Chapter - 7

Conclusion

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In this thesis, the synthesis, characterizations and luminescence properties of undoped, single rare earth doped and double rare earth doped pervoskite phosphor has been described. The main purpose of this study is to enhance luminescence properties of pervoskite phosphor which has large area of applications. To achieve this aim various double pervoskite phosphors were synthesized using hydrothermal method, solid state reaction method and combustion synthesis method.

Strontium Cerium Niobium Oxide (Sr_2CeNbO_6) was synthesized successfully using hydrothermal method. The hydrothermal method has been proved to be extremely efficient both in the search for new compounds with specific physical properties. The systematic physicochemical was investigation of intricate multicomponent systems at elevated temperatures and pressures. Strontium Gadolinium Niobium Oxide (Sr_2GdNbO_6) was synthesized by solid state reaction method. In solid state this pervoskite was heated up to $1200^{O}C$ for 3 hours and then cooled to room temperature naturally. Europium doped Barium Cerium Niobium oxide (Ba_2CeNbO_6) and undoped, single rare earths doped and double rare earth doped Sr_2GdTaO_6were synthesized by combustion synthesis method. In this method phosphors are heated up to $900^{O}C$ in muffle furnace for 3 hours and then cooled it to room temperature naturally. The phosphors synthesized by solid state reaction and combustion methods for the study of characterizations and luminescent properties.

Firstly, the synthesized phosphors were characterized using powder x-ray diffraction (XRD) to examine the formation of the required phosphors. The XRD studies of all samples were consistent as per the literature. XRD of all synthesized phosphors reveals that they have monoclinic phase. Further FTIR characterizations have been performed for the confirmation of bond formation in the host structure. For the FTIR study, IR spectra of all the phosphors were recorded using KBr pallet. FTIR spectrum showsall possible bond formation in pervoskite phosphor related to the present samples. The surface morphology of the phosphors was studied by SEM analysis. SEM images confirmed nano size crystalline formation. Photoluminescence of all phosphors were recorded using Shimazdu spectrofluorometer at room temperature with xenon lamp as a source.

- **Synthesis and Photoluminescence studies of Strontium Cerium Niobate Nanophosphor:**

Double Pervoskite phosphor Strontium Cerium Niobate (SCN) oxide present in this chapter-III was synthesized by the hydrothermal method. The X-ray diffraction measurement of Strontium Cerium Niobate (SCN) oxide revels that phosphor has a monoclinic phase with space group $P2_1/n$ (# 014). The phosphor under study is having nanocrystallinesize which was measured through Scherrer's method and Williamson-hall plot method. From the graph there is a shifting in XRD patterns which was observed in the Williamson–Hall plot, it is occurred due to the highly strained and distorted environment in the Sr_2CeNbO_6 lattice**.**

FTIR measurements of Sr_2CeNbO_6 give information, that the phosphor has a nano-size pervoskite structure with an edge-connected Nb-O octahedral. The observed shoulder peak at 715 cm^{-1} recommends the overlapping of Sr_2O_6 and NbO_6 stretching bands with the displacement toward higher frequencies of the NbO_6 bands. The symmetric stretching vibrations from 911 cm^{-1} completely support the possible presence of edge-connected Nb-O octahedra.

SEM image shows that Sr_2CeNbO_6 phosphors have different shapes and sizes with 10 minuet stir time. With increasing stir time, phosphor shows pattern of particle as cotton flower-shaped type.

Room temperature photoluminescence spectra of phosphor were recorded using a Xenon lamp as a source. The emission spectra shows as broad and asymmetric band emission centered at about 394 nm attributed to the 4f – 5dtransition. The intensity of this broad peak increases with increase in stir time. It is concluded that the formation of compound ratio increases with stirring time. The emission spectra of SCN nanophosphor fitted into two Gaussian curves, which represent the $^5d \rightarrow ^2F_{5/2}$, $^2F_{7/2}$ inter-configurational transitions at room temperature. According to the CIE coordinates, the values situated in the blue region. It recognizes that the Sr_2CeNbO_6 samples are applicable for blue-colored solid-state lighting applications.

- **Photoluminescence studies of Europium doped Strontium Gadolinium Niobate Oxide**

Eu^{3+} doped Strontium Gadolinium Niobate (SGN) oxide has been synthesized by the solid state reaction method. The X-ray diffraction measurement of Strontium Gadolinium Niobate (SGN) oxide reveals that phosphor has a monoclinic phase with space group $P2_1/n$ (# 014). The present pervoskite phosphor is nano crystalline in size which was measured through Scherrer’s method and Williamson-hall plot method. From the graph there is a shifting in XRD patterns which was observed in the Williamson–Hall plot, it is occurred due to the highly strained and distorted environment in the Sr_2GdNbO_6 lattice**.**

FTIR of Sr_2GdNbO_6 gives information that phosphor has a nano-size pervoskite structure with an edge-connected Nb-O octahedral. The bands at 542 cm^{-1} are assigned to the Gd-O vibration. The observed shoulder peak at 704 cm^{-1} recommends the overlapping of Sr_2O_6 and NbO_6 stretching bands with the displacement toward higher frequencies of the NbO_6 bands. The symmetric stretching vibrations from 838.8 cm^{-1} completely support the possible presence of edge-connected Nb-O octahedra.

Room temperature photoluminescence spectra of phosphor recorded using a Xenon lamp as a source. From photoluminescence studies of Eu^{3+} doped Sr_2GdNbO_6 phosphor concludes that Eu^{3+} substituted at A-site for excitation wavelength such as 254nm, 262nm and 277nm. Photoluminescence spectra of phosphor show high-intensity peaks at 590nm and 610nm due to $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ transitions of Eu^{3+} ions. The substitution of Eu^{3+} at Sr^{2+} site in Sr_2GdNbO_6 is followed by Sr^{2+} ion vacancy due to charge imbalance and lattice strain was observed due to different ionic radius. With the increasing europium concentration, the colour tone of the emanating light shifts from orange to the red region. The emission colour corresponding to coordinate points yields a mixture of light with colour in the orange-red region possess glow correlated colour temperature, i.e., CCT in the 1700K – 2500K range. It is recognized that Eu^{3+} doped Sr_2GdNbO_6samples are applicable red coloured solid state lighting application.

- **Synthesis and Photoluminescence studies of undoped and Europium doped Barium Cerium Niobate Oxide:**

Eu^{3+} doped Barium Cerium Niobate (BCN) oxide has been synthesized by the combustion synthesis method. The X-ray diffraction measurement of Barium Cerium Niobate (BCN) oxide revels that phosphor has a monoclinic phase with space group $P2_1/n$ (# 014). The pervoskite phosphor under study is having nano crystalline size which is measured through Scherrer’s method and Williamson-hall plot method. From the graph, angle Shift in XRD patterns are observed in the Williamson–Hall plot and it is occurred due to the highly strained and distorted environment in the Ba_2CeNbO_6 lattice**.**

FTIR of Ba_2CeNbO_6 gives information that phosphor has a nano-size pervoskite structure with an edge-connected Nb-O octahedral. The peak at 552cm^{-1} is due to the Ba-O. One small hump is at 1750 cm^{-1}, which is due to the presence of adsorbed moisture in KBr. The lower energy band found at around 450–650 cm^{-1} is related to the deformational mode of CeO_6octahedra. A small intensity peak at 1100 cm^{-1} likely corresponds to the presence of overtones of the fundamental vibrations in Ba_2CeNbO_6.

Room temperature photoluminescence spectra of phosphor were recorded using a Xenon lamp as a source. Photoluminescence studies of Eu^{3+} doped Ba_2CeNbO_6 phosphor shows that Eu (III) is substituted at a non-centrosymmetric site in the host lattice for excitation wavelength of 275nm and 466nm. Photoluminescence spectra of phosphor show high-intensity peaks at 590nm and 613nm due to $^5D_0 \rightarrow ^7F_1$ and $^5D_0 \rightarrow ^7F_2$ transitions of Eu^{3+} ions. The obtain emission peak at 623nm is maybe due to electronic transition ($^5D_0$ → 7F2) of Eu^{3+}.The substitution of Eu^{3+} at Ba^{2+} site in Ba_2CeNbO_6 is followed by Ba^{2+} ion vacancy due to charge imbalance and lattice strain is observed due to different ionic radius. With the increases of europium concentration, the colour tone of the emanating light shifts from orange to the red region. The emission colour corresponding to coordinate points yields a mixture of light with colour in the orange-red region possess glow correlated colour temperature, i.e., CCT in the 1800K – 5000K range.

- **Synthesis and Photoluminescence studies of undoped, single doped and double doped Strontium Gadolinium Tantalum Oxide**

Undoped, single doped and double doped Strontium Gadolinium Tantalum (SGT) oxide has been synthesized by the combustion synthesis method. The X-ray diffraction measurement of all Strontium Gadolinium Tantalum (SGT) oxide phosphor reveals that all phosphors have a monoclinic phase with $P2_1/n$ (# 014) space group. The pervoskite phosphors under study having a nanocrystalline in size measured through Scherrer’s method and Williamson-hall plot method. From the graph here is angle Shift in XRD patterns which was observed in the Williamson–Hall plot, which occurred due to the highly strained and distorted environment in the Sr_2GdTaO_6 lattice**.**

FTIR spectra of Sr_2GdTaO_6 give information that the phosphor has a nano-size pervoskite structure with an edge-connected Ta-O octahedral. The energy band at 380 cm^{-1}is occurred due to the asymmetric bending of the TaO_6 octahedra. The strong energy band at 566 cm^{-1} attributed to the asymmetric stretching of the TaO_6octahedra. The weak band at around 1456 cm^{-1} likely corresponds to the overtones of the fundamental vibrations in undoped, single doped, and Eu(III), Er (III) double doped Sr_2GdTaO_6. A very small peak at 1627 cm^{-1} is of the carrier $KBr.(H_2O)n$. The absorption peaks at 992 cm^{-1} and 860 cm^{-1} due to legend formation were assigned to stretching characteristics of $SrCO_3$.

Room temperature photoluminescence spectra of phosphor recorded using a Xenon lamp as a source. The effect of Eu^{3+} in the PL spectra of $Sr_2GdTaO_6$is not predominant; the reason for this may be due to crystal field quenching.

PLE spectrum for Eu^{3+} and Er^{3+} doped Sr_2GdTaO_6 shows broad band having intense peaks at 265nm and 276nm. These peaks are mainly due to theintra configuration of the 4f–4f transitions of Eu^{3+}. The broad band peaking at 265 nm can be ascribed to the charge transfer (CT) transition of the filled 2p orbitals of O^{2-} ions to the partially filled 4f orbitals of Eu^{3+} ions when in the octahedral field, of which the position is mainly determined by the Eu – O distance. Emission spectra show intense peaks at 584nm, 596nm, and 614nm of Eu^{3+}. Emission peaks occurred with low-intensity at 499nm, 535nm, and 538nm were seen and assigned to the electric transition of $^4F_{5/2} \rightarrow {}^4I_{15/2}$ and $^4S_{3/2} \rightarrow {}^4I_{15/2}$ of erbium. The spectral profile of phosphors shows remarkable variations with increasing erbium concentration regarding the mixed emission light chromaticity, when more green light element added to the overall mixed emission fluorescence. The emission color corresponding to coordinate points which yields a mixture of light with color in the white-light region possess glow correlated color temperature, i.e., CCT in the 3000K – 6000K range. The white-light generated exhibits low CCT owing to the presence of red components in the emission spectra of the Eu(III), Er(III) double-doped phosphors. In view of the results, it is proposed that Eu(III), Er(III) double-doped phosphors find suitable application for tunable solid state lightning.

Future Studies: By doping different RE dopants in the above systems can help in developing good phosphor material for SSL applications.