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Positron annihilation spectroscopy and photoluminescence investigation of LaOF:Tb^{3+} nanophosphor fabricated via ultrasound assisted sonochemical route

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ABSTRACT

LaOF:Tb^{3+} nanophosphors were synthesized by modified sonochemical route using extracted Epigallocatechin gallate (EGCG) from green tea powder as surfactant. Powder X-ray diffraction patterns confirm the tetragonal phase of samples. Morphology of the products was tuned by changing the influential experimental parameters. Positron annihilation spectroscopy (PAS) was used to investigate the defect chemistry of the prepared samples. PAS specified the presence of defects at crystallite boundaries, vacancy clusters and large voids in the prepared compounds. Photoluminescence emission spectra consists of characteristic green emissions owing to $^5D_4 \rightarrow {}^7F_J$ (J = 6, 5, 4, 3) transitions of Tb^{3+} ions. The estimated critical distance between dopant ions was found to be ~16.60 Å is majorly responsible for the dipole-dipole interaction and concentration quenching. The photometric study such as Commission Internationale de L'Eclairage, Correlated Color Temperature and Color purity indicates that the obtained phosphors could be a promising green component for optoelectronic applications in particular to white LEDs.

1. Introduction

In recent years, rare earth ions doped inorganic luminescent materials have fascinated due to their diverse potential applications namely white light-emitting diodes (WLEDs), sensors, biological imaging, field emission displays (FEDs), solar cells etc. [1–3]. The luminescent properties of Ln^{3+}-doped phosphors are host independent due to the transitions of inner f-shell electrons [4,5]. Therefore, the selection of appropriate inorganic phosphors with efficient luminescent performance creates numerous interests for research community. Until now, some inorganic hosts, namely molybdates, oxides, fluorides, and silicate, were extensively investigated towards display device applications and were listed in Table 1 [6–15]. Among, fluorides LaOF possess low cut-off phonon energy with decreasing the possibility of different non-radiative transition and thus leading to superior luminescent properties [16,17].

Further, during fabrication commonly occurred lattice defects such as voids or pores, clustered vacancies and mono vacancy greatly affected the luminescence. Positron annihilation spectroscopy (PAS) has been considered as new probe to illustrate surface defects and to understand the effect of size, quantum effects as well as surface defects of the nanomaterials, due to the better diffusion length of positrons as compared with crystallite size of the nanomaterial which makes restrictions on surface of the particles [18–21]. After thermal treatment, embedded positrons may diffuse in the medium followed by electron annihilation. High tendency of positrons induce defects in the material which results longer lifetime; therefore, longer positron life-times can be related with crystallite size and defect concentration [22–24].

Moreover, the Doppler broadening (DB) in the γ-spectrum was utilized to notice the particular type of defects, preserving and

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