PL CHARACTERISATION OF $BaAl_2O_4:Gd^{3+}$ FOR PHOTOTHERAPY LAMP

Kapil Dev[1], R. G. Kunghatkar[2], M. Aynyas[3], Vibha Chopra[4], S. J. Dhoble[2]
[1]Sadhu Vaswani College, Sant Hirdaram Nagar, Bhopal, India
[2]Department of Physics, R.T.M. Nagpur University, Nagpur, India
[3]Department of Physics, Govt. P.G.College, Sehore, M.P., India
[4]P.G. Department of Physics & Electronics, DAV College, Amritsar, Punjab, India

ABSTRACT

The preparation of Barium Aluminate by combustion method was discussed in this manuscript. The photoluminescence (PL) characterisation analyses that the well incorporation of dopant Gd^{3+} in host lattices $BaAl_2O_4$. The UVB emission at 314 nm when excited by λ_{ex} = 274 nm is very useful in the treatment of psoriasis and vitiligo. UVB emitted Gd^{3+} activated materials are used as phototherapy lamp phosphor in the treatment of skin diseases.

Keywords: Photoluminescence, UVB, phototherapy, skin diseases.

I. INTRODUCTION

Phosphor materials emit light when excited by external energy such as ultraviolet, X-rays, etc. These types of phosphor materials has been widely used in the medical field, lamp industry, display device field, etc. Phototherapy is the therapy in which artificial UVB, UVA emission are used in the treatment of more than 40 types of skin diseases like psoriasis, vitiligo, etc. The UV region consists of three types viz:

a) UVC (from 200-280 nm)
b) UVB (from 280-320 nm)
c) UVB (from 320-400 nm)

UVA is further classified into two subtypes

i) UVA1 (from 340-400 nm)
ii) UVA2 (from 320-340 nm).

Long exposed to ultraviolet radiation causes many skin diseases and skin cancer. But at particular wavelength with short exposer the skin problems should be definatly cure. According to effectiveness of the wavelength region of radiation sources, phototherapy can be classified into: a) Narrow band UVB phototherapy b) Psoralen UVA phototherapy (PUVA) and c) Near UV-Visible light phototherapy. UVB and UVA emission are very much useful in the medical field, while UVC is hazardous for human skin and generally used in germicidal applications such as killing bacteria in drinking water [1].

$BaAl_2O_4$ has a hexagonal crystal structure with space group P63 (No. 173) [2]. Good luminescence materials should have better chemical consistency and high surface area in a quick, low-cost single step operation. The $BaAl_2O_4$ offers high thermal and chemical stability, hydrophobic behaviour, high mechanical resistance, low sintering temperature, and high quantum yields [3]. It is a wide-band gap semiconductor, which occurs naturally as the mineral gahnite and is a member of the spinel family; it can be used as transparent conductor and optical material [4]. The new phosphor originally included only the Eu^{2+} and Dy^{3+} doped MAl_2O_4 (M= Ba, Ca and Sr) [5]. $BaAl_2O_4$ materials mostly prepared by solid state method [2], solution combustion method [3], self-propagating high temperature synthesis [6] and combustion [4] methods. The objective of this work is to study the PL properties of $BaAl_2O_4$: Gd^{3+} phosphor.

II. METHODS AND MATERIAL

The series of $BaAl_2O_4$ doped with Gd^{3+} was synthesized by combustion method. The starting materials were taken in nitrate form as $Ba(NO_3)_3.6H_2O$, $Al(NO_3)_3.9H_2O$, $Gd(NO_3)_3$ and

urea ($CO(NH_2)_2$) as a fuel. To perform the combustion reaction, the appropriate materials were taken in mortar and crushed with a very minimum quantity of double distilled water. The thick paste was transferred into the china dish and the china dish was introduced into a muffle furnace preheated at 500°C. After combustion reaction, the dish was removed from the furnace. The product obtained from combustion process was fluffy and crushed into fine powder. The resulting powder was used for further characterisation.

III. RESULTS AND DISCUSSION

Figure 1 shows the excitation spectra of Gd^{3+} activated $BaAl_2O_4$ in the 270-280 nm range. This excitation spectra exhibits single peak in UV region at 274 nm. Figure 2 shows the emission spectra of $BaAl_2O_4:Gd^{3+}$ in UV region with excitation wavelength fixed at 274 nm. The emission peak exhibit the intense peak centred at 314 nm. The intense peak at 314 nm results from the transition between the first excited state ($^6P_{7/2}$) and ground state ($^8S_{7/2}$). As well as Figure 3 shows the concentration quenching plot between concentration of Gd^{3+} and observed intensity.

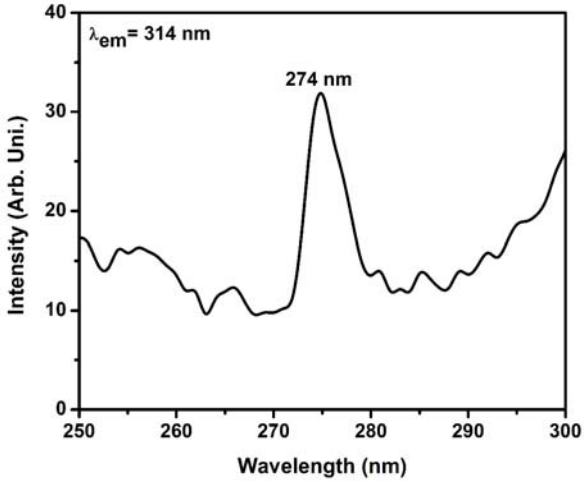

Figure 1: PL excitation spectra of $BaAl_2O_4:Gd^{3+}$

The excitation peak in photoluminescence spectra is attributed to the Gd^{3+}, 4f-4f intra configuration transition between the ^8S ground state and ^6D_J excited state. The excitation peak at 274 nm is attributed to transition $^8S_{7/2} \rightarrow {}^6D_J$. Emission spectra at 314 nm is attributed to $^6P_{7/2} \rightarrow {}^8S_{7/2}$. The emission is about 314 nm is due to electric dipole transition [7]. The concentration quenching plot shows the maximum intensity of Gd^{3+} ion is observed at 5 mol%. After that the intensity goes on decreasing. The emission at 314 nm in $BaAl_2O_4:Gd^{3+}$ is well suitable for the treatment of Psoriasis and Vitiligo. Narrow band UVB emitting phosphors are important for the production of phototherapy lamps.

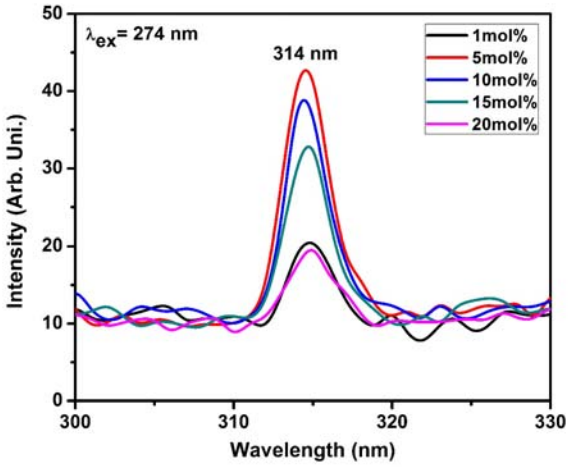

Figure 2: PL emission spectra of $BaAl_2O_4:Gd^{3+}$

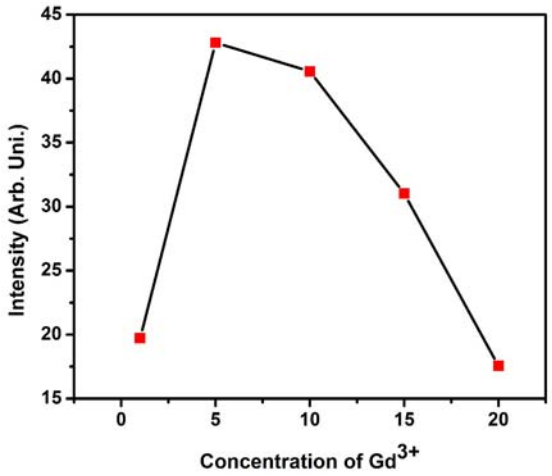

Figure 3: Concentration quenching plot of $BaAl_2O_4:Gd^{3+}$

IV. CONCLUSION

$BaAl_2O_4:Gd^{3+}$ phosphor was prepared by combustion method. PL properties reveals the emission of Gd^{3+} in UV region, which is used for phototherapy lamp. The UVB (280-320 nm) emission at 314 nm is used as NB-UVB emitting phosphor. This narrow band emission is useful in the treatment of skin treatment. The analysis of data has demonstrated; with an increase in the concentration of gadolinium, the luminescence intensity increases upto 5mol% then decreases due to concentration quenching.

The UVB emission of $BaAl_2O_4:Gd^{3+}$ phosphor may be used in the phototherapy lamp.

V. ACKNOWLEDGEMENT

One of the author RGK is thankful to CSIR for providing financial assistance through CSIR-SRF scheme via sanction letter 164296/2K15/1.

VI. REFERENCES

[1] B. Gawande, R. P. Sonekar, S. K. Omanwar. 2013. AIP Conference Proceeding.
[2] R. Stefani, L. C. V. Rodrigues, C. A. A. Carvalho, M. C. F. C. Felinto, H. F. Brito, M. Lastusaari, J. Holsa. 2009. Optical Materials, DOI:10.1016/j.optmat.2008.12.035.
[3] K. K. Satapathy, G. C. Mishra, F. Khan. 2013. International Journal of Engineering Science Invention, ISSN No.: 2319-6734.
[4] L. C. V. Rodrigues, R. Stefani, H. F. Brito, M. C. F. C. Felinto, J. Holsa, T. Laamanen, M. Malkamaki, M. Lastusaari. 2010. Journal of Solid State Chemistry, DOI: 10.1016/j.jssc.2010.07.044.
[5] B. Cheng, L. Fang, Z. Zhang, Y. Xiao, S. Lei. 2011. The Journal of Physical Chemistry C, DOI: 10.1021/jp109796u.
[6] S. Niyomwas, T. Sathaporn, S. Singsarothai. 2011. IOP Conference Series: Materials Science and Engineering, DOI: 10.1088/1757-899X/18/7/072001.
[7] E. J. Bosze, G. A. Hirata, L. E. Shea-Rohwer, J. McKittrick. 2003. Journal of Luminescence, DOI: 10.1016/S0022-2313(02)00663-4.