Luminescence study of Erbium doped $CaZrO_3$ Phosphor

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Abstract. Erbium(Er)-2.0 wt%, 2.5 wt% doped $CaZrO_3$ phosphors were prepared by using Solid State Reaction method. The Luminescent properties, Crystal structures and Crystal sizes of $CaZrO_3$ were Studied using Photo Luminescence, X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). The Photo Luminescence spectra show peaks in green region. The crystallite size lying in nano range.

INTRODUCTION

$CaZrO_3$ are important materials for different applications. They are used in field emission displays, 3-D display technology, Laser devices, Solar cells and in Sensors.[(1-6)]. The rare earth elements had and continue to have a distinctive and significant impact on how we live our daily lives. The rare earth elements exhibit unique luminescent capabilities due to their empty 4f electronic structure, which might be exploited to create a wide range of novel materials with a variety of uses. Rare earth doped $CaZrO_3$, $CaTiO_3$, and $SrTiO_3$ have only been described optically by a few number of scientists [(7–14)] .The synthesis and characterization methods of Er^{3+} doped $CaZrO_3$ phosphor are discussed in this study.

EXPERIMENTAL

To create the powder samples, stoichiometric mixes of $CaCO_3$, ZrO_2, and Er_2O_3 were fired for three hours at 1200^{o}C. PL, XRD, SEM, and FTIR were used to characterize the produced phosphors as previously indicated. The specifics of the instrumentation utilized for characterization of the experimental setup and the explanation of synthetic phosphor is provided below.
The following are the characterization tools employed in this study:
• Bruker D8 Advance X-ray Diffractometer used for the X-ray diffraction technique (XRD).
• Shimadzu's Spectro Fluoro Photometer (SPF) RF 5301 PC is used for (PL).
• Jasco FTIR-4100 spectrophotometer used for Fourier Transform Infrared Spectroscopy (FTIR).
• Tecnai 20 G2 FEI scanning electron microscopy (SEM).

RESULTS AND DISCUSSION

X-Ray Diffraction

Figure 1 depicts the XRD pattern of the Er (2%) $CaZrO_3$ phosphor. Scherrer's formula, $D=K\lambda/\beta Cos\theta$, is used to determine the crystallite size. "K" stands for the Scherrer constant (0.94). Phosphor has crystals that are about 47.8 nm in size.

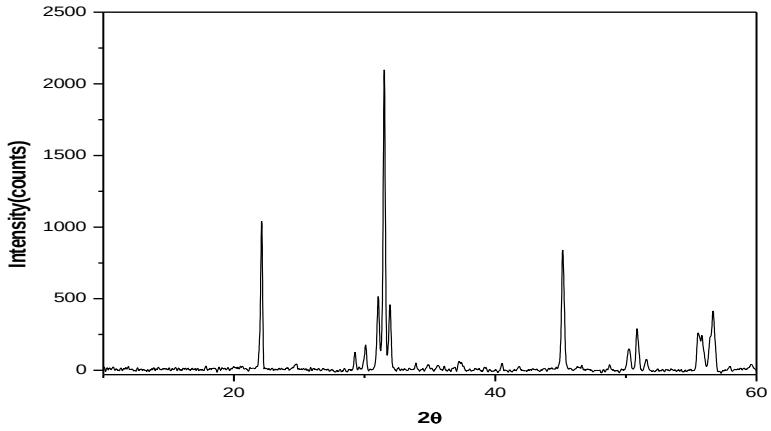

Fig.1: XRD pattern of Er (2%) doped $CaZrO_3$ phosphor

Photo Luminescence

Fig: 2,3,4 and 5 are the PL excitation and emission spectra of Er(2.0%) and Er(2.5%) doped $CaZrO_3$ Phosphor respectively

$CaZrO_3$- Er (2.0%) Phosphor:

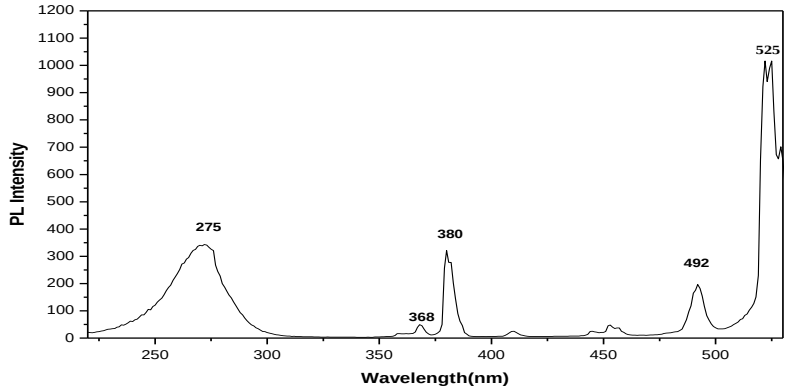

Fig.2: Excitation spectrum of Er (2.0%) doped $CaZrO_3$ phosphor monitoring under 545nm

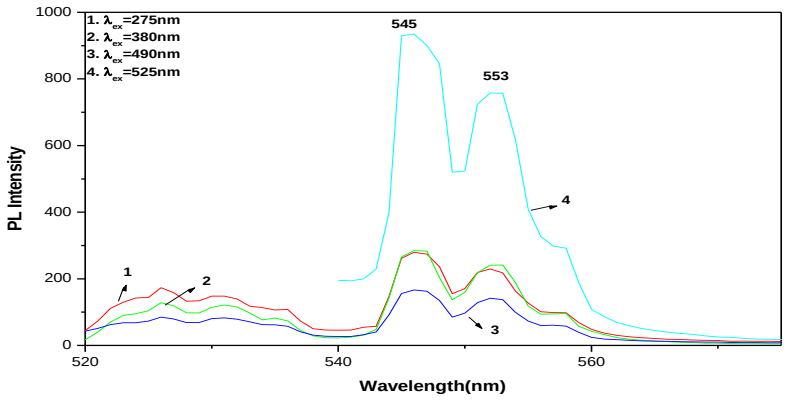

Fig.3: Emission spectrum of Er (2.0%) doped $CaZrO_3$ phosphor under different excitations

Table:1

Compound	Excitation Wavelength	PL Intensity	
		545	**553**
$CaZrO_3$ Er (2.0%)	275	282	230
	380	285	241
	490	163	142
	525	934	756

$CaZrO_3$- Er (2.5%) phosphor:

When the Er-concentration is 2.5% in $CaZrO_3$, the PL studies reveals that not much change is observed in 275nm and 380nm excitation followed by emissions at 545nm and 553nm .It is observed that a marginal reduction in intensity. However when the phosphor is excited with 490 and 525nm marginal increase of intensity of 545nm and 553nm peaks are found. The same data is tabulated in 2.

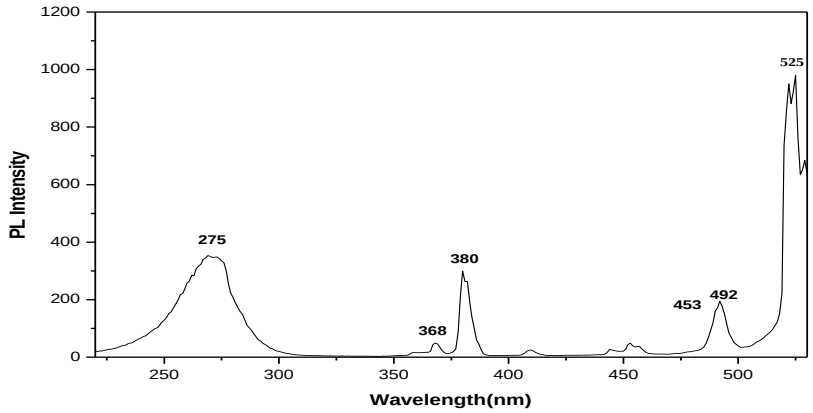

Fig.4: Excitation spectrum of Er (2.5%) doped $CaZrO_3$ phosphor monitoring under 545nm

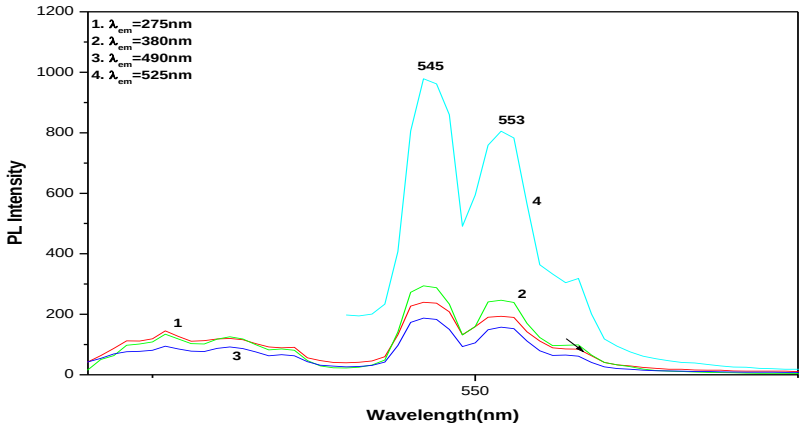

Fig.5: Emission spectrum of Er (2.5%) doped $CaZrO_3$ phosphor under different excitations

Table-2:

Compound	**Excitation Wavelength**	**PL Intensity**	
		545	**553**
$CaZrO_3$ Er(2.5%)	275	240	190
	380	294	241
	490	182	158
	525	979	805

From the above two tables, it is found when the Erbium concentration is 2% in $CaZrO_3$, the emission intensities at 545 and 553nm are more when compared to 2.5% Erbium doped $CaZrO_3$.

SEM

Figure 6 shows the SEM micrographs of Er (2%) doped $CaZrO_3$ phosphor. The study of Scanning Electron Microscope under various magnifications are shown here. From all the SEM micrographs, it is found that irregular shapes of different size of phosphor particles are seen.

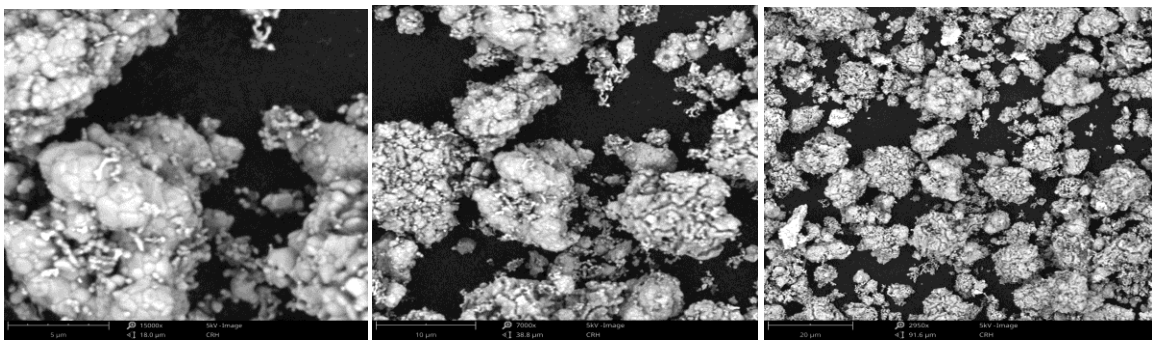

FIGURE (6).*SEM Images at different resolutions of Eu (2%) doped $CaZrO_3$ Phosphor*

FTIR Evaluation

The FTIR spectra of 1000 to 4000 cm^{-1} wave number is shown in Figure 7. However, the fundamental metal oxide stretching is seen between 400 and 1000 cm^{-1}. According to the FTIR graphs, the majority of the bands are stretching Ca-O, Zr-O [19–20], metal oxides, and RE oxides. The fact that O-H stretching and C-O stretching are not present in this instance is interesting. This enables us to draw the conclusion that the investigated phosphors did not absorb any water.

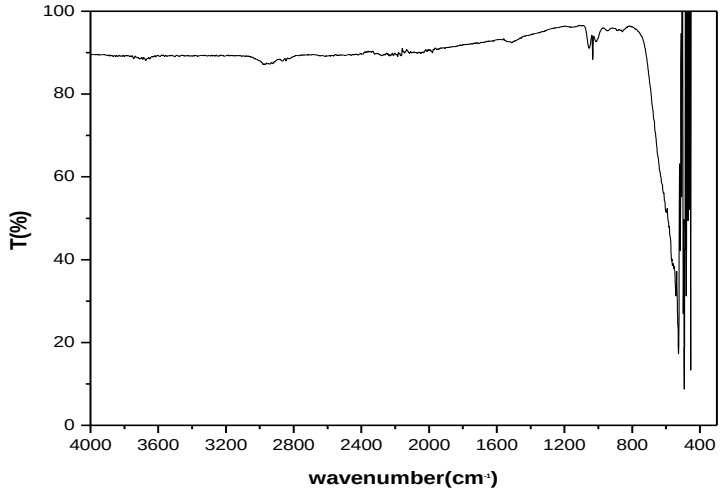

FIGURE- 7: FTIR spectrum of Er(2%) doped $CaZrO_3$ phosphor

CONCLUSIONS

1. The green luminescence peaks in the present studied phosphor at 545 and 553 and other minor peaks resolved in $CaZrO_3$: Er(2.5%) are due to Zr →Er transitions which are allowed and is from $^4S_{3/2} \rightarrow {}^4I_{15/2}$ transitions of Er^{3+}which is a green band.
2. Erbium as dopant in $CaZrO_3$ reveals that all the Erbium emissions are well resolved since the starting material used is in the form of Oxide.
3. It is also concluded that the presence of Erbium in $CaZrO_3$ phosphor acts as a good dopant.
4. The crystal size of $CaZrO_3$: Er(2.0%) phosphor is around 47.8 nm
5. FTIR plots shows that most of the bands are from M_x-O and M_y -O stretching's which are standard ones.

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