Optical Materials 36 (2014) 1299–1304

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat

Solution combustion synthesis and optimization of phosphors for plasma display panels

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ARTICLE INFO

Article history:
Received 13 October 2013
Received in revised form 5 March 2014
Accepted 5 March 2014
Available online 3 April 2014

Keywords:
Combustion synthesis
Optimization
Photoluminescence
PDP phosphors

ABSTRACT

The optimization of primary phosphors required for display panels were carried out. Phosphors were synthesized by simple solution combustion technique. The synthesis is based on the exothermic reaction between the fuel (urea) and oxidizer (ammonium nitrate).The heat generated in the reaction is used for auto combustion of precursors. The crystal structures of the prepared samples were confirmed by powder XRD technique and particle morphology by FE-SEM. The Photoluminescence properties were investigated under ultraviolet (UV) and vacuum ultraviolet (VUV) radiations respectively. Prepared phosphors were found to have the best luminous performance with respect to intensity and color purity under 254 nm and 147 nm wavelength radiations.

1. Introduction

A plasma display panel (PDP) is the modern and distinguish technique to fabricate and developed a large screen, flat panel display, high definition television (HDTV) and mercury free lamps. Presently PDPs considerably attract attention of researcher towards developments of next generation display devices, because it provides a full viewing angle, large screen, less energy utilization, stable and enhance performance [1–3]. In development of PDP based devices phosphor play an important role, phosphors in the PDPs are mainly excited by vacuum-ultraviolet (VUV) radiation lines of Xe atoms at 147 nm and Xe^2 molecular line at 172 nm wavelength. The display picture quality of a PDP device depends mainly on the RGB phosphors. Moreover the maintaining essential conditions in PDPs are another restricting factor in using phosphors. Therefore the development of the new, low cost RGB phosphors with high thermal stability, high luminance performance becomes extremely important. In most of PDPs devices well known and conventional phosphors, such as Y_2O_3:Eu and (Y,Gd)BO_3:Eu for red, $BaMgAl_{10}O_{17}$:Eu for blue and Zn_2SiO_4:Mn for green, which were already known as lamp, CTV phosphors were used as PDP materials. However, quit consistence problems are associated with them, for example, Y_2O_3: Eu phosphor has less luminescence efficiency. (Y,Gd)BO_3:Eu has poor colour purity it generates orange-red emission instead of red [4]. Zn_2SiO_4: Mn is known to have a long decay time and a high discharging voltage [5]. $BaMgAl_{10}O_{17}$: Eu degrades fast [6], precipitation of Eu as $EuMgAl_{11}O_{19}$ in different phases violet stability of this compound. To improve luminescence efficiency charge transfer mechanism of rare earth activated ion in host compound was proposed [7]. Although several researchers groups reported one or many of these PDP phosphors but most of them used sophisticated synthesis techniques and costly chemicals leads to increase cost of PDP display devices, further conventional solid state diffusion or acid base titration synthesis required high temperature. Therefore in progressive research we developed a modified solution combustion technique for preparation of phosphors which has distinguish advantages over the other conventional methods which includes–

- An exothermic self propagative reaction to sustain itself and rapid prototype operating at low temperature.
- Require less sophisticated techniques, uses low cost chemical therefore it helps to reduce the cost of phosphor production; moreover it has high level of repeatability.
- Powder particles are non-agglomerates with narrow size particle distribution because of the decrease in reaction time (a few seconds during the combustion reaction).
- Small-sized grains, high-purity and densely spherical phosphors particle because precursors homogeneously mixed in liquid phases at atomic level.

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http://dx.doi.org/10.1016/j.optmat.2014.03.015
0925-3467/

- Due to non formation of inter- mediate phases of compounds remove the repeated cycles of heating and cooling followed after crushing the material.
- Nano size particles of phosphors can be obtained with ease at relatively low temperature.

In present study solution combustion technique was employed to prepare the phosphors $(Y,Gd)Al_3(BO_3)_4:Eu^{3+}$ (Red), $Na_3La_2(BO_3)_3:Tb^{3+}$ (Green), Nano-size $BaMgAl_{10}O_{16}:Eu^{2+}$ (Blue). We predict that with use of excess boric acid evaporating losses during combustion can be compensate while good crystallinity and regular morphology phosphor particles are obtain which produce better and improved photoluminescence properties for color rendering under UV, VUV excitation, these results are favorable to employed them for display applications.

2. Experimental techniques

2.1. Combustion synthesis of phosphors

The samples were prepared by a novel solution combustion technique, the various steps involve in the preparation were systematically describe in flowchart in Fig. 1. Some of our paper were reported by this methods [8–11]. The starting ingredients $Y(NO_3)_3$, $Eu(NO_3)_3$, $Tb(NO_3)_3$, $Gd(NO_3)_3$ and $La(NO_3)_3$ (IRE Ltd.), $NaNO_3$, $Al(NO_3)_3$,$Ba(NO_3)_2$,$Mg(NO_3)_2$,H_3BO_3, NH_4NO_3 & $NH_2–CO–NH_2$ (S D Fine AR) were used. The stoichiometric amounts of the ingredients required were calculated from multiplier of coefficient in balanced chemical reaction listed in Table 1. Ingredients were thoroughly mixed in an Agate Mortar, adding little amount of double distilled water an aqueous homogeneous solution obtained. The aqueous solution was then transferred into a china basin and introduced into preheated muffle furnace maintained at 550 °C. The solution boils, foams and ignites to burn with flame and obtained a voluminous, foamy powder. The entire combustion process was over in about 5 min following the combustion, the resulting fine powders were annealed in a slightly reducing atmosphere provided by burning charcoal at temperature 900 °C for about 2 h and suddenly cooled to room temperature.

2.2. Characterization of samples

The X-ray diffraction (XRD) pattern of prepared host samples were recorded on Rigaku MiniFlex diffractometer with Scan speed 2.00 deg./min. The morphology of the phosphor particles were studied by using Hitachi model S-4800 type-2 field emission scanning electron microscope**.** Ultraviolet Photoluminescence (UV PL) and PLE measurements at room temperature were performed on a Hitachi F-7000 spectrofluorometer equipped with a 450 W Xenon lamp in the range 200–600 nm, with spectral slit width of 2.5 nm. VUV PL spectra were measured by FLS-920T fluorescence spectrophotometer with a VM-504-type vacuum monochromator using a deuterium lamp as the lighting source. The excitation spectrum can be corrected by sodium salicylate, whose quantum efficiency is almost constant in this region. All the measurements were performed at room temperature. The emission spectrums were recorded under 147 nm excitation.

3. Result and discussion

3.1. $(Y,Gd)Al_3(BO_3)_4:Eu^{3+}$

Fig. 2 shows the powder XRD patterns of host lattice $(Y,Gd)Al_3(BO_3)_4$ calcinated at 900 °C for 90 min is match with ICDD Card No. 00-052-0232 corresponds to the formation of pure-phase of $YAl_3(BO_3)_4$ indicating Gd^{3+} doped ion takes complete site of Y^{3+} this may due to comparable ionic radii of Y^{3+} and Gd^{3+} .Host materials shows rhombohedral structure with space group symmetry R32(155) with unit cell parameter of $a = b = 9.295$ A^0, $c = 7.243$ A^0 and interfacial angles $\alpha = \beta = 90°$ and $\gamma = 120°$ and allowed non-centrosymmetry. Solution combustion process can achieve the in depth mixing of reactants on the atomic level, leading to an

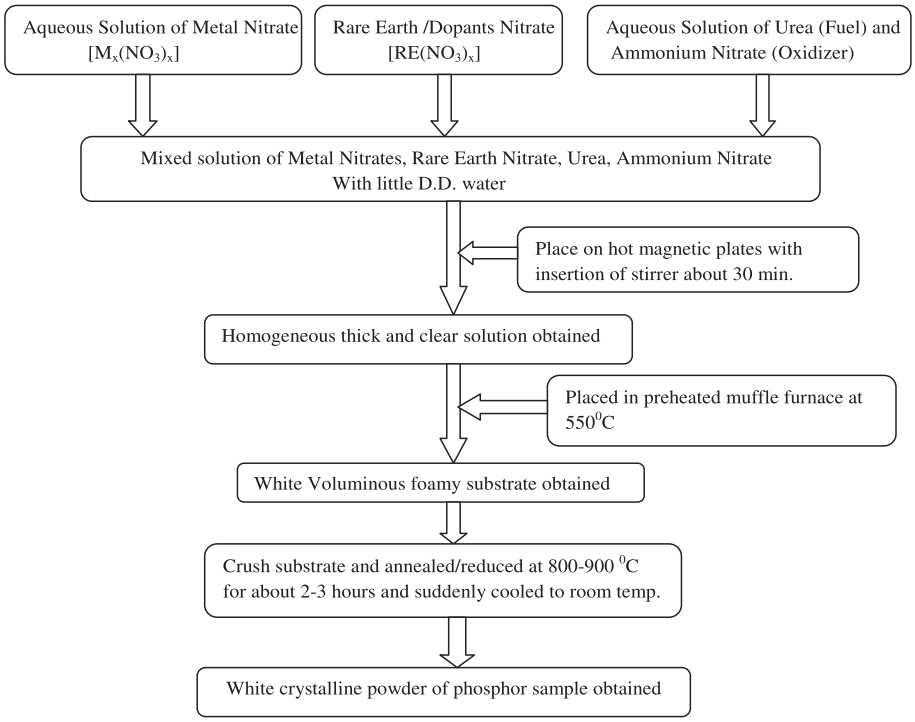

Fig. 1. Flow chart of Step wise solution combustion synthesis of phosphors.