levels of $^5D_1$, $^5D_2$ and $^5D_3$ of Eu^{3+} ions in $Ca_2Al_2SiO_7$ were also calculated.

1. Introduction

Silicate-based phosphors such as $M_3MgSi_2O_8$ (M: Ba, Ca, Sr) [1], $Sr_2MgSi_2O_7$ [2], $M_2Al_2SiO_7$ (M: Sr, Ca) [3,4] have been used as a good host for luminescent materials due to their high chemical stability and water-resistance properties [2,4,5]. In particular, calcium aluminosilicate (CAS:$Ca_2Al_2SiO_7$) doped with rare earth (RE) ions is an interesting phosphor and has been studied for white light-emitting diodes [5–7], laser [8,9], piezo-electrification [7,10] and applications in thermoluminescence [7,10,11]. In this direction, CAS doping with Eu^{3+} ions is used as a red emission phosphor for white light-emitting diodes (white-LEDs) to yield a high color reproducibility and a high color rendering index [12]. Furthermore, the effect of compensator (Na, Al) on optical properties of $Ca_2Al_2SiO_7$:Eu^{3+} phosphors [13], adjustable double center emission of Eu^{3+} and Eu^{2+} co-doped $Ca_2Al_2SiO_7$ [14], energy transfer from Pb^{2+} or Bi^{3+} to Eu^{3+} in $Ca_2Al_2SiO_7$ [15,16] have also studied and reported. In the structure of CAS, cations has found on three types of sites: eightfold coordinated sites occupied by Ca^{2+} ions and two types of tetrahedral sites (T1, and T2) for Al^{3+} and Si^{4+} ions [6,9] and when RE ions are doped into CAS lattice, they substitute Ca^{2+} ions in the eightfold coordinated sites [9]. Several studies have shown that luminescence of Eu^{3+} ions is affected by the number of site occupancy of Eu^{3+} in host lattice: C. G. Liu [17] and J. Zhou [18] reported that Eu^{3+} ions occupy at two different sites in $12CaO.7Al_2O_3$ powders and in $Na_3LuSi_3O_9$ phosphor, respectively and the luminescence of these phosphors is a sum of emissions of Eu^{3+} at two sites. Yanlin Huang et al., have shown three different sites of Eu^{3+}

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