Chapter - 6

Conclusion

Conclusion

In this thesis, the research of the synthesis, characterization and luminescence properties of RE^{3+} doped and co-doped Strontium Pyrophosphate ($Sr_2P_2O_7$) have been described with the main purpose to enhance the luminescence properties which has large area of application. To achieve the aim of research, the RE^{3+} doped $Sr_2P_2O_7$ phosphors were synthesis by combustion synthesis method, which is the most versatile technique for the development of luminescence phosphor and other material. In combustion method flux plays an important role which act as catalyzer for the chemical reaction. In this research, Urea is been used as flux for the synthesis of RE^{3+} doped and co-doped Strontium Pyrophosphate ($Sr_2P_2O_7$). For this research, Ce^{3+}, Eu^{3+}, Tb^{3+}, Dy^{3+}, Er^{3+}, Gd^{3+} doped $Sr_2P_2O_7$ phosphors were synthesized for the doping concentration 0.5, 1.0, 1.5, 2.0, 2.5 and 5.0 mol% of RE^{3+} ions. For the study of sensitizing process to tune the emission color of phosphor, RE^{3+} co-doped $Sr_2P_2O_7$ phosphors were synthesized by taking 1.0 mol% Ce^{3+} as fixed dopant with 1.0 mol% Eu^{3+}, Tb^{3+}, Dy^{3+}, Er^{3+}, Sm^{3+},and Gd^{3+}. All samples were prepared at temperature 1200°C. The synthesized phosphors were grounded to conduct the experiment for the study of characterizations and luminescent properties.

Firstly, the synthesized phosphors were characterized to powder x-ray diffraction (XRD) to examine the formation of the desire phosphors. The XRD study of all samples were consistent as per the literature. The XRD patterns of RE^{3+} doped and co-doped $Sr_2P_2O_7$ samples are compared with JCPDS standard card no. 24-1011, which is very consistent. The XRD analysis of all synthesized $Sr_2P_2O_7$ samples confirm that the samples have a pure α-phase with crystallization in the orthorhombic structure and space group of P_{nam}. The doping of various RE^{3+} ions and the percentage change in concentration does not make any perceptible change in XRD patterns as well as no other peaks found for the doping ions. There is a small peak shifting observed in the xrd pattern towards the higher diffraction angle with increase in doping concentration, which could be resulting due to the incorporation of doping ions in the host structure. The crystal structure parameters are decreasing as the concentration of doping ion increasing. As a result the unit cell volume and crystallite size of the phosphor are decreasing gradually. The xrd results gives the good agreement for the formation of the desire phosphor for luminescent device applications.

Further FTIR characterization have been performed for the bond formation in the host structure. For the FTIR study, IR spectra of all the phosphors were recorded through KBr pallet. The fingerprint region of the FTIR spectra shows all desire transmittance humps for the phosphate group formation in the host structure which gives the information of the formation of pyrophosphate $(P_2O_7)^{4-}$ group. Like a XRD spectra, there is no other band formation occur due to the doping impurity. Therefore the FTIR results also confirms the XRD result that the synthesized phosphor is mostly in single phase.

The surface morphology, shape and size of the particle are the important parameters for the luminescent phosphors. The surface morphology of the phosphors were studied by SEM analysis. The SEM image are obtained for Ce^{3+}, $Eu^{3+}$and Tb^{3+} doped $Sr_2P_2O_7$ samples. Eu^{3+} doped $Sr_2P_2O_7$ phosphors are loosely agglomerated and are composed of particle of small size of the order of 2-5 μm in size. The powder form of Eu^{3+} doped $Sr_2P_2O_7$ phosphor shows high crystalline with uneven surface morphology the average grain size of 2 – 3 μm. Eu^{3+} doped $Sr_2P_2O_7$ phosphor have porous structure of particles and possess foamy nature or cotton like structure. The SEM results cannot give any powerful result for the evident conclusion.

Output of RE^{3+} doped $Sr_2P_2O_7$

The photoluminescence and thermoluminescence studies for RE^{3+} doped $Sr_2P_2O_7$ phosphors displayed fascinating results, the following are the logical conclusions:

- Ce^{3+} doped $Sr_2P_2O_7$ phosphor exhibited broad emission around at 385 nm in near UV region under the excitation wavelengths 254, 268 and 310 nm. The broad emission from 360 to 440 nm in UV to Violet Blue region is observed due to the 5d-4f transitions of Ce^{3+}. The Gaussian fitting of the emission band revealed the energy discrepancy of 2081 cm^{-1} between the two Gaussian peaks located at 363 nm and 395 nm due to the spin orbital coupling of 4f state. The prominent emission occur under 310 nm excitation wavelength. The PL emission intensity increases with the doping concentration gives the conformation of the incorporation of Ce^{3+} increase with higher concentration. The crystallite size affects the PL emission, where the PL emission increases with decease in crystallite size. The result obtained from Ce^{3+} doped $Sr_2P_2O_7$ phosphors gives its potential use as near UV [360-400 nm] and LED [450-480 nm] application.

- Eu^{3+} doped $Sr_2P_2O_7$ phosphor was excited under it major excitation wavelength of 396 and 466 nm. The PL emission occur at 618 nm which is a red emission useful for LED applications. PL emission intensifications with increases in doping concentration, the maximum intensity of 618 nm emission peak for the 5.0 mol% Eu^{3+} is increased by 5-6 time than that of the 0.5 mol% Eu^{3+}. The PL emission also depends on the crystallite sized, for Eu^{3+} doped $Sr_2P_2O_7$ phosphor the PL intensity increase with decrease in crystallite size. The PL emission results of Eu^{3+} doped $Sr_2P_2O_7$ phosphor suggest its potential application for wLED under blue excitation.
- Tb^{3+} doped $Sr_2P_2O_7$ phosphor showed prominent emission of the Tb^{3+} transition under 323 nm excitation. It gives green emission under UV excitation. PL emission intensity of Tb^{3+} doped $Sr_2P_2O_7$ phosphor increases with doping concentration as well as the decrease in the crystallite size. Tb^{3+} doped $Sr_2P_2O_7$ phosphor is good candidate for as a green phosphor under UV excitation.

Thermoluminescence (TL) studies of RE^{3+} doped $Sr_2P_2O_7$ phosphor were cried out after β-irradiation by Sr^{90} source. Ce^{3+} doped $Sr_2P_2O_7$ phosphor showed the maximum TL emission at around 383 K temperature. Eu^{3+} doped $Sr_2P_2O_7$ phosphor showed the maximum TL emission at around 460 K temperature. Tb^{3+} doped $Sr_2P_2O_7$ phosphor showed the maximum TL emission at around 425 K and other peak intensity at around 560 K temperature. Dy^{3+} doped $Sr_2P_2O_7$ phosphor showed the maximum TL emission at around 465 K temperature. Out of all four RE^{3+} doped $Sr_2P_2O_7$ phosphors, Eu^{3+} and Dy^{3+} doped phosphor showed maximum TL intensity of about 50000 units, which is a good TL outcome. TL glow curve intensity of RE^{3+} doped $Sr_2P_2O_7$ phosphors increases linearly with doping concentration and exposure dose. The fading of the TL intensity is very low for the storage of 30 day, which is less than 7%. The reusability of the phosphor were studied for ten cycles, which is consistent for each use for exposure. All the phosphors are very sensitive to the lower doses. The TL parameters obtained for different RE^{3+} doped $Sr_2P_2O_7$ phosphors are very consistent and nearby the traditional TLDs. The results suggests that the RE^{3+} doped phosphors may be the potential for environmental dosimetry and accidental dosimetry applications.

Output of RE^{3+} co-doped $Sr_2P_2O_7$

The photoluminescence studies for RE^{3+} co-doped $Sr_2P_2O_7$ phosphors displayed fascinating results, the following are the logical conclusions:

- 1.0 mol% Ce^{3+}, 1.0 mol% Eu^{3+} doped $Sr_2P_2O_7$ phosphor shows prominent 618 nm red emission under the excitation wavelength 396 nm. The emission under the excitation wavelength 254 and 268 nm shows weak emission due to the weak interaction between the Ce^{3+} and Eu^{3+} ions. Therefore, Eu^{3+} reduces the Ce^{3+} emission. This phosphor gives light red emission under 396 nm excitation.
- 1.0 mol% Ce^{3+}, 1.0 mol% Tb^{3+} doped $Sr_2P_2O_7$ phosphor shows prominent 395 nm UV emission under the excitation wavelength 232, 268 and 310 nm. The emission peak observed at 545 nm is occur due to the incorporation of Tb^{3+} ion in host. There is small amount of sensitizing occurs between Ce^{3+} and Tb^{3+} ions. Due to the combine effect of Ce^{3+} and Tb^{3+}, the emission color obtained in UV-Blue region of CIE diagram.
- 1.0 mol% Ce^{3+}, 1.0 mol% Dy^{3+} doped $Sr_2P_2O_7$ phosphor shows prominent 395 nm UV emission which is out of scale under the excitation wavelength 254, 264 and 310 nm. The emission occur due to allowed electron transition of Dy^{3+} are observed at 481 nm and 574 nm. The observation suggests that there is energy transfer process occur between Ce^{3+} and Dy^{3+}, which arise due the co-coping in phosphor.
- 1.0 mol% Ce^{3+} doped with 1.0 mol% Sm^{3+}, Er^{3+}, and Gd^{3+} did not give emission except the basic Ce^{3+} emission around at 395 nm as observed in RE^{3+} doping. This could be occur due to the non radiative transitions of Sm^{3+}, Er^{3+}, and Gd^{3+}.