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Synthesis and Photoluminescence properties of $BaGa_2S_4$ Phosphor doped with Ce^{3+}

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ABSTRACT

The synthesis method and photoluminescence properties of Ce^{3+} doped $BaGa_2S_4$ phosphors for white light emitting diode (LEDs) are reported. The photoluminescence excitation spectrum of $BaGa_2S_4$:Ce^{3+} shows two excitation bands centered at 280 nm and 380 nm, assigned to host-lattice absorption. $BaGa_2S_4$:Ce^{3+} shows the blue emission band at about 445 nm due to Ce^{3+} transition from 5d state to 4f state for 380 nm excitation. The excitation band shows excellent spread in NUV region of the spectrum. This makes it potential candidate for LED application. $BaGa_2S_4$:Ce^{3+} is used as blue emitting phosphor excited by a near-UV LED.

Keywords: Photoluminescence, $BaGa_2S_4$ phosphors, near-UV LED phosphors, Ce^{3+} activator.

I. INTRODUCTION

Barium thiogallate ($BaGa_2S_4$) belongs to the large family of semiconductor compounds with general formula II-III2-VI4 [1]. These compounds are regarded as promising materials for optoelectronics and photonics applications, due to their interesting physical properties[2,3]. Barium thiogallate ($BaGa_2S_4$) belongs to the same family of compounds [1] and crystallizes in the cubic structure with a band gap of 4 eV [4]. The cerium-activated alkaline earth thiogallates are efficient cathodoluminescent phosphors. Peters and Baglio [1] have reported cathodoluminescent (CL) spectra, CL efficiencies, and relative photoluminescence intensities for $MIIGa_2S_4$:Ce, Na (M = Ca, Sr, and Ba) powders. These phosphors were prepared by solid state reaction.

J. Kane and M. Ling [5] prepared $BaGa_2S_4$:Ce blue emitting thin films and TFEL devices by RF sputtering. Fluorescence properties of Ce^{3+} single doped and Ce^{3+}/Eu^{2+} co-doped $BaGa_2S_4$ phosphor was discussed by Marceddu and Anedda [6].

II. EXPERIMENTAL

The wet chemical co-precipitation method is used to prepare the ternary sulphide $BaGa_2S_4$:Ce^{3+}. The precursors used for this particular phosphor are Gallium oxide (99.9% A. R. Grade), Barium chloride (99.9% A. R. Grade) and sulphur (G. R. Grade). Cerium is incorporated during synthesis in the form of Cerium Chloride. Cerium Chloride is prepared from dissolving Cerous sulphate in HCl and evaporating the excess acid. X-ray diffraction pattern was recorded on Philips PAN analytical expert pro-diffractrometer. PL characteristics in the range 200 nm – 700 nm at room temperature were studies using Hitachi F-7000 spectrophotometer, with 1.5 nm spectral slit width.

III. RESULTS AND DISCUSSION

A. XRD Pattern

Figure 1 represents the powder XRD pattern of $BaGa_2S_4$:Ce^{3+} phosphor prepared by this method which is in good agreement with JCPDS card 25-0066. $BaGa_2S_4$ exhibits cubic crystal structure. The reported lattice constants are a = 12.660 A^o, b = 12.660 A^o, c = 12.660 A^o with cell volume of V = 2029.0890 A^{o3} and

the cell formula units Z= 12. The values for $\alpha=90^0$, $\beta=90^0$, $\gamma=90^0$.

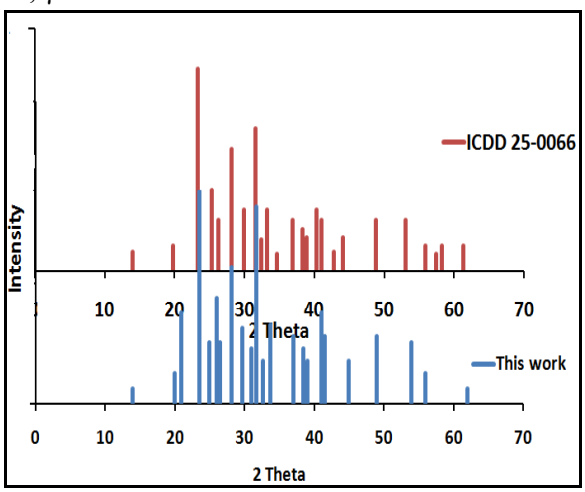

Figure1: XRD of $BaGa_2S_4:Ce^{3+}$ phosphor

The diffraction symmetry and systematic absences correspond to the tetrahedral space group Th^6-Pa^3[7]. Since the general position for this space group is twenty-four fold and because there are 12 formula-weight units per unit cell, the barium ions must be in two different sites; 8 Ba ions lie in the special position c with point symmetry 3, and 4 Ba ions lie in the special position a or b with point symmetry 3. Since it is assumed that activator ions substitute for Ba, these ions also lie in two different sites.

B. Crystal Structure

The $BaGa_2S_4$ crystallize in the cubic system with space group Pa3 which is isotopic with $BaAl_2S_4$[8]. The lattice parameter is 1266pm. The Ba ions are located in holes with coordination number 6.

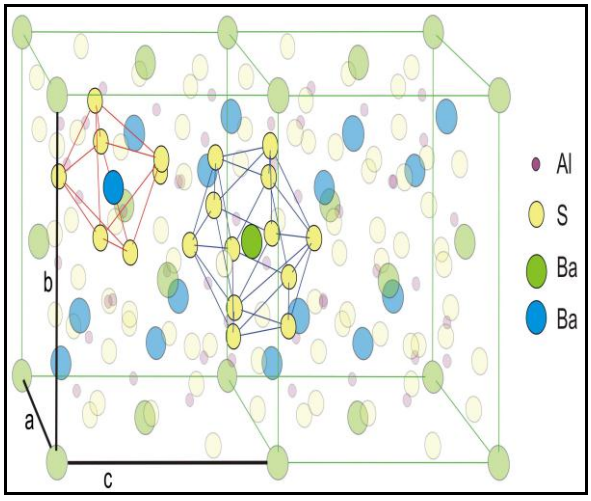

Figure 2. Schematic representation of the crystal structure of cubic $BaAl_2S_4$ (a = b = c =1265pm). The two different Ba sites with octahedral and icosahedral coordination are highlighted. The ionic radii of the elements are not to scale.

C. Photoluminescence

Cerium ion can exist in the oxidation state +3 and +4 in the phosphors. Figure 3 shows the photoluminescence excitation and emission spectrum of $BaGa_2S_4:Ce^{3+}$ for 1 mol %.The excitation spectrum monitored at 445 nm emission exhibits a broad band from 220 – 420 nm which can be assigned to host absorption.PL band is peaked at 445 nm and shoulder is observed in the 470–490 nm spectral ranges. The components at 445 nm and 470 – 490 nm arise from Ce^{3+} radiative transitions from the 2D level to the $^2F_{5/2}$ and $^2F_{7/2}$ levels respectively [1, 9]. The excitation spectra shows excellent spread in near UV region suggesting its utility for solid state lighting with nUV LED chip.

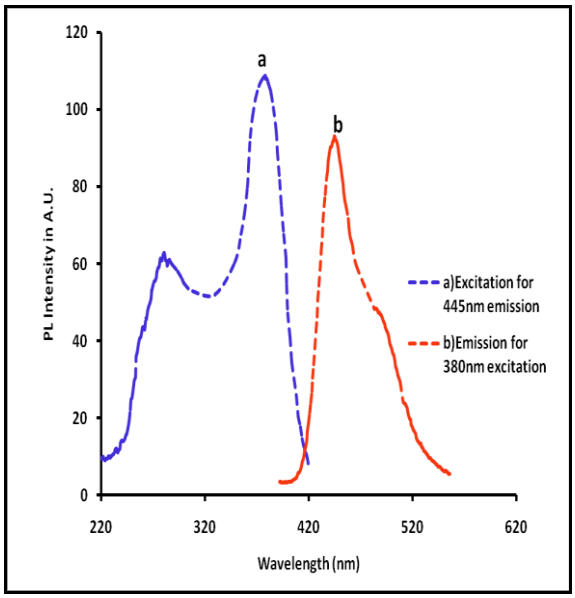

Figure 3. Photoluminescence spectra of $BaGa_2S_4:Ce^{3+}$ (1 mol%) .

D. CIE Color Co-ordinates

Figure 4 Shows CIE color coordinates of the phosphor $BaGa_2S_4:Ce^{3+}$ (1 mol %). The color coordinates CIE 1931 for the as-synthesized phosphor are (0.145, 0.061) where as the commercial blue phosphor $BAM:Eu^{2+}$ shows the color co-ordinates as (0.14, 0.107) indicating the as-synthesized phosphor suitable for solid state lighting.

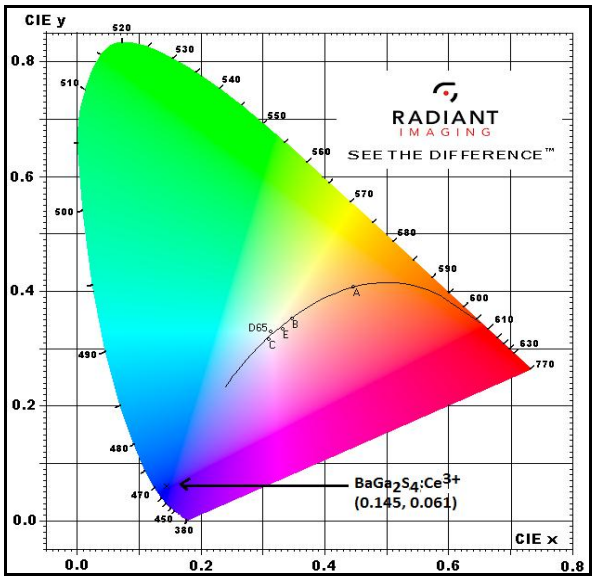

Figure 4. CIE color Co-ordinates of the phosphor $BaGa_2S_4:Ce^{3+}$

IV. CONCLUSION

$BaGa_2S_4:Ce^{3+}$ phosphor was prepared by soft chemical route shows good luminescent properties. In $BaGa_2S_4:Ce^{3+}$ the excitation spectrum monitored at 445 nm emission exhibits a broad band from 220 – 420 nm which can be assigned to host absorption. The color coordinates CIE 1931 of $BaGa_2S_4:Ce^{3+}$ phosphors are (0.145, 0.061). The excitation spectra shows excellent spread in near UV region suggesting its utility for solid state lighting with nUV LED chip.

V. REFERENCES

[1]. T.E .Peters and J.A.Baglio,J.Electrochem.Soc.119,230(1972).
[2]. P. Bernalloul, C. Barthou, C. Fouassier, A. N. Georgobiani, L.S. Lepnev, A.N. Gruzintsev,B.G.Tagiev, Oktay. B. Tagiev, R.B. Jabbarov, J. Electrochem. Soc. 150 (1), G62-G65 (2003).
[3]. A.N. Georgobiani, Jpn. J. Appl. Phys. 39, 434-439 (2000).
[4]. M.-Y. Kim, W.-T. Kim, J. Korean Phys. Soc. 41, 774-777 (2002).
[5]. J. Kane and M. Ling, J. Electrochem. Soc., 141, 10, (1994).
[6]. M. Marceddu , A. Anedda, R. Corpino, A.N. Georgobiani, P.C. Ricci. Materials Science and Engineering B 146, 216-219 (2008).
[7]. International Tables for X-ray Crystallography, Vol. 1, The Kynock Press, Birmingham, England (1959).
[8]. B. Eisenmann, M. Jakowski, H. Schafer; Mat. Res. Bull. 17,1169-1175 (1982).
[9]. P. Dorenbons, J. Lumin. 91, 155-176 (2000).