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Optical property of narrow UVB emitting Phosphor $NaAlO_2$: Gd^{3+} prepared with Solution combustion synthesis

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Abstract

The narrow UVB emitting alkali metal aluminate phosphor doped with Gd^{3+} has been prepared by a solution combustion synthesis technique. The formation of the sample was confirmed by powder X-ray diffraction technique. The spectroscopic property of prepared material was studied at room temperature. The phosphor $NaAlO_2$ shows emission in narrow band UVB under the excitation of 275 nm. Stokes shift of sample also been calculated using corresponding excitation and emission wavelengths. Because of narrowband ultraviolet (UV) emission the phosphor could be effective choice for UV phototherapy lamps.

Keywords: Narrowband UVB, Phototherapy Lamp, Stoke shift, Combustion synthesis.

Introduction

The fraction of the electromagnetic spectrum covers by the ultraviolet radiation. According to physical and biological properties the UV radiation sub divided into UVA (320nm - 400nm), UVB (290nm - 320nm) and UVC (200nm - 290nm) radiation.

The use of artificial source of ultraviolet radiation is effective way of treatment for many skin disorders, such as psoriasis[1], vitiligo[2], ofujisdisease[3], erythropoetic protoporphyria[4], pityriasisrosea[5], uremicpruitus[6], lichensclerosuset atrophicus etc.

From the literature survey it has been confirmed that till date various inorganic material with different color emission has been developed as well as reported for the display application. In recent time luminescent material of aluminate family has got much attention due to their number of capable properties which are agreeable for lighting and display devices[7, 8].

In the present work we have tried $NaAlO_2$ as a host for luminescence and material was prepared by solution combustion synthesis technique. The phase purity of synthesize material was characterized using the powder XRD. And the photoluminescence properties of as prepared sample carried out using spectrofluorometer at room temperature.

Methodology

Synthesis of Phosphor: The phosphor $NaAlO_2$:Gd^{3+} phosphor was successfully prepared by using solution combustion synthesis technique. The synthesis technique was well explained by Palan *et.al,*[9-11]. The stoichiometric amounts of starting materials, $Na(NO_3)_2$ (99.99%), $Al(NO_3)_2$ (99.99%.), $CO(NH_2)_2$ (99.99), NH_4NO_3 (99.99) were mixed thoroughly in china basin so that the paste was formed. The stoichiometric amount stock solution of dopant $Gd_2(NO_3)_2$ was then added in formed paste. After that the formed paste placed on the hot plate at temperature 80ºC to obtain the clear solution. The obtained solution directly faced to the preheated furnace (550ºC) and stay for 5min. In the interval of 5min exothermic redox reaction take place and the final product of $NaAlO_2$ was formed. The obtained powder calcinated for 2hr at 750ºC to eliminated the carbon impurities[12].

Characterizations: The synthesized phosphor was then put through to the XRD analysis on Rigaku miniflex II X-ray diffract meter with scans peed of 2.000º/min and with Cu Kα radiation (k = 1.5406 Å). The measurement of photoluminescence spectra were carries out on a Hitachi F-7000 spectrophotometer by setting all the parameters constant.

Results and Discussion

X-ray Diffraction Analysis: Figure-1 represents the X-ray diffraction pattern of as prepared phosphor $NaAlO_2$:Gd^{3+}. The pattern shows sharp peaks from which we conclude that the prepared material is well crystalline. The XRD pattern of synthesized material carefully matched with the ICDD files no.-01-083-0316 and it was observed that the diffraction peak of synthesized sample has fine agreement with ICDD file. There is no other significant diffraction peak observed due to the other impurities. It shows that the addition of dopants i.e. Gd^{3+} do not considerably influence the structure of host. The structure of aluminate $NaAlO_2$ is well explained by Kaduk *et al.*[13]. According to him synthesized material consist of orthorhombic structure having lattice parameter a=5.38712 (18) Å, b=7.03203

(23) Å, c= 5.21798 (17) Å, α=β=γ=90ºC and volume = 197.67 $Å^3$ and space group Pna21[14].

In addition the $NaAlO_2$ lattice, the ionic radius of Gd^{3+} (0.938 nm, C.N. = 6) was nearly equal to Na^+ (0.99 nm, C.N. = 6). Hence the position of Na^+ ion can be replaced by Gd^{3+}ion. Because of same ionic radii we decided to add this dopant into the host and expected the possible incorporation of Gd^{3+} ions at Na^+ site.

Photoluminescence of Gd^{3+} in $NaAlO_2$: Figure-2 represent combined excitation and emission spectra for $NaAlO_2$: $_{0.005}Gd^{3+}$ phosphor. The photoluminescence excitation spectrum consists of weak broad spectrum from 240 - 265 nm corresponds to $^8S_{7/2}$ to ^6D_J transition of Gd^{3+}. Also the excitation spectrum shows the strong excitation having maximum intensity at 275 nm. The Photoluminescence spectrum shows sharp emission in the narrow band UVB region around 313 nm corresponding to $^6P_J \rightarrow {}^8S_{7/2}$ transition under the excitation of 275nm. In emission spectra the weak line observed at 306 nm which is corresponds to $^6P_{5/2} \rightarrow {}^8S_{7/2}$ transitions of the Gd^{3+} ion. Generally the emissions in the UVB region (280-320nm) effectively use for phototherapy. The Stokes shift was determined to be about 4414 cm^{-1}.

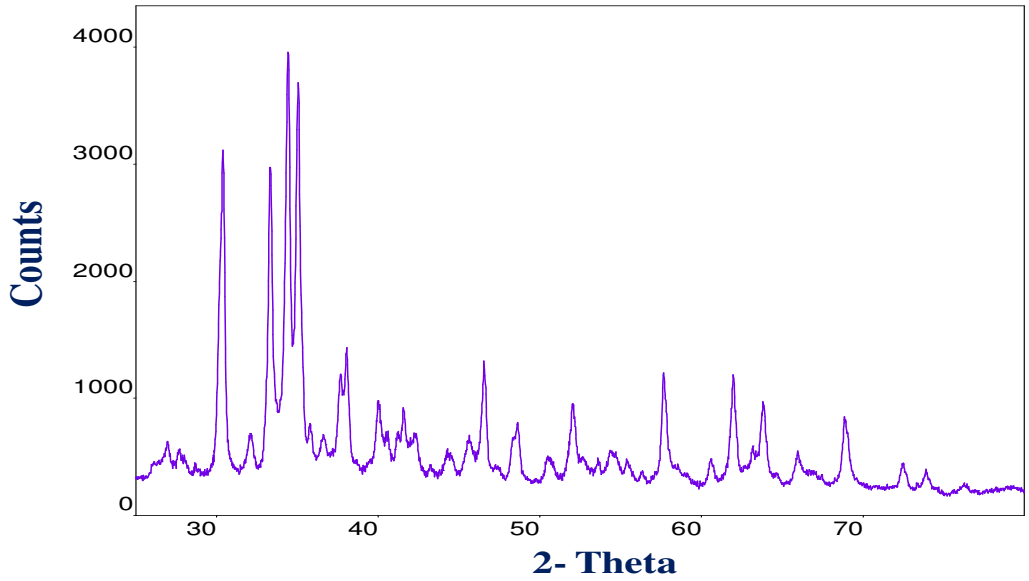

Figure-1
X-ray diffraction pattern for $NaAlO_2$: $_{0.005}Gd^{3+}$

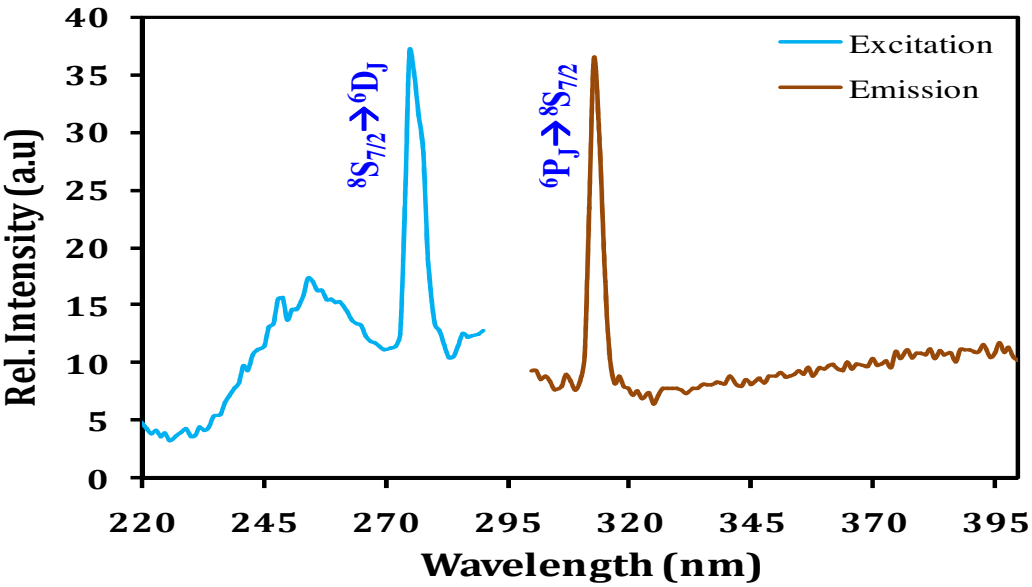

Figure-2
Combined photoluminescence spectra for $NaAlO_2$: $_{0.005}Gd^{3+}$

Conclusion

The phosphor $NaAlO_2$ doped with rare earth (Gd^{3+}) ions was successfully prepared using solution combustion synthesis. The phase purity of prepared sample confirmed using X-ray diffraction pattern which is well agree with the slandered ICDD file. According to pattern the prepared sample is in totally crystalline. The sharp and intense emission at 313 nm corresponds to $^6P_J \rightarrow {}^8S_{7/2}$ transition of Gd^{3+} ion under the excitation of 275nm. The narrow band UVB emission and simple preparation of this system make this phosphor a useful material for application in phototherapy lamp.

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