

Coating Process and Mechanism of PDP Phosphor with Composite Alumina and Silica Oxide

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Abstract: A coating on PDP phosphor by a thin and homogeneous layer of nano-scale colloidal Al_2O_3 and SiO_2 using the sol-gel method was investigated and the mechanism was studied. ICP-AES, SEM, FT-IR and powder XRD were employed to characterize the coating.

Key words: PDP phosphor; coating; mechanism

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As well known, the PDP (plasma display panel) phosphors are excited under a high energetic VUV radiation^[1,2], and the luminescence intensity are always degraded due to the long-term high energy radiating and the bombing from heavy particles, which may always deteriorate the properties of phosphor material. In addition, there are a lot of defects in the particle surface of phosphor materials. Unfortunately, the luminescent efficiency of luminescence materials is sensitive to the defects. Coating process on the surface of particles of phosphor is a very useful and effective technique in amending the appearance structure, decreasing the surface defects, modifying the surface structure, and resisting the bombing from heavy particles.

At present, there are several coating materials which have been used for covering the surface of phosphor powder, including inorganic compound, such as SiO_2 , Al_2O_3 , TiO_2 , ZnO_2 , and organic polymers, such as polystyrene, etc^[3,4]. In this paper, coating process of the oxide composite of Al_2O_3 and SiO_2 on the surface of the PDP green phosphor particles was studied. The coating of Al_2O_3 and SiO_2 on phosphor powders is characterized by Scanning Electric Microscopy (SEM), Induction Couple Plasma Atomic Emission Spectroscopy (ICP-AES) and X Ray Diffraction Spectroscopy (XRDS). The chemical bonds between the coating species and the surface of phosphor particles were characterized by the diffuse-reflectance Fourier

Transform Infra-Red (FT-IR). The properties of the coated phosphor were tested.

1 Experimental

9.6572 g $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ (AR) was dispersed in a 40 mL distilled water and stirred till dissolved. 1.5 g polyvinyl alcohol (PVA) was dispersed in 40 mL distilled water at 80 °C and stirred till dissolved completely, and then transferred into AlCl_3 solution prepared above. The pH was adjusted to 3.5 by $\text{NH}_3 \cdot \text{H}_2\text{O}$ with stirring throughout the whole process in order to avoid producing precipitation and the emulsion of AlCl_3 was prepared. 1.0 mL $\text{C}_5\text{H}_8\text{O}_2$ was dispersed into the emulsion of AlCl_3 above. Then 0.4 mL H_2O_2 was added into the emulsion of AlCl_3 , and stirred at the constant temperature of 50~60 °C for 2 h. And a nano-scale colloidal alumina solution was prepared by sol-gel process.

10 g PDP phosphors was dispersed in the nano-scale colloidal alumina solution prepared above, and stirred for 0.5 h. Then, 15 mL 0.1 mol/L Na_2SiO_3 solution was added, with continuous stirring for 0.5 h. Adjust the pH to 7-8 using hydrochloric acid (HCl) and stir for 2 h. The powders were separated via centrifugation at a rotational speed of 2000 r/min for 15 min. Then, the powders were washed with distilled water for several times till neutrality and dried at 80 °C for 5 h, followed by calcining at 450 °C. A thin,

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homogeneous and amorphous coating layer of Al_2O_3 and SiO_2 were made onto the phosphor particle surface.

2 Results and Discussion

2.1 Analytical results ICP-AES

In the coating process, Al^{3+} and SiO_3^{2+} were adsorbed onto the surface of the particles of phosphor powder which is very important. After the powders was dipped and separated, the Al^{3+} and SiO_3^{2+} concentration in the solution were determined by ICP-AES and colorimetry for the aqua solution of uncoated and coated. The Al^{3+} concentration decreased from 0.03912 to 0.01224 mol/L; the SiO_3^{2+} concentration decreased from 0.06873 to 0.02151 mol/L. The concentration of Al^{3+} and SiO_3^{2+} greatly decreased, respectively; no doubt which indicated that Al^{3+} and SiO_3^{2+} deposited onto the surface of phosphor powders.

2.2 Coating characteristics by XRD, FT-IR, and SEM

The typical diffraction curves are in Fig.1. The XRD patterns indicated that there are not any changes about the host phase of the coated phosphor, which still are hexagonal crystal structure. But the diffraction peaks of Al_2O_3 and SiO_2 are not observed, which indicated that Al_2O_3 and SiO_2 might only exist on the surface of the phosphor without any separate second phase. No crystalline states were detected in the composite oxide of coating of Al_2O_3 and SiO_2 , which means that Al_2O_3 and SiO_2 all exist in the form of amorphism.

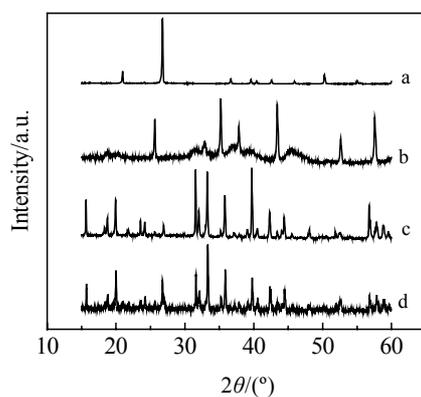


Fig.1 XRD patterns: (a) SiO_2 , (b) Al_2O_3 , (c) uncoated phosphor, and (d) coated phosphors

From the FT-IR spectra in Fig.2, the peaks of uncoated phosphors at 720, 700, 995 and 600 cm^{-1} , were observed, and it belong to Ba-O, Sr-O, Al-O, and Mn-O respectively, which evidenced the suspending chemical bonds mentioned above. But in Fig.2b, no peaks mentioned above are observed, or some peaks obviously decreased in the coated phosphors, which indicated that

the surface of the phosphors were covered and the suspending metal-oxygen chemical bonds were eliminated. The absorbance at about 1115 cm^{-1} is the result of Si-O bond and Al-O bond mixed with together.

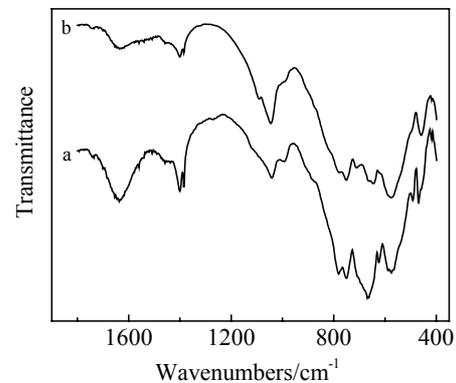


Fig.2 FT-IR spectra for the uncoated(a) and coated(b) phosphor powders

Fig.3 shows the SEM micrograph of phosphor particles uncoated and coated with Al_2O_3 and SiO_2 . The dispersal of phosphor powders coated was obviously improved. The surface of the coated phosphor particles became smoother than that of uncoated. It can be seen that there is a thin, continuous and homogeneous coating layer on the surface of the phosphor particles. The results are consistent with that of XRD of the phosphor particles coated with Al_2O_3 and SiO_2 .

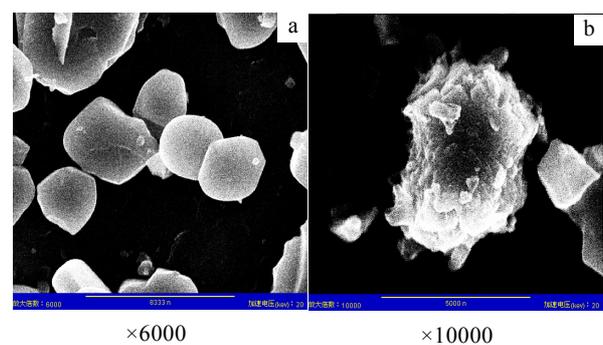
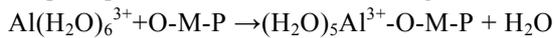


Fig.3 SEM images of the uncoated(a) and coated(b) phosphor powders

2.3 Coating mechanism of Al_2O_3 and SiO_2

The results given above reveal that there are M-O chemical bonds suspended on the surface of the phosphor particles. The oxygen ions have a very high intensity of electronics, while the charge of Al^{3+} is high and iron radius is small, which makes the ability close to electrons. The combination is formed very easily between oxygen ions with high density of charge and

Al^{3+} , and the process maybe take place on the surface of the phosphor particles surface as following:



Wherein M are Ba, Mn, Sr, Mg and Al. P represents phosphor particle, and O-M-P represents metal-oxygen chemical bonds suspended on the surface of phosphor particle. $\text{Al}(\text{H}_2\text{O})_6^{3+}$ presents the existing form of Al^{3+} in aqua solution. In fact, from the equation, there is a substitute reaction between P-M-O and complex $\text{Al}(\text{H}_2\text{O})_6^{3+}$ can be inferred.

After Al^{3+} adsorbing onto the surface of particles, the phosphor powder is positively charged. Thus, by drawing the support from the electric statistic force, the SiO_3^{2-} can be adsorbed onto the surface of phosphor in which a positively charged with Al^{3+} . After the negative charged SiO_3^{2-} ions were adsorbed onto the surface of the particles by electrostatic forces, the expected chemical precipitation reaction happened as following: $2\text{Al}^{3+} + 3\text{SiO}_3^{2-} + 6\text{H}_2\text{O} \rightarrow 2\text{Al}(\text{OH})_3\downarrow + 3\text{H}_2\text{SiO}_3\downarrow$. Thus a thin, homogeneous and amorphous coating layer of Al_2O_3 and SiO_2 were formed by controlling pH value in the range of 7~8, in which the dissolution of ions from phosphor powders is not significant in the neutral solution. And in the meantime, the pH value of 7~8 is consistent with that of the dispersion for the phosphor powders in the needed solution.

3 Conclusions

$\text{BaMgSrAl}_{10}\text{O}_{17}$: Mn green PDP phosphor powders can be homogeneously coated with a thin layer of composite oxide Al_2O_3 and SiO_2 using sol-gel techniques. Hydro-alumina ions were first chemically adsorbed onto the surface of the phosphor powders by chemical substitute reaction. Then the SiO_3^{2-} ions were adsorbed onto the surface of the particles of phosphor positively charged with Al^{3+} by the electrostatic forces. The chemical precipitation reaction happened through controlling pH value in the range of 7~8. Thus a thin, homogeneous and amorphous coating layer of Al_2O_3 and SiO_2 were formed on the surface of the particles of the phosphor powders. SEM, ICP-AES and XRD show the coating of Al_2O_3 and SiO_2 on phosphor powders. The chemical bonds between the coating species and the surface of phosphor particles were characterized by FT-IR.

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PDP 荧光粉表面包覆 Al_2O_3 - SiO_2 复合膜及机制研究

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摘要: 通过溶胶-凝胶法在 PDP 绿色荧光粉 $\text{BaMgSrAl}_{10}\text{O}_{17}$: Mn 的表面包覆纳米尺度的 Al_2O_3 - SiO_2 复合膜, 并对包覆机制进行了探讨。通过 ICP-AES、SEM、FT-IR 和 XRD 对包覆过程及包覆结果进行了表征。

关键词: PDP 荧光粉; 包覆; 机制

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