Phosphors development for LED and PDP Applications

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Abstract
The recent development of InGaN-based white light emitting diodes (LEDs) has expanded their potential applications in areas such as white electric home appliances, backlight for mobile phone or notebook PC, and indoor lightings. In this lecture, recent researches related to the phosphors for LEDs applications and their luminescent properties were reviewed. PDPs are considered as the most potential flat panel displays with a large-screen size. Phosphors in PDPs directly affect the brightness and lifetime. So, many researchers have tried to improve the luminescence characteristics of the phosphors especially under vacuum ultraviolet (VUV) excitation. We overviewed recent research trends and conclusive achievements for the PDP phosphors.

Introduction

Light emitting dioide (LED) is a semiconductor converting the electric signal to ultraviolet or visible light. Since reporting GaN blue-light emitting diode by Nichia Chemical Industries, high brightness light-emitting diodes (LEDs) have much attention due to their great potential in the field of information display devices because combining the blue LED with red and green LED generates full colors close to natural one[1]. In addtion, the fabrication of white LEDs with high brightness will lead a renovation in the indoor and the outdoor light sytem because they have low power consumption, long lifetime, fast response time, and small in size compared with the convetional light-emtting devices.

The performance of the LEDs using blue or near-UV LED for obtaining a white color strongly depends on the converson efficiency of phosphors. Obviously, the primary requisition for a phosphor to convert the radition from a LED into visible light is the ability to efficiently absorb the wavelength. So, many researchers have focused on the development and designing of LED phosphors with high exctitation efficiency at near-UV light. Figure 1 shows a schematic diagram showing the structure of LED which uses a UV-LED chip and RGB phophors to produce white color and the emittion spectra.

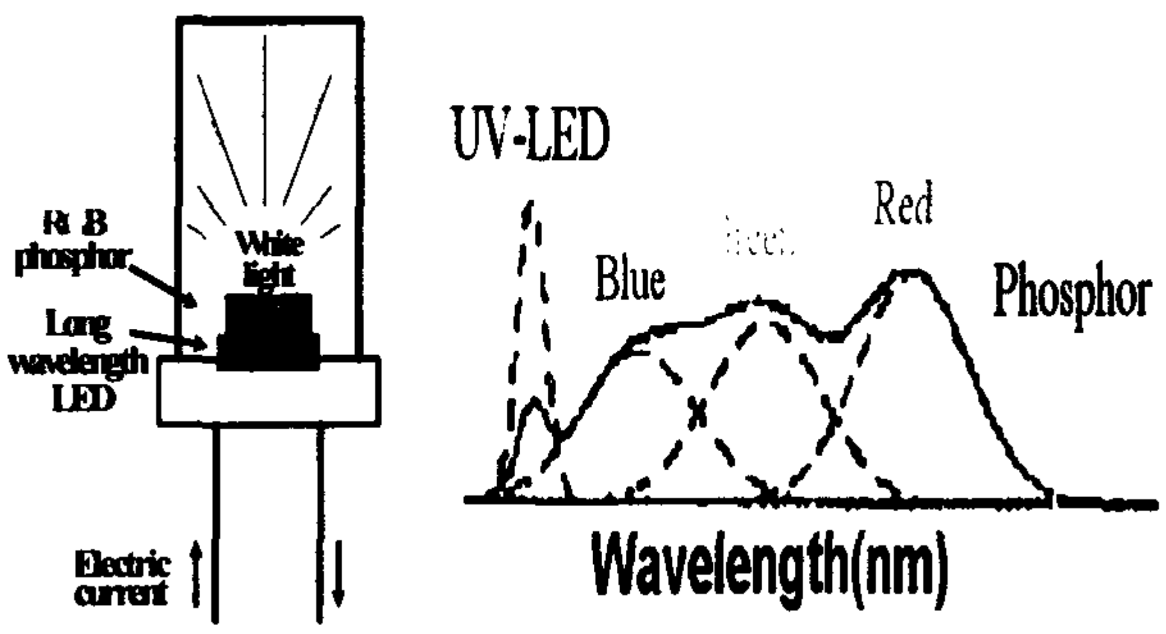

Figure 1 LED structure and emission spectra

Now, most potential application of LEDs is the key-pad of mobile phone, the signal lamp, and the back light of the car. If the brightness of white LEDs is improved gradually, they will be used as the TFT-LCD backlight and replace all fluorescence lamps for in and outdoor light.

Plasma display panels (PDPs) are a representative flat panel display (FPD) with large screen and lightweight.[2] In PDPs, vacuum ultraviolet light (VUV) emitting from the discharge of gas mixture of Ne with Ar or Xe is converted into visible light by phosphors. Thus, PDP phosphors should absorb VUV light, effectively. The parameters affecting the luminescence property of phosphors are phase purity, crystallinity, homogeneous distribution of activator ions, morphology, particle size, etc. Now, the PDPs have a requisition for higher resolution, higher brightness, lower power consumption, longer lifetime, and larger screen size. Phosphors are directly connected to the lifetime, brightness, and resolution of PDPs. Accordingly, the development of high luminescence efficient phosphor materials is of importance in optimizing the plasma display panel (PDP). Also, the morphology of phosphor materials greatly affects the PDP performance. It has been reported that the spherical morphology has many advantages in the fabrication of PDP with high brightness and resolution. Until now, the screen printing technique has been used to make phosphor layer within the barrier rib, which has a long stripe shape. In order to improve the performance of PDP, many researchers are changing its barrier structure. For example, the segmented electrode in delta color arrayed rectangular subpixel (SDR) structure is known to be more effective in achieving good PDP performance. However, the screen printing technique is not effective for making a good phosphor layer within the barrier rib of the SDR structure. To form a good phosphor layer within each separated cell of the SDR structure, the dot printing technique is more effective than the screen printing one. The spherical morphology is essential to the preparation of a good phosphor layer within the barrier rib of the SDR structure by the dot printing technique. Therefore, the attention of many researchers has devoted to making phosphor particles with a spherical shape.

The representative PDP phosphors are $(Y,Gd)BO_3:Eu^{3+}$ (red), $Zn_2SiO_4:Mn^{2+}$ (green), and $BaMgAl_{10}O_{17}:Eu^{2+}$ (blue). These phosphor materials, however, still have several problems such as color purity (red), high discharging voltage (green), long decay time (green) and low brightness (blue). Particularly, the PDP fabrication process is known to accompany the thermal degradation of blue phosphor. These weaknesses should be improved for the PDP to give competitiveness in FPD world market.

The luminous and morphological properties of PDP phosphors are affected by the preparation technique. The solid-state reaction technique is well established and by which most of commercial PDP phosphors have been prepared. Given that spherical-shaped and fine-sized phosphors are essentially needed to produce the next-generation PDPs satisfying the end user, a new preparation process by which the morphology and luminescence property of phosphors are easily tailed should be explored. At this point of view, spray pyrolysis is considered as a promising technique for the preparation of spherical-shaped high luminous phosphor particles. Figure 2 shows SEM photos and emission spectra of RGB phosphors prepared by spray pyrolysis. The particles have high photoluminescence intensity under VUV excitation and a spherical shape as well as fine size of less than 2 μm.

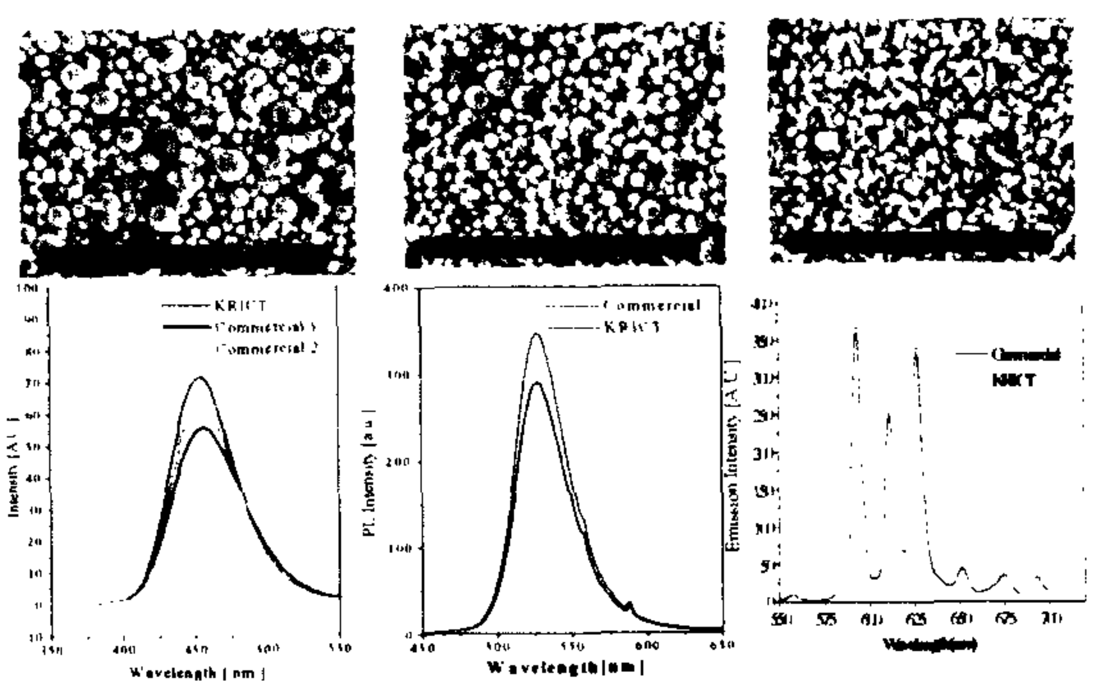

Figure 2. SEM photos (up) and emission spectra (down) under VUV excitation for RGB phosphors prepared by spray pyrolysis.

References

[1] Mueller-Mach et al., IEEE J. Selected Topics in Quantum Electronics, 8 (2002) 339.

[2] Kim et al., J. Alloys and Comp. 311 (2000) 33.