Combustion Synthesis and photoluminescence properties of Cerium doped Sodium Strontium Borate Phosphor

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Abstract:

Solution combustion synthesis is a simple method, easy to handle and requires no absolute control on the temperature. During the synthesis, oxidizer and fuel will automatically decide the reaction temperature.The intense blue emitting phosphor $NaSrBO_3:xCe^{3+}$ is synthesized by this time saving and economical method, using urea as fuel. X-ray power diffraction (XRD) analysis confirmed the formation of the said phosphor. The SEM image was recorded to study the surface morphology. It shows the particles with an irregular shape and the particle size ranging in 5-10 µm.

Photoluminescence measurements showed that the phosphor exhibited intense blue emission peaking at 430nm, corresponding to 5d→4f transition of Ce^{3+}ion.The excitation spectra monitored at 430nm shows peaks at 275nm and 355nm.The former resulted from the host absorption and the later is due to typical Ce^{3+} transition.

The CIE colour coordinates of the as-synthesised sample were recorded by using Radiant Imaging colour calculator.

Keywords*: : photoluminescence, combustion synthesis* , Ce^{3+} transition

1.Introduction:

White LEDs are promising candidates to replace conventional incandescent and fluorescent lamps in the coming future due to their merits of a long operation life time, energy saving capabilities and high material stability [1].During past few years white LEDs fabricated using near ultraviolet LEDs [2-3]coupled with red, green and blue phosphors have attracted much attention due to several advantages.For solid state lighting using near UV chips, phosphors with excitation in the range 365-400 nm are required. Hence researchers in this field are exploring with new hosts as well as dopants that could lead to the phosphor materials having excitation to the longer side [4-7].Borates are excellent host materials for the phosphors since they have large band gap, low synthesising temperature and high chemical and physical stability. Many rare earth doped borate phosphors are reported previously for variety of applications [8-11]. The crystal structure of $NaSrBO_3$ was first reported by Wu et al [12]. Then blue emitting Ce^{3+} doped [13] and red emitting Eu^{3+} doped phosphors [14] in this host were reported. But the conventional methods for the synthesis of these phosphors required heat treatment for long hours. We successfully synthesised and reported Eu^{3+} doped phosphor in the same host by solution combustion synthesis method [15]. That prompted us to prepare $NaSrBO_3$:xCe^{3+} phosphor by the same simple, time saving, economical method of modified solution combustion synthesis.

2. Experimental:

The sample was prepared by solution combustion synthesis [16] method. The synthesis is based on the exothermic reaction between the fuel (urea) and oxidizer (metal nitrate). The constituent raw materials were weighed in stoichiometric proportions and fired at 550^0C. Following the combustion, resulting fine powder was reduced in CO atmosphere at 700^0C for two hours. (Fig.1).

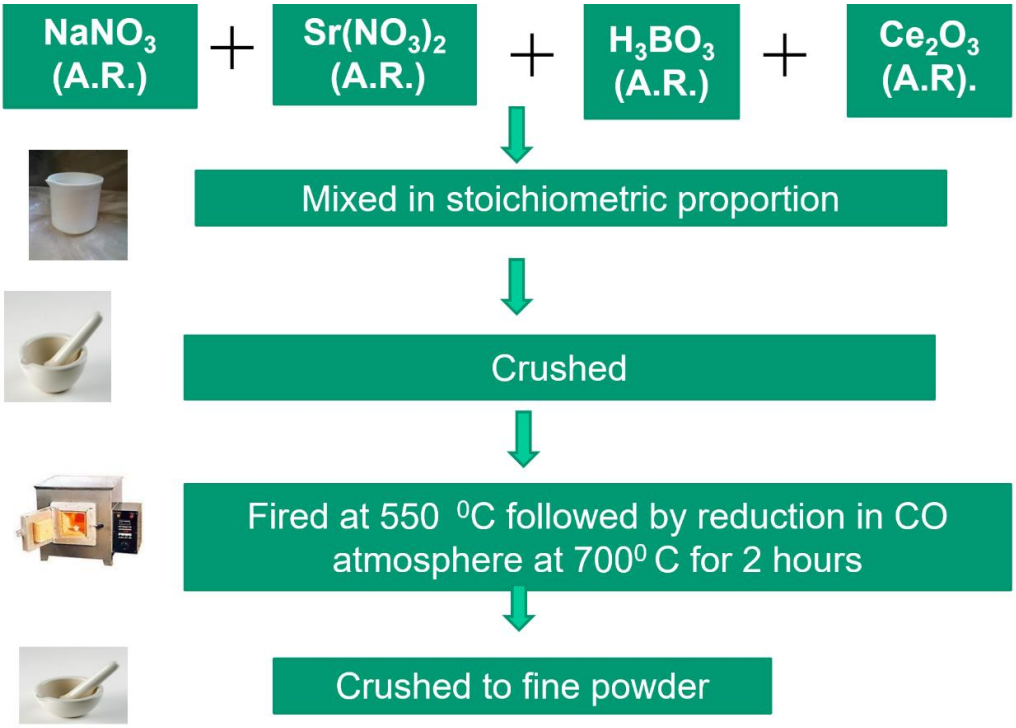

Fig.1: Flow chart describing the modified solution synthesis method phosphor.

3. Results and Discussion:

The powder XRD pattern is in good agreement with ICDD data (Fig.2).The SEM image was recorded to study the surface morphology. It shows the particles with an irregular shape and the particle size ranging in 5-10 μm(Fig.3).

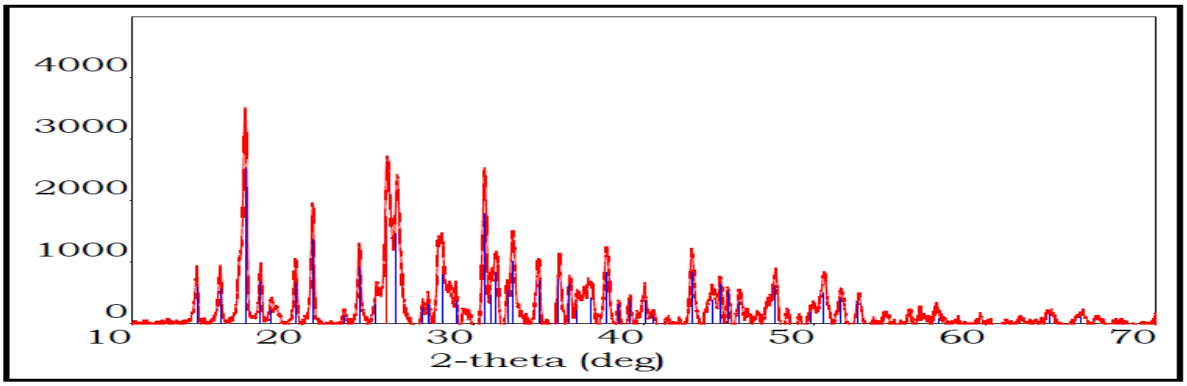

Fig.2: The powder XRD pattern of $NaSrBO_3:xCe^{3+}$

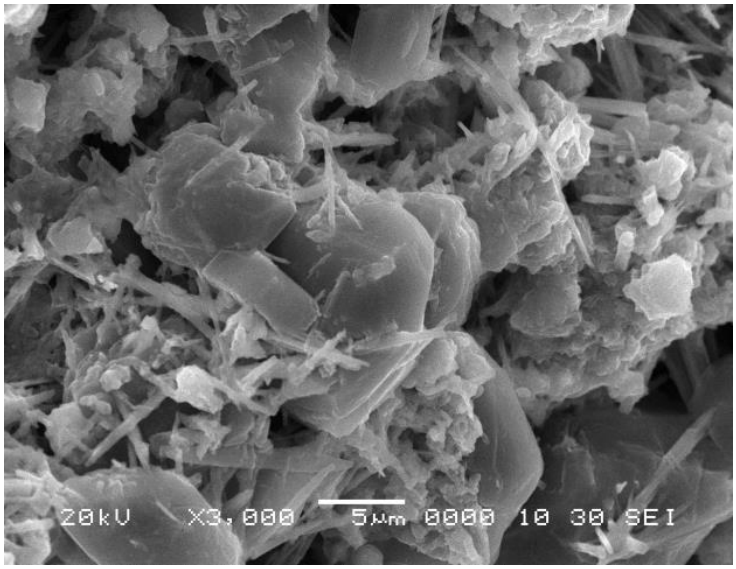

Fig.3: SEM image of as-synthesised $NaSrBO_3:xCe^{3+}$phosphor.

Photoluminescence measurement shows intense blue emission peaking at 430nm, corresponding to 5d→4f transition of Ce^{3+} ion (Fig.4). The excitation spectra monitored at 430nm shows peaks at 275nm and 355nm.The emission intensity increases with Ce^{3+} doping concentration and is maximum for x=0.01, after that concentration quenching is observed. The CIE colour coordinates of the as-synthesised phosphor were recorded by using Radiant Imaging colour calculator.Fig.5 shows the CIE coordinates of the as-synthesised sample by modified solution combustion synthesis method .The values are (0.15,0.05) indicating blue colour emission.

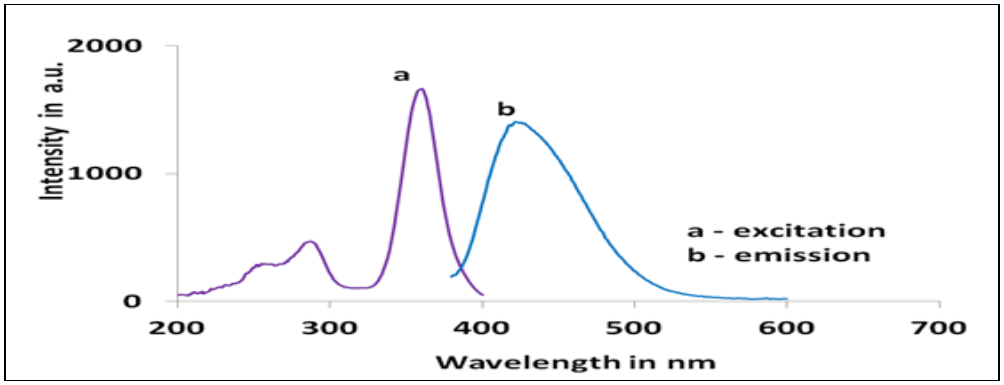

Fig.4: PLE (a) and PL (b) curve for$NaSrBO_3:xCe^{3+}$(for x=0.01).

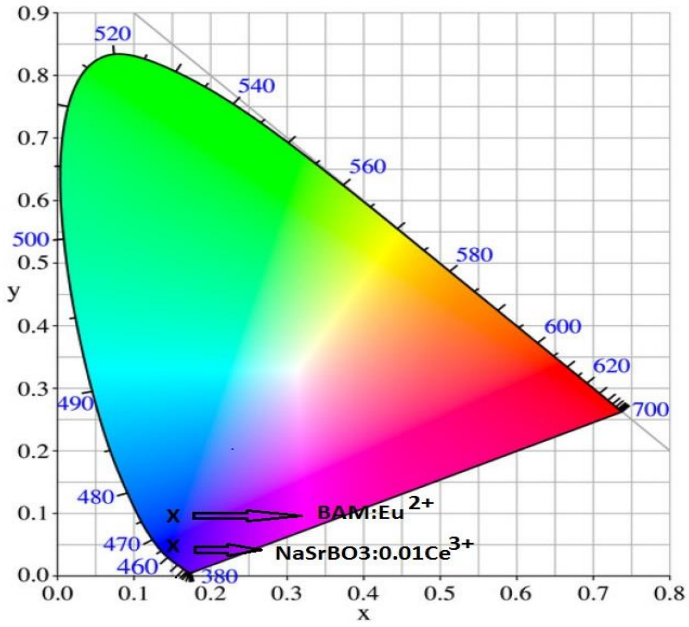

Fig.5: CIE 1931 color coordinates for $NaSrBO_3:xCe^{3+}$(for x=0.01).

4.Conclusion:

The intense blue emitting phosphor $NaSrBO_3:xCe^{3+}$ is synthesized by simple, time saving, economical method. The XRD pattern confirms the formation of single phase $NaSrBO_3$.The as-synthesized phosphor shows blue emission at 430 nm. The excitation spectrum monitored at 430 nm shows excellent spread in nUV region of the spectrum. The CIE 1931 color coordinates are (0.15,0.05) for highest emission intensity. It is thus a **potential blue emitting phosphor for solid state lighting using nUV LED chip.**

References:

[1] W.B.Im, Y.I.Kim, N.N.Fellows, H.Masui, G.A.Hirata, S.P.DenBaars and R. Seshadri, ***Appl. Phys Lett***,93 (2008)091905

[2] Zhao Xiaoxia, Wang Xiaojun, Chen Baojiu, Meng Qingyu,Di Weihua, Ren Guozhong, Yang Yanmin, ***Journal of Rare Earths***, 25(2007)15

[3] WANG Zhijun, YANG Zhiping, et al, ***Journal of Rare earths***, 28 (2010)30

[4] P.A. Nagpure, N.S Bajaj, R.P. Sonekar, S.K. Omanwar***, Indian journal of pure***

and applied physics 49 (12) (2011) 799-802

[6] D. Chikte (Awade), S.K.Omanwar, S. V. Moharil. , ***Journal of Luminescence*** 145(2014) 729-732

[7] G. Ramakrishna, Ramachandra Naik, H. Nagabhushana, R.B. Basavaraj,S.C. Prashantha, S.C.Sharma, K.S. Anantharaju, ***Optik*** , 127(5),(2016), 2939–2945

[8] Shahare, D. I., Deshmukh, B. T., Moharil, S. V., Dhopte, S. M., Muthal, P. L., & Kondawar, V. K. Synthesis of Li2B4O7: Cu phosphor. ***physica status solidi (a),*** 141(2)(1994)329-334.https://doi.org/10.1002/pssa.2211410210

[9] Duan, C. J., Delsing, A. C. A., & Hintzen, H. T.Photoluminescence properties of novel red-emitting Mn2+-activated MZnOS (M= Ca, Ba) phosphors**.** ***Chemistry of Materials,*** 21(6)(2009) 1010-1016. https://doi.org/10.1021/cm801990r

[10]Geng, W., Zhou, X., Ding, J., & Wang, Y. ***Journal of the American Ceramic Society***, 101(10)(2018)4560-4571. https://doi.org/10.1111/jace.15693

[11]Gaffuri, P., Salaün, M., Gautier-Luneau, I., Chadeyron, G., Potdevin, A., Rapenne, L., ... & Ibanez, ***Journal of Materials Chemistry C***, 8(34)(2020) 11839-11849. https://doi.org/10.1039/D0TC02196B

[12] Wu L, Chen X L, Zhang Y, Kong Y F, Xu J J, Xu Y P**.** ***J. Solid State Chem***.179(4) (2006) 1219.

[13] Liu W R, Huang C H, Wu C P, Chiu Y C, Yeh Y T, Chen T. M. ***J. Mater.Chem***.,21(2011), 6869.

[14] Fan Yang, Yujun Liang, Mingyu Liu, Xuejing Li , Mengfei Zhang , NanWang ***Optics & Laser Technology*** 46 (2013) 14–19

[15] D. Chikte (Awade), S.K. Omanwar, S. V. Moharil, ***Journal of Luminescence*** 142 (2013) 180– 183

[16] Patil K C. ***Bull. Mater*** 16(6) (1993) 533