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Synthesis and Characterization of Er Doped $CaZrO_3$ Phosphors

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Abstract: The present paper reports the synthesis and Photoluminescence (PL) studies of the Er rare earth ions doped in $CaZrO_3$ phosphor at a concentration of 2 mol%. Starting materials like Calcium carbonate ($CaCO_3$), Zirconium oxide(ZrO_2),Erbium Oxide (Er_2O_3). The samples were prepared by the conventional solid-state reaction method, which is the most suitable for large-scale product ion. The received phosphor samples were characterized using XRD, SEM and PL techniques. Undoped $CaZrO_3$ exhibits good photoluminescence emission. The PL emission mainly concentrates around 467 nm, when excited with 254 nm wavelengths. The $CaZrO_3$ phosphor, when doped with Er the PL emission was observed from 400 to 560 nm range peaks around 527 ,531,545 and 553nm with high intensity. The present phosphor can act as host for greenlight emission in compact fluorescent (CFL) and fluorescent lamps.

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I. Introduction

Phosphor are used in cathode ray tubes (CRTs), projection televisions (PTVs), fluorescent tubes, X-ray detectors and field emission displays (FED) etc. Concerning many of these applications, the availability of systems consisting of uniform particles in size and shape is also an essential prerequisite for improved performance, and new synthetic routes are been developed in order to reach these systems. This material has been found to exhibit luminescence under excitation with cathode and X-rays . In addition, it has also been established that $CaZrO_3$ exhibits photoluminescence under excitation with irradiation of ultraviolet rays.. The luminescence associated with Er contained in different host lattices has found applications related to its green light emission, which is important in the fields of displays, sensors and lasers. The past few decades have seen a lot of work reported on the use of divalent/trivalent Erbium as, dopant in phosphors as they have very good optical properties (in the blue–red regions), which make them part of many display devices. Among all the rare-earth ions, Er^{3+} is the most extensively studied, owing to the simplicity of its spectra and also its use in commercial green phosphors. In this study, we prepared Calcium zirconate phosphor (undoped $CaZrO_3$ and $CaZrO_3$:Er) that exhibits broad Excitation ranges of 240–400 nm using high temperature solid state reaction method. Furthermore, the photo luminescent properties of the powders resulting from variations of such synthesis conditions as temperature, activator concentration, were investigated. The characterization of the prepared materials was done using XRD, SEM, PL, FTIR and CIE studies.

II. Experimental

Calcium Carbonate ($CaCO_3$), Zerconium oxide (ZrO_2), Erbium Oxide (Er_2O3) of high purity (99.9%) chemicals were used as starting materials to prepared $CaZrO_3$and Er, doped phosphor. Calcium carbonate (CaCO3), Zirconium oxide(Zr_2O3) in stoichiometric proportions the samples are weighed and ground into a fine powder using agate mortar and pestle. The grounded samples were placed in an alumina crucible and fired at 900, 1000, 1100 and 1200 1C for 3 hr in a muffle furnace with a heating rate of 5 ^{0}C/min. The samples are allowed cool to room temperature in the same furnace for about 20 h. Rare earth ion Er was doped at a concentration of 2.0 mol% . Spectrofluorophotometer (SHIMADZU, RF-5301 PC) was used for PL studies. The 1200 ^{0}C fired samples show good PL. Therefore 1200 ^{0}C fired material was used for XRD studies using Rigaku-D/max 2500 using Cu Ka radiation. The microstructures of the samples were studied using a scanning electron microscopy (SEM) (XL 30 CP Philips). All the spectra were recorded at room temperature.

III. Results and discussion

3.1. XRD Study

The XRD pattern of undoped $CaZrO_3$ and doped with Er 2.0 mol% are shown in Fig. 1. From the XRD pattern it was found that the prominent phase formed is $CaZrO_3$, after the diffraction peaks are well indexed based on the JCPDS no. 20-0254 . A Comparision of the data with the standard JCPDS file reveals that the diffraction peaks of the $CaZrO_3$:Er^{3+} phosphors match with those of the standard hexagonal phase.The crystallite size was calculated using

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620 – 622

the Scherrer equation D=kλ/βcosθ, where k the constant (0.94), λ is the wavelength of the X-ray (0.154nm or 1.54 A˚), β the full-width at half maxima (FWHM) and θ the Bragg angle of the XRD peak (1,1,0). The

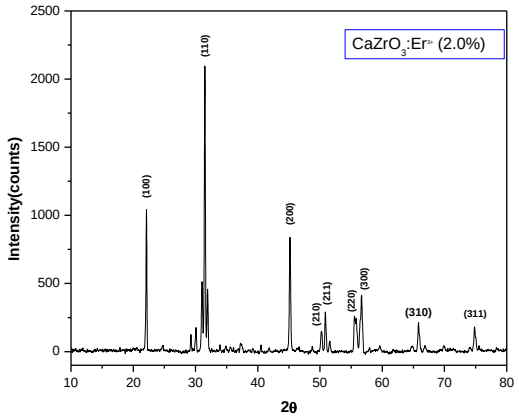

Fig.1. XRD Pattern of $CaZrO_3$:Er (2.0%).

From Fig. 1 it is found the diffraction peaks are same for all the phosphors, which conclude that the dopant did not affect the host structure except change of the peak intensities.

3.2. SEM study

Fig. 2 shows the SEM micrograph of the Er -2% doped $CaZrO_3$ Phosphor.

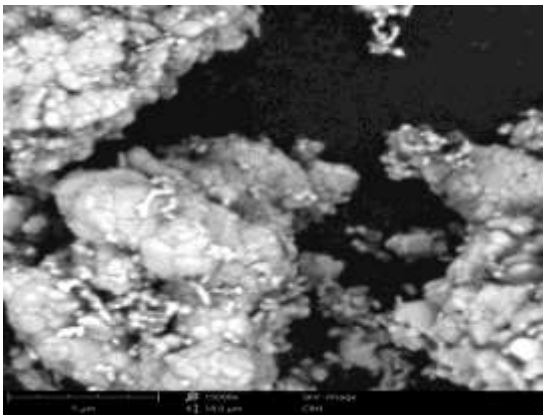

Fig.2. SEM image of $CaZrO_3$:Er(2%).

3.3. Photoluminescence study

Fig.3 is the PL excitation spectra of prepared phosphors. The main PL excitation spectra monitored at 546 showing three peaks at 275,380 and 492 nm.

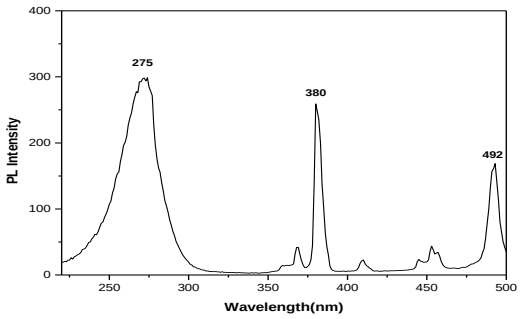

Fig.3.Excitation spectrum of Er doped $CaZrO_3$ monitoring at 546nm.

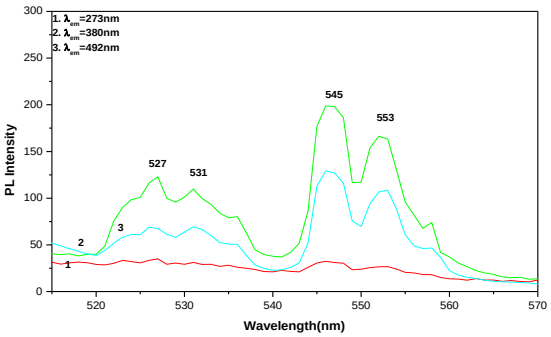

Fig.4.Emission spectra of $CaZrO_3$ phosphor doped with Er(2%) with different excitations.

Fig.4. shows the emission spectra of $CaZrO_3$ phosphor doped with Er(2%).However effect of Erbium doping is shown predominently on emission of host phosphor. The effect of Er doping generates 527, 531, 545 and 553 nm peaks. From the above figure it is clear that the maximum emission intensity is observed for 292 nm excitation for all the PL peaks of Erbium. The excitation spectrum is monitored under 545 nm wavelength.

IV. Conclusions:

Pure $CaZrO_3$ phosphor and Er doped in $CaZrO_3$ phosphor were synthesized via high temperature solid state reaction. The characteristic blue emission of the $CaZrO_3$ phase was quenched in favor of the green emission of Er^{3+} ions.It is conclude that this may be due the crystal host as a donor to transfer the energy and the Er ion is a receptor of energy. However, under 492 nm excitation, Er(2%) doped $CaZrO_3$phosphor shows high emission intensity.

From XRD studies the present phosphor is in single phase. From the PL studies, it is concluded that Er (2.0%) doped phosphor under 492nm excitation can act as a single host for producing green light with good intensity for all practical display devices in particular compact fluorescent lamps.

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