Synthesis and characterization of Y_2O_3:Eu nano phosphor powder by a new technique

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Abstract

In this paper, a new technique has been adopted for synthesis of nanophosphor particles of Y_2O_3:Eu at low temperature. The optical properties of the prepared nanophosphor particles have been measured and the results have been compared with the properties of its bulk phosphor particles. The particle sizes of Y_2O_3:Eu nanophosphor powder with doped-Eu concentration of 10wt% synthesized by our procedure is about 40nm. When the concentration of Eu was 10wt%, intensity of PL appeared the highest and 95% efficient as compared with bulk phosphor.

1. Introduction

Nanoparticles and nanocluster materials are a new class of advanced materials exhibiting unique chemical and physical properties compared to those of their bulk materials. In addition they have improved qualities with respect to their potential applications to various optical, electrical mechanical, magnetic and catalytic areas. Extensive research on semiconductor quantum dots has shown that nanocrystals doped with optically active luminescent centers may create new opportunities in the study and application of nano-scale materials.

Yttrium oxide doped with Eu^{3+}(Y_2O_3:Eu) is one of the main red-emission phosphor used in high efficiency cathode ray tube(CRT), field emission display(FED) and fluorescent lights[1][2].

Traditionally, yttria doped with Eu^{3+} is prepared mainly by solid-state reactions. In solid-state reactions, high reaction temperature (1400 ~ 1500 ℃), long heating time (several hours), and a milling process are required to obtain a pure phase of the multi-component particles. Therefore, producing agglomerated particles of irregular shape by solid-state reaction is unavoidable. Another disadvantage of the solid-state reaction method is the destruction of phosphor material during grinding and milling. The destruction results in the greatly decreasing of luminescence efficiency. To achieve high quality nanophosphor particles, various preparation routes have been adopted to reduce the reaction temperature, especially wet chemistry methods, such as sol-gel, co-precipitation, etc.[3]

In this paper, a new technique has been adopted for synthesis of nanophosphor particles of Y_2O_3:Eu at low temperature. This new synthesis method can produce nanophosphor particles with high luminescence efficiency by the simple process. The optical properties of the prepared nanophosphor particles have been measured and the results have been compared with the properties of its bulk phosphor particles. Various experimental conditions have been tested to optimize the optical properties of nanophosphor particles.

2. Experimental

Yttrium acetate hydrate $(CH_3CO_2)_3Y$(99.9%), europium acetate hydrate $(CH_3CO_2)_3Eu$(99.9%) and methanol(99.9%) were used as the starting ingredients. Diethylene glycol monoethyl ether (DGME) and diethylene glycol monoethyl ether acetate (DGMA) were used as passivation agent of precursor, where DGME and DGMA were mixed volume rate of 1:1.

The procedure used to prepare nano-sized Y_2O_3:Eu phosphor particles is as follows. At first, yttrium acetate hydrate $(CH_3CO_2)_3Y$ and europium acetate hydrate $(CH_3CO_2)_3Eu$ were respectively dissolved in methanol(99.9%) of the same amount.

Solution which mixed solutions dissolved perfectly in methanol and solution which mixed DGME and DGMA were pour into rotary evaporation system, and then the methanol solution, DGMA and DGME were

removed by drying in rotary evaporation at 60℃ temperature. As the resulting we obtained white powder precursor. The final product was isolated as a white powder after the heat treatment in a tube furnace at 500℃ for 1h in O_2 ambient condition.

3. Results

The prepared powder was characterized by X-ray diffraction analysis (XRD) using Cu Kα radiation (λ = 0.1505nm). The particle sizes of the samples were investigated by using BET analyzer and TEM micrographs. The photoluminescence (PL) properties were characterized at room temperature on FS900CDT spectrometer using a xenon lamp as excitation source. The wavelength range of the measurement was from 560 nm to 650 nm.

Fig.1 shows the x-ray diffraction patterns of Y_2O_3:Eu (Eu concentration = 8, 10, 15 wt%) made from the precursors respectively calcinated in O_2 ambient condition at 500℃ for 1h.

The diffraction peaks are in accord with powder data in JCPDS card No 37-1484. According to that the samples are cubic crystalline Y_2O_3:Eu without impurity. With increasing doped-Eu concentration from 8 to 15wt%, no new diffraction peak appears and the best intensity of main peak of XRD is indicated at doped-Eu concentration of 10wt%.

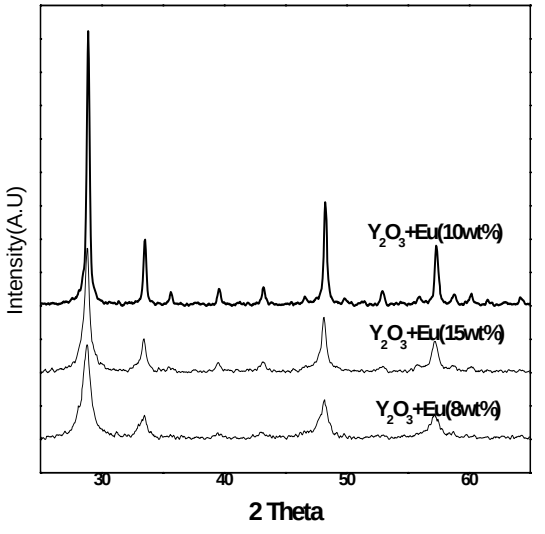


Fig.1. XRD patterns of Y_2O_3:Eu (Eu concentration = 8, 10, 15 wt%) calcinated in O_2 ambient condition at 500℃ for 1h.

A TEM micrograph for nano phosphor powder of Y_2O_3:Eu doped Eu of 10wt% is given in Fig. 2 showing lattice fringes and confirming the average grain size of 40nm.

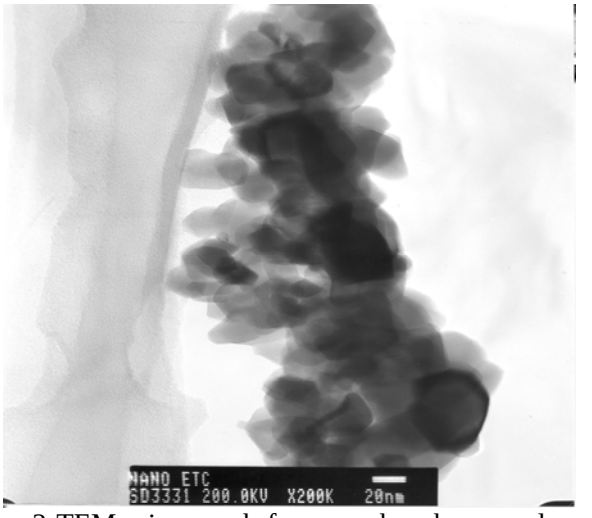


Fig. 2 TEM micrograph for nanophosphor powder of Y_2O_3:Eu doped Eu of 10wt%.

Fig. 3 shows the emission spectra of the nano phosphor Y_2O_3:Eu with doped-Eu concentration of 8wt%, 10wt%, and 15wt% after excitation at the wave length of 254 nm into the charge transfer state. The spectra are described by the well known $^5D_0$-^7F_j line emissions (J=0, 1, 2,…) of the Eu^{3+} ion with the strongest emission for J=2 at 611nm.[1]

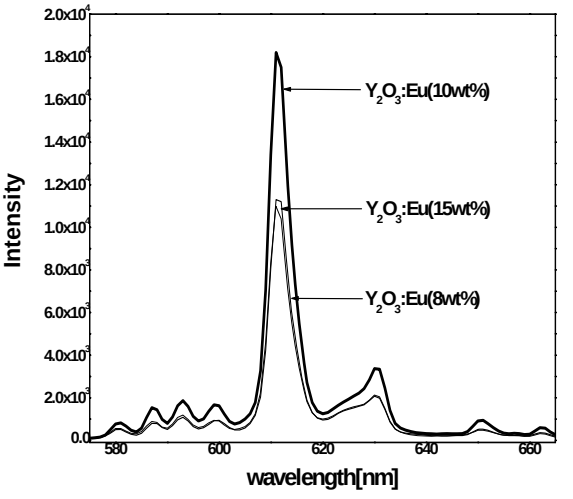
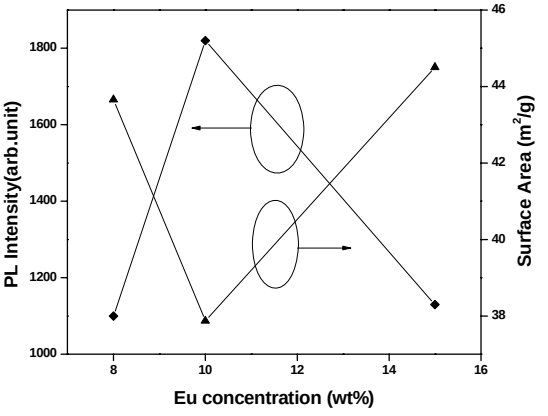


Fig. 3 The emission spectra of the nanophosphor Y_2O_3:Eu

No differences in line position are observed. Furthermore no emission of a mono clinic phase was detected in our sample. The strongest intensity of 611nm peak is indicated at Y_2O_3:Eu nanophosphor with doped-Eu concentration of 10wt%.

Fig. 4 shows the PL intensity and surface area of Y_2O_3:Eu nano powder for variation of Eu concentration. When the Eu concentration of 10wt% was doped, PL intensity appeared the strongest and the surface area appeared the smallest. So, we can regard that the increasing of PL intensity is due to increasing of particle size.



. Fig. 4. PL intensity and surface area of Y_2O_3:Eu nano powder for variation of Eu concentration

Fig.5 shows emission spectra of bulk and nanophosphor europium doped yttria. The emission spectra are taken with an excitation wavelength of 254 nm. The emission peak of nanophosphor used new synthesis method is located at the same position of their peak with the bulk phosphor. Integration over the emission spectra shows that the nanophosphor is 95% efficient as compared with the bulk phosphor[2].

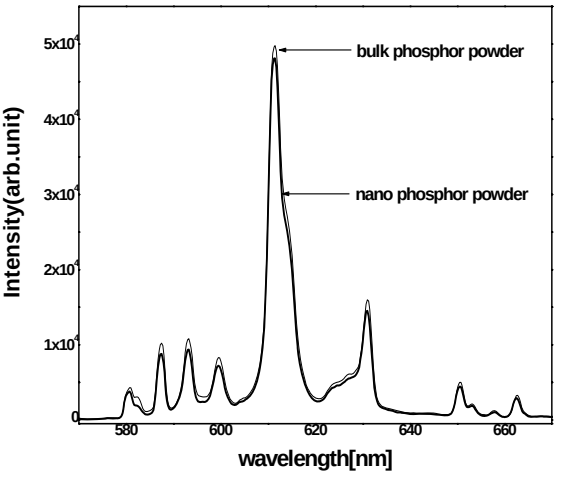


Fig.5 The emission spectra of bulk and nanophosphor europium doped yttria

4. Conclusion

We have synthesized nano powder phosphor of Y_2O_3:Eu with red emission by new technique with simple procedure. The particle sizes of Y_2O_3:Eu nanophosphor of doped-Eu concentration of 10wt% synthesized by our procedure is about 40nm. When the concentration of Eu was 10wt%, Intensity of PL appeared the highest and 95% efficient as compared with bulk phosphor.

5. References

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