AUTO COMBUSTION SYNTHESIS AND PHOTOLUMINESCENCE OF MN^{2+} DOPED ZINC SILICATE NANO-PHOSPHORS

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Abstract

Micro and Nano-crystalline powder samples of Mn^{2+} activated Zinc silicates $Zn(2-x)SiO_4:xMn^{2+}$ have been prepared by one step simple route of solution combustion technique, the synthesis of phosphors material is based up on the exothermic reaction between the fuel (urea) and oxidizer (ammonium nitrate), the heat generated in reaction is utilize for self propagation and sustainable combustion of ingredients, the phase form and structure of obtained silicates material are confirm by powder XRD pattern. The photoluminescence (PL) properties of prepared phosphor $Zn_2SiO_4:Mn^{2+}$ are studied under UV/VUV excitation, and found best luminous performance around 550 nm with respect to intensity and color purity. The results obtained suggest that phosphor could useful for plasma display panel (PDPs) and w-LEDs.

Keywords: Combustion synthesis, Silicates, photoluminescence, PDPs phosphors.

1. Introduction

$Zn_2SiO_4:Mn^{2+}$(willemite) green phosphor has been studied extensively as one of traditional and widely applied inorganic phosphors [1-3]. Nano-scaled $Zn_2SiO_4:Mn^{2+}$ has a wide range of applications. This phosphors offer a potential for advancing the display device technology in the area of photonic applications [4-6], such as plasma display panels (PDPs), field emission displays (FEDs) and backlight of liquid crystal displays(LCDs), Electroluminescence (EL),cathode ray tubes (CRT), fluorescent lamps, solid state lasers etc., however, the existing surface state and large amount of grain boundaries in the $Zn_2SiO_4:Mn^{2+}$nanophosphors, which may have a chance to generate some novel aspects. There search of photoluminescence (PL) properties in the $Zn_2SiO_4:Mn^{2+}$nano-phosphors are significant in understanding the physical properties and practical applications of nano-phosphors. Keeping these facts in mind, we optimize this composition for its improved PL properties under VUV radiation as nanophosphors with different particle sizes, prepared by solution Combustion synthesis.

2. Experimental

2.1 Combustion synthesis of $Zn_2SiO_4:Mn^{2+}$

Phosphors are prepared by the simple route of solution combustion technique [7-12]; the stoichiometric amounts of ingredients required for synthesis were calculated on the basis of coefficients as an multipliers of molar ratio in balanced chemical reaction. All the ingredients were thoroughly mixed by adding little amount of double distilled water, which then transferred in to a china basin and placed in preheated muffle furnace maintained at 600°C, the solution boils, froths and ignites to burn with golden flame and obtained a voluminous foamy substrate, the entire combustion process was complete within 5 minutes, after combustion the foamy substrate crushed and grinded to obtain fine powder which then annealed at 900°C and reduced in the environment of activated burning charcoal for about 3 hours and suddenly cooled to room temperature.

Solution combustion synthesis used following chemical reaction

$$(2\text{-}x)\ Zn(NO_3)_2 + x\ MnCl_2.H_2O + 1SiO_2 + 3\ NH_2CONH_2 + 4\ NH_4NO_3$$

$$\underline{550^0C}\ (\textbf{reduced}) \rightarrow Zn_2SiO_4:Mn^{2+} + \text{Gaseous products } (H_2O\uparrow, NH_3\uparrow \text{ and } NO_2\uparrow$$

2.2 XRD Analysis and Particle morphology

The XRD pattern of host materials are compared with standard files for confirmation of structure and found to be well match with ICDD Card No.01-078-5357 shown in Fig.1, while Fig.2 presents SEM images, the average pore size of the particles is about 500nm to 1μm. The regular and defined particle morphology leads to an excellent luminescence.

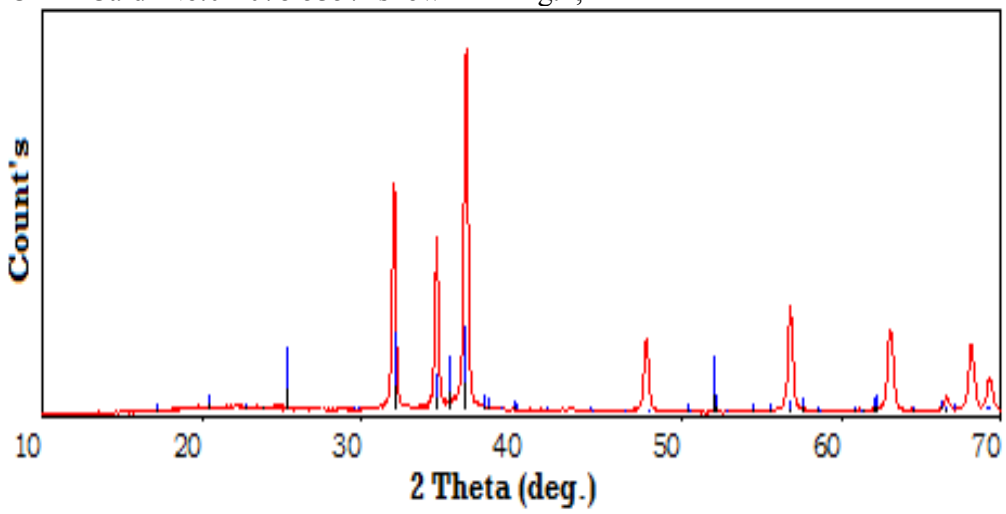

Fig.1 XRD pattern of host Zn_2SiO_4 (ICDD Card no.01-078-5357)

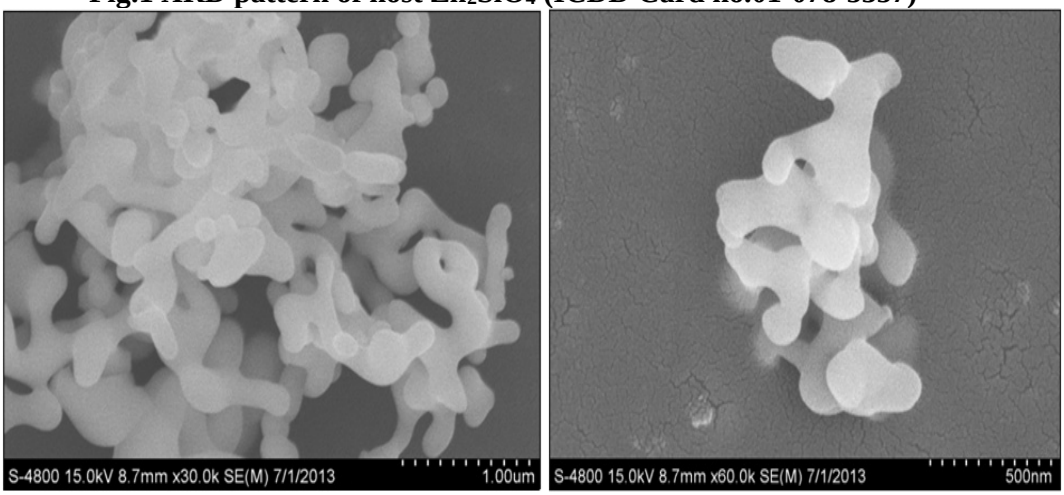

Fig. 2. Micro and Nano-size micrograph of $Zn_2SiO_4:Mn^{2+}$

3. Photoluminescence Study

In Fig.3 shows the emission spectra of optimized composition of $Zn_{1.94}\ SiO_{4:0.06}\ Mn^{2+}$ nano- phosphors with the obtained particle sizes under UV/VUV excitation. The broad band emission at about 550nm, which attributed to the $^4T_1$-$^6A_1$ transition of Mn^{2+} ions at 254 nm excitation and is identical for $Zn_2SiO_4:Mn^{2+}$ reported different methods of preparation for different sizes of particle samples. Under 147 nm VUV excitation Zn_2SiO_4:Mn phosphor shows a broad band emission peaking at 550 nm shown in Fig.4. The life time for emission of Mn^{2+} in Zn_2SiO_4:Mn is quite significant (25ms), since the transition is spin-and parity-forbidden. Such a life time is too long for TV application but suitable for minimum flicker in displays.

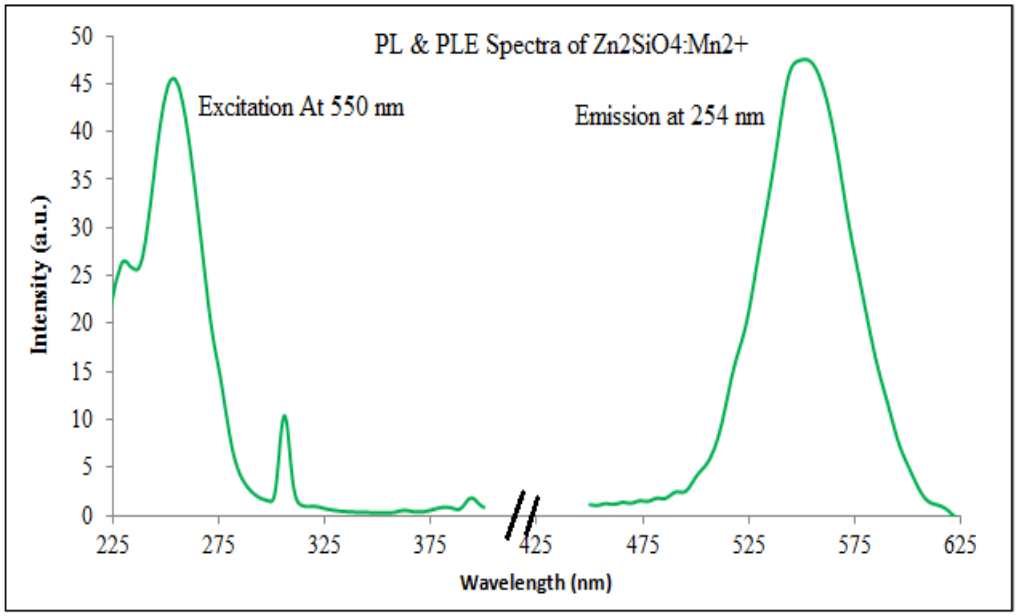

Fig.3 UV PL and PLE Spectra of $Zn_2SiO_4:Mn^{2+}$

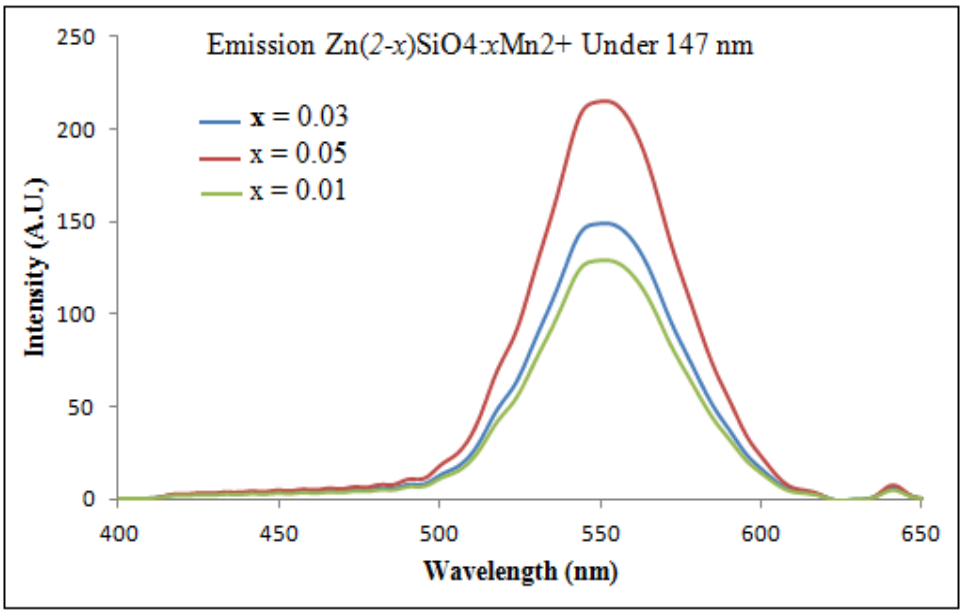

Fig.4. VUVPL Emission spectra of $Zn_2SiO_4:Mn^{2+}$ under147 nm

4. Conclusion

The simple route of solution combustion synthesis was successfully employed for the preparation of silicate host phosphors i.e $Zn_2SiO_4:Mn^{2+}$ the technique is simple, time saving and low cost. The photoluminescence properties of $Zn_2SiO_4:Mn^{2+}$ under UV254/VUV147 nm excitation shows deep green emission at 550 nm these results are in favors to develop and employ them for lightning and PDPs applications.

5. References

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