

Judd Ofelt Analysis And Energy Transfer Mechanism In Pr³⁺ Doped Mg₂SiO₄ Nanophosphors

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Abstract. Pr³⁺ (1- 11 mol%) rare earth doped Mg₂SiO₄ (Forsterite) nanophosphors were analyzed using Judd-Ofelt theory for the electronic transitions of Pr³⁺ ions to evaluate various intensity parameters (Ω_2, Ω_4). The variations in radiative transition probability (A_r) and calculated radiative lifetime (τ_{rad}) have been discussed. Further, energy transfer from the host to Pr³⁺ ions was studied. The critical energy transfer distance (R_c) between Pr³⁺ ions in Mg₂SiO₄:Pr³⁺ phosphor is calculated to be 16.3 Å. The interaction between the Pr³⁺ ions is found to be dipole-dipole interaction

Keywords: Mg₂SiO₄, Judd-Ofelt, Energy transfer.

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INTRODUCTION

Mg₂SiO₄ (Forsterite) is a significant material in the magnesia silica system with many prominent properties, such as high melting point, great electrical and refractory characteristics, chemical stability even at high temperatures, as well as good mechanical properties, bioactivity and biocompatibility [1,2]. It has got applications in many industrial areas, e.g. electronics as insulators working at high frequencies [1], refractory industry[3], advanced technologies such as SOFC (solid oxide fuel cells) [4], biomedicine [5] and luminescent technology [6]. Trivalent lanthanide ions are extensively applied in phosphors, laser gain media and scintillator crystals or ceramics. Especially praseodymium (Pr³⁺) shows a large variety of different applications as activator ion, viz. UV phosphors, laser materials, up and down-conversion phosphors [7]. The intensity of the transitions for the rare earth ion can be calculated by using the Judd-Ofelt theory [8, 9]. This theory defines a set of three intensity parameters Ω_t ($t = 2, 4, 6$) which are sensitive to the environment of the rare earth ion. These intensity parameters are used to calculate radiative transition probability for spontaneous emission and radiative life time of the excited state [10]. The energy transfer from the host to

rare earth ions is very weak. The weakness of energy transfer has been partially attributed to aggregation of rare earths on the grain boundary due to the limitation of solubility. The other more important reason is weak interaction between carriers and doping ions [11]. In the present paper, the applicability of Judd-Ofelt theory to the luminescence of Pr³⁺ in luminescent lanthanide complexes is investigated by comparing experimentally determined emission spectra and radiative lifetimes to theoretical predictions.

RESULTS AND DISCUSSION

The photoluminescence spectra of Pr³⁺ doped Mg₂SiO₄ nanophosphors excited at 320 nm is shown in Fig. 1. The spectra consist of emission peaks at 525, 566 and 610 nm is corresponding to ³P₀→³H₄, ³P₀→³H₅ and ³P₀→³H₆ transitions of Pr³⁺ ions respectively [12]. The photoluminescence intensity of 3 mol % Pr³⁺ sample was maximum; thereafter it decreases due to concentration quenching. The concentration quenching might be explained on the basis of following two factors: (i) the excitation migration due to resonance between the activators is enhanced when the doping concentration was increased, and thus the excitation energy reaches quenching centers, and (ii) the activators are paired or