Nano phosphors for PDP RGB and their PL characteristics

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Abstract

RF plasma and aerosol nano process were developed for a volume production of nanoscale phosphors. R, G, and B PDP phosphors were synthesized and the characteristics were optimized through the proprietary power treatments. PL intensities were confirmed to be enhanced up to 70% of that of present commercial phosphors.

1. Introduction

A cost-effective production process for display materials is a strong problem-solving approach for the current PDP and LCD as well. Sooner or later the ink jet printing will be adopted as a basic electronic printing technology. Accordingly the nanoscale precursor powders which are essential for the printable inks become more important in near future. The present study was focused on the nanoscale phosphor powders applicable to digital printable inks for display panels. The powder shape and size, size distribution, photo luminance and powder process are critical issues for the promising market of a new emerging display markets. Therefore the present study was focused on the development of optimized production process of nano phosphors having potential characteristics comparable with the commercial micron powders.

2. Experimental

The properties of currently commercial PDP phosphors of red(Y_2O_3, YBO_3), green(Zn_2SiO_4), and blue ($BaMgAl_{10}O_{17}$) were bench-marked for the development of nano phosphors in terms of powder size, shape, and PL intensity taking into account the process availability. Basically, (1) RF plasma process, and (2) aerosol combustion process were employed for the production of nano phosphors. In this study the technique of feeding the precursor was classified into two methods, i.e., solid precursor and liquid precursor. For the plasma process, (a) dry powder precursor→nano phosphor→doping an exciter in liquid was proved to be effective taking into account the obtained PL intensity and powder shape. (b) Feeding either suspension or solution precursor→nano phosphor→heat treatment showed a non-homogeneous nano powders which resulted in an inferior PL intensity to the commercial one even after an elaborated heat treatment. (c) Feeding solution precursor for the aerosol process was found to be very effective in terms of shape and size distribution of the nano powers synthesized. However, production yield must be improved for a commercial chance.

3. Results and discussion

3-1. Nano phosphors synthesized via RF Plasma process

Fig 1(a) shows nano green phosphors of Zn_2SiO_4:Mn made by feeding dry precursors. In general 12 at.% Mn was doped for appropriate properties and heat treated at 1200 ℃ for 1 hr with hydrogen environment. Considering only the PL intensity the synthesized nano phosphors exhibited an inferior brightness to the commercial micron powders as shown in Fig 1(b). However, the decay time of emission was found to be shortened very much by the effect of nano process.

Fig. 1(c) indicates the shortened decay time of nano phosphor which is generally found from every synthesized green, blue and red nano phosphors in this study. This shortened decay time was more prominent when appropriate Li was doped as shown in Fig 2(a) and (b). By doping Li

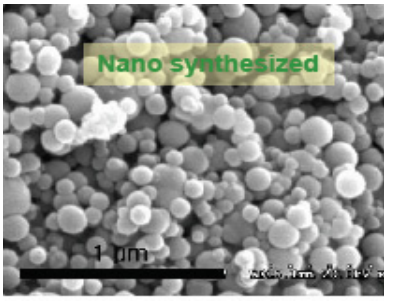

Fig.1(a) Nano green phosphor of Zn_2SiO_4 processed by RF plasma

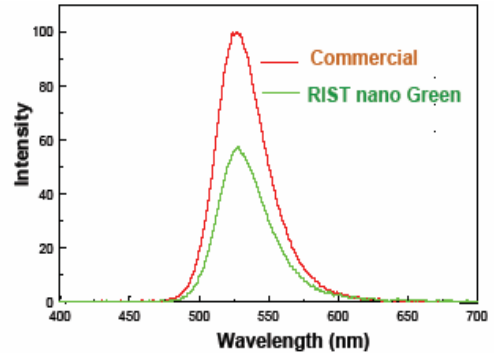

Fig.1(b) Comparison of PL intensity measured at 147 nm emission spectra

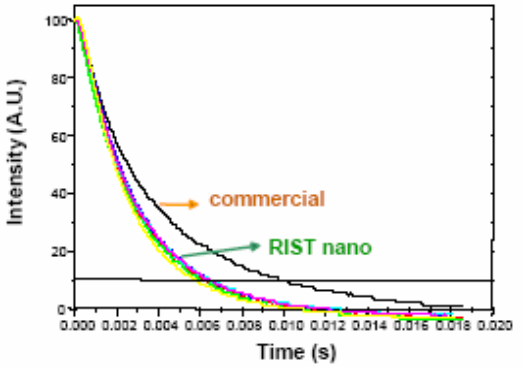

Fig.1(c) Shortened decay time by the effect of nano process

appropriately PL intensity of green phosphor was enhanced more than 16% of that of commercial green as shown in Fig2(a). Also the decay time shows a consistent enhancement compared with any other commercial phosphors as shown in Fig. 2(b).

Nano blue phosphor of $BaMgAl_{10}O_{17}$:Eu was synthesized by feeding the dry precursor. And then appropriate heat treatment was carried out. The PL intensity of every nano phosphors after synthesis showed inferior properties to optimized

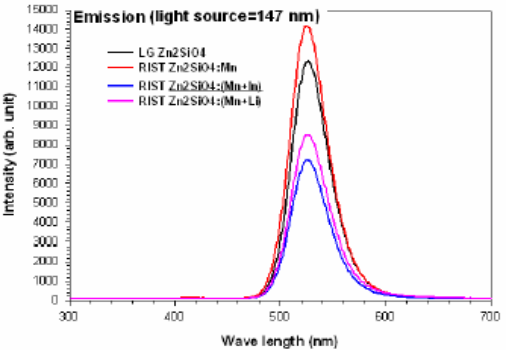

Fig.2(a) The effect of Li doping on the PL intensity compared with the commercial phosphor

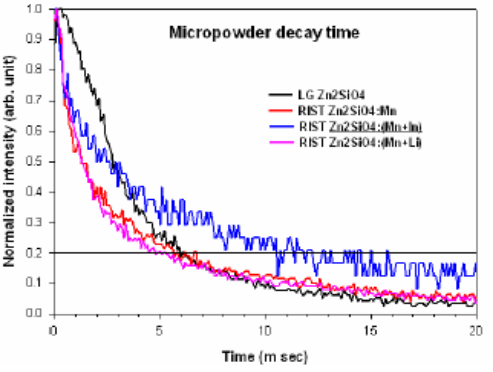

Fig.2(b) Prominently shortened decay time by appropriate doping of Li

phosphors which were heat treated elaborately. Fig. 3 indicates the effect of heat treatment on the typical BAM blue nano phosphors which shows an enhanced PL intensity by varying the duration at 1400 ℃ in H_2 environment. Optimized treatment resulted in almost 70% of PL intensity of commercial BAM blue.

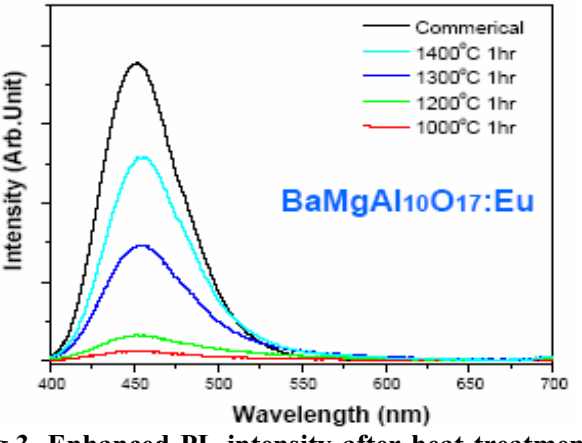

Fig.3. Enhanced PL intensity after heat treatment of the typical nano BAM

The inferior properties of both the nano green and blue phosphors were found to be enhanced approximately 60~70 % by controlled doping of Li and Eu, respectively.

RF plasma process was also employed in producing red nano phosphors of Y_2O_3;Eu and (YGd)BO_3:Eu. However, the doping process of exciter Eu was pursued in various approaches. Most promising technology was that host materials are nano processed first and then dipped into Eu-nitrated solution which is followed by an optimized heat treatment. Fig. 4(a) shows the typical Y_2O_3;Eu nano red phosphor synthesized by feeding the dry precursor and then dipped into Eu $(NO_3)_3$ solution followed by the heat treatment at 900 ℃ for 2~3 hr. This process enabled the host material to dope Eu up to 6.4 at. % where the highest PL intensity is shown in the figure.

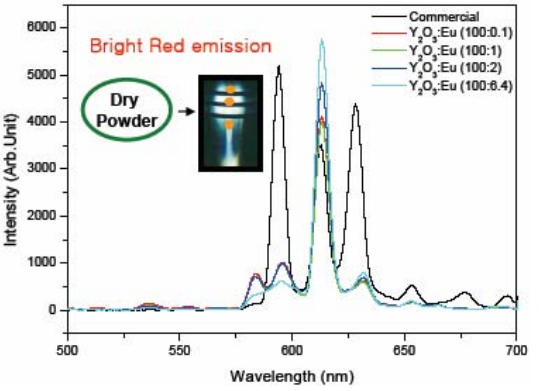

Fig. 4(a). Nano red phosphor of Y_2O_3:Eu processed by feeding the dry precursor

Processing the dry precursor into nano phosphors followed by an appropriate heat treatment is the promising route of RF plasma synthesis. Only the problem of inferior properties must be solved by developing a certain type of cycle of heat treatment, and optimized doping of exciter. In general, the shape and size distribution of nano powders synthesized by dry precursor show an excellent condition as shown in Fig. 4(b).

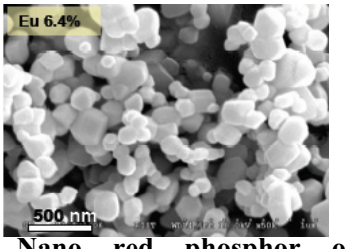

Fig. 4(b) Nano red phosphor of Y_2O_3:Eu synthesized by dry process

3-2. Nano phosphors synthesized by feeding liquid precursors

Two approaches are possible in producing nano phosphors by feeding liquid precursor. One is feeding the precursor of suspension composing micron host material with the salt containing exciter. The other is mixing the solution of both the salts of host and exciter. Fig. 5(a) shows the PL intensity obtained form nano red of Y_2O_3:Eu by feeding the suspension precursor into RF plasma reactor. The host was micron sized Y_2O_3 powder and the exciter was Eu$(NO_3)_3$. Plasma power was optimized for an appropriate parameter. The figure suggests that an enhanced PL intensity

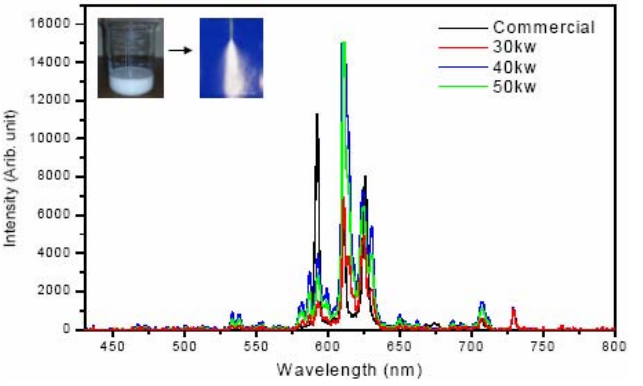

Fig. 5(a). Pl intensity of nano red phosphor of Y_2O_3:Eu process by suspension precursor via RF plasma

could be obtained by controlling the plasma power. Probably the higher the power the better the PL intensity could be obtained. Besides the PL intensity of red phosphor again was proved to be enhanced very much by doping Li appropriately as shown in Fig. 5(b) where excellent PL intensity is achieved by adding Li about 5 at.%. By that treatment the PL intensity shows the better quality compared with commercial red of Y_2O_3:Eu when only the intensity is concerned. The powder shape and size distribution were also good enough compared with those of powders processed via dry process. Fig. 5(c) shows the powder shape made via suspension process.

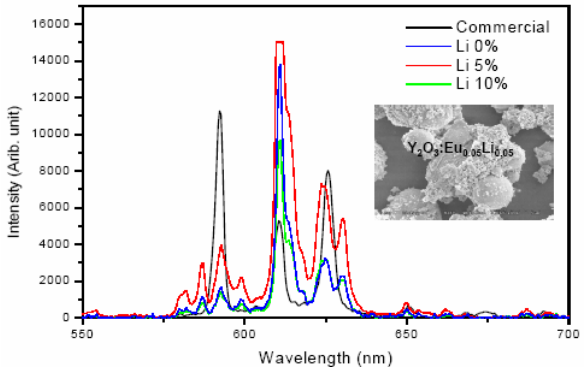

Fig. 5(b). PL intensity of nano red of Y_2O_3: Eu processed by suspension process. Li was varied for an enhanced PL

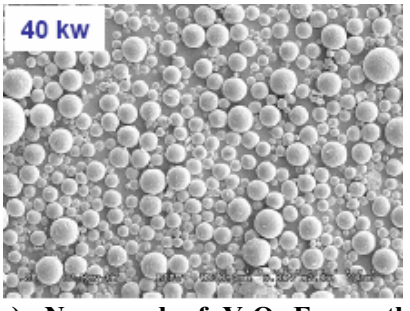

Fig. 5(c). Nano red of Y_2O_3:Eu synthesized by suspension precursor

Finally, nano red phosphor of Y_2O_3:Eu processed by feeding solution precursor has been developed via aerosol nano synthesis. The precursor of $Y(NO_3)_3$ and $Eu(NO_3)_3$ were mixed and then fed into proprietary aerosol combustion nozzle as shown in the figure. Fig. 6 shows the PL intensity obtained from the nano red synthesized by feeding the solution precursor.

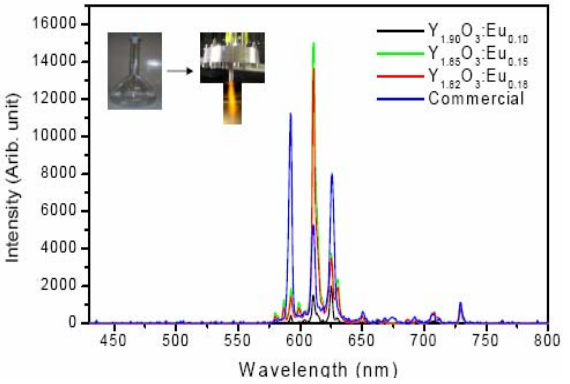

Fig. 6. PL intensity of nano Y_2O_3:Eu by varying Eu via aerosol nano process

The average powder size was proved to be 20 nm, and size distribution was uniform. The best PL intensity was obtained from the phosphor of Y_2O_3:$Eu_{0.15}$ which is a little bit higher comparing with those of green or blue phosphors made by RF plasma process.

The processed nano red particles were found to coarsen a little bit when the addition of Eu or Li is over a certain amount. However, the growth was negligible. Fig. 7 shows the effect of Li addition into host Y_2O_3. The optimized addition

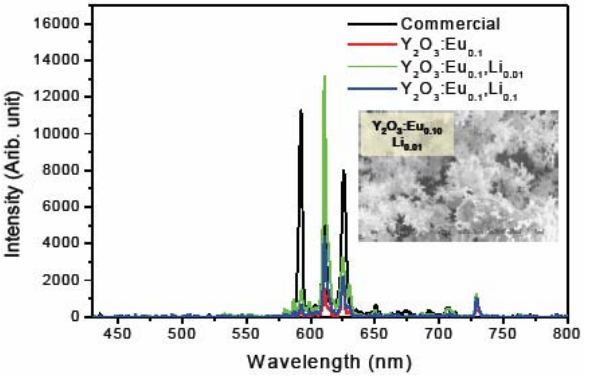

Fig.7. The effect of Li addition on enhancement of PL intensity via aerosol process

of Li was found to be almost identical comparing with those of dry processed phosphors. Probably, by this synthesis of solution precursor a delicate control of host and exciter elements might be possible which is also suggested by the fine size of synthesized phosphor particles as shown in the figure.

4. Summary

As far as the properties are concerned nano process of phosphor powders via solution precursor is promising if the production yield is improved for the commercial production.

5. Reference

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Acknowledgements

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