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The Effects of the Electron Reflecting Layer Screen-printed with the Lead Tungsten Oxides on the Shadow Mask in CRT

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ABSTRACT

To reduce the doming of the shadow mask due to thermal expansion and to prevent the color discrepancy, the electron reflecting layer with lead tungsten oxides on the electron gun side of shadow mask was formed by screen printing method and doming property was evaluated in CRT. First, the lead tungsten oxides were prepared by calcining the mixture of lead oxide and tungsten oxide above 600°C. Second, the paste which has the anti-doming composition including the lead tungsten oxides was coated by screen-printing method. As a result, the doming of the shadow mask was reduced about from 30 to 45%.

Key words*: *Doming, Mislanding, Shadow mask, Electron reflecting layer, Lead tungsten oxide, Screen-printing

1. Introduction

The shadow mask CRT to have a excellent color quality, response time, brightness and viewing angle is mainly applied to television set and computer monitor for many years. Improvement of the color quality and the construction such as styling and fashion has led to the fully developed product.[1-3]

Alongside of system improvement such as digital technology and HDTV, the massive growth in computer application and the rapid development in multi-media era in particular are going to help ensuring that the shadow mask CRT remains the main mass produced by means of display for a long time to come. For this, the more excellent qualities are required and the color purity is one of the required qualities. For the color purity, a special term called landing is being used. Landing is defined as the way in which the right electron spots strike the right phosphor.[4] The meaning of landing is closely related to the definition of color purity. In case in which the mislanding of electron beam occurred, the beam spot lands to one side of the right phosphor area or lands on the wrong phosphor area. These give rise to a lack of color or the wrong color, so the color purity comes to worse.

Almost everything in and around the color CRT can have influenced on color purity. The main affecting factors on color purity are the black matrix and phosphor coating, shadow mask, electron gun, deflection coil and manufacturing process. The shadow mask of the main factors has two functions that are separating the beams of UV light during the exposure process and separating the electron beams when CRT is in operation. Shadow mask heats up to around 80°C in 3 min after operation. This rise of temperature causes the shadow mask to expand and bulge. This bulging is called doming. Doming leads to displacement of the mask holes and the changes of landing called mislanding.

Heavy metal oxides like WO_3, Bi_2O_3, PbO have been generally used to reduce the doming of the shadow mask. It was reported that the several methods such as spray coating, thermal evaporation, screen printing are used to form the electron reflecting layer on the shadow mask with these heavy metal oxides as antidoming materials, and the screen-printing method was the best effective among these methodes.[5-10] But the researches for the new electron reflecting materials are still kept on trying.

In this paper lead tungsten oxides as new materials to shadow mask was studyed to overcome the former patents of other companies about doming and to reduce the doming property, and the effects of the electron reflecting layer with lead tungsten oxide on the shadow mask in CRT was reported.

2. Experimental Procedures

2.1. Preparation of the lead tungsten oxide

PbO(Practical, Junsei Chemical Co. Ltd., Japan) and WO_3(Industrial, Taegu Tec Ltd., Korea) powders sieved with 350 mesh were mechanically mixed by using ball mill. The mixture was calcined at 600°C for 1 h and was crushed into the smaller particles whose size is under 2 μm.

2.2. Preparation of paste for screen printing

The calcined powder, nitrocellulose as organic binder, glass frit as inorganic binder and buthylcarbitol as dispersive agent, and buthylcarbitolacetate as solvent were used

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to make paste for screen printing. These materials were placed in a round bottomed container and were mixed for 1 h. The mixture was kneaded by 3 roll mill for 3 h and was changed to paste.

2.3. Screen printing on the shadow mask

Paste with lead tungsten oxide was coated on the Aluminum Killed(AK) shadow mask by screen-printing method, and was dried at 80°C for 10 min. The shadow mask with electron reflecting layer was formed and was blackened. Then CRT with this shadow mask was prepared.

2.4. Characterization

X-ray powder diffraction (D/Max-C, Rigaku, Japan) was performed for identification of crystal phase on the calcined powder. Cu-K_α radiation was used and was monochromatised by a second graphite monochrometer. The rheology property of paste was measured by using B type rotary viscometer(DV-II+, Brookfield Eng. Labs. Inc., U. S. A) Scanning electron microscopy (JSM-6300, JEOL, Japan) was used to identify microstructure of the screen-printed layer on shadow mask. The mislanding of electron beam for doming property in CRT was measured by using universal tester(YAM22, MECC, Korea) and display analyzer (SEFT DA-T, SEFT Lab.,Japan).

Green emitting cathodoluminescence of CRT with printed shadow mask is measured by color spectroscope(CS-1000, Minolta Co. Ltd., Japan) to evaluate the degration of color purity owing to beam mislanding. The backscattered coefficients have been measured by Auger electron spectroscopy (Φ-670, Perkin-Elmer, U. S. A) at accelerating voltages of 3 kV, 7 kV, 10 kV, 20 kV and 30 kV. Primary beam current was 1 nA and the grid of secondary electron detector was 150 V, the tilted angle of sample was 0° in measuring backscattered coefficients. TMA(TMA7, Perkin-Elmer, U. S. A) was used to identify the property of thermal expansion for the shadow mask.

3. Results and Discussion

Fig. 1 shows the result of X-ray diffraction analysis for the calcined mixture with PbO and WO_3 at 600°C for 1 h. As a result, the crystal phases show the phase of $PbWO_4$ and Pb_2WO_5 in Fig. 1. From these results, it was thought new compound was prepared from the thermal and chemical reaction between PbO and WO_3 and composed of the mixture of $PbWO_4$ and Pb_2WO_5.

When electrons come out of the electron gun and impact on the shadow mask, the impacted electrons change to heat energy or occur electron reflection on the surface of shadow mask by the back scattering of the electron. The change to heat increases the surface temperature of the shadow mask. If the high reflection of the electron occurred, the change to the heat energy is reduced and the surface temperature of the shadow mask is reduced. Electron reflection depends on the atmoic number of the material. The electron reflection of

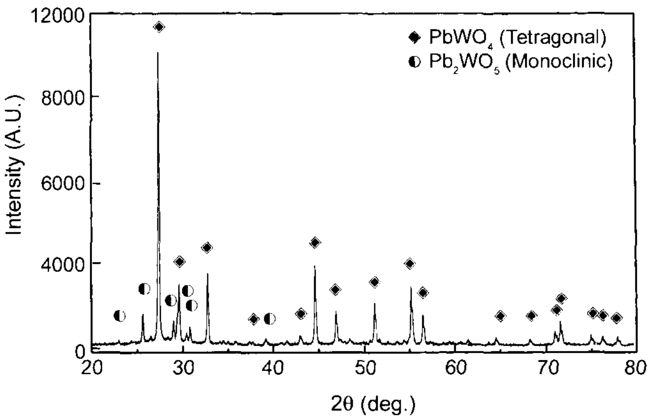


Fig. 1. XRD diffraction pattern of the lead tungsten oxides screen-printed on AK shadow mask.

the material increases if the material has elements with high atmoic number like Bi, W, Pb. Therefore the coating of the oxides with these elements have been applied to the shadow mask by spraying, screen-printing or eveporation.[4]

So far these compound like PbO, Bi_2O_3 and WO_3 was nearly reported to reduce doming in CRT.[6-10] So it is thought the meaning of these new materials like $PbWO_4$ and Pb_2WO_5 is great in forming electron reflecting layer on shadow mask.

These oxides like Bi_2O_3 or WO_3 are used formally as electron reflecting materials.[4] The density of Bi_2O_3 is 8.7 g/cm^3 and the density of WO_3 is 7.4 g/cm^3, but the densities of lead tungsten oxide like $PbWO_4$ and Pb_2WO_5 are 8.4 g/cm^3 and 8.1 g/cm^3 (JCPDS 19-0708, JCPDS 36-1495) and they are higher than that of WO_3. So it is thought that lead tungsten oxides are better than WO_3 in the electron reflection effects.

Fig. 2 shows the rheological behavior for the paste with lead tungsten oxides. Though the viscosity of the paste largely changes with the speed and time of spindle revolution from Fig. 2, the viscosity of paste with the lead tungsten oxide was higher than 50,000 cps. It is thought that the paste with the high viscosity is used to form the electron reflecting layer on shadow mask. The paste has high viscosity and low fluidity, so the screen-printed layer as electron reflecting layer on the electron gun side of the shadow mask

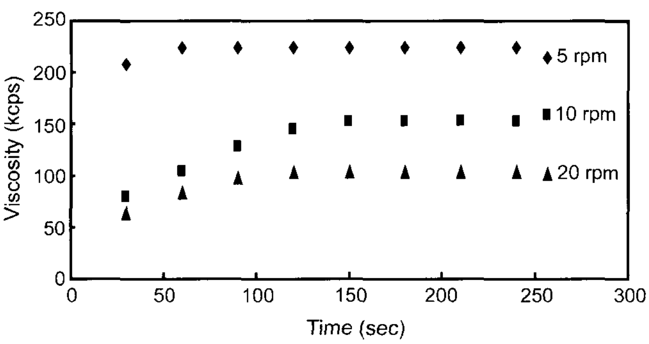
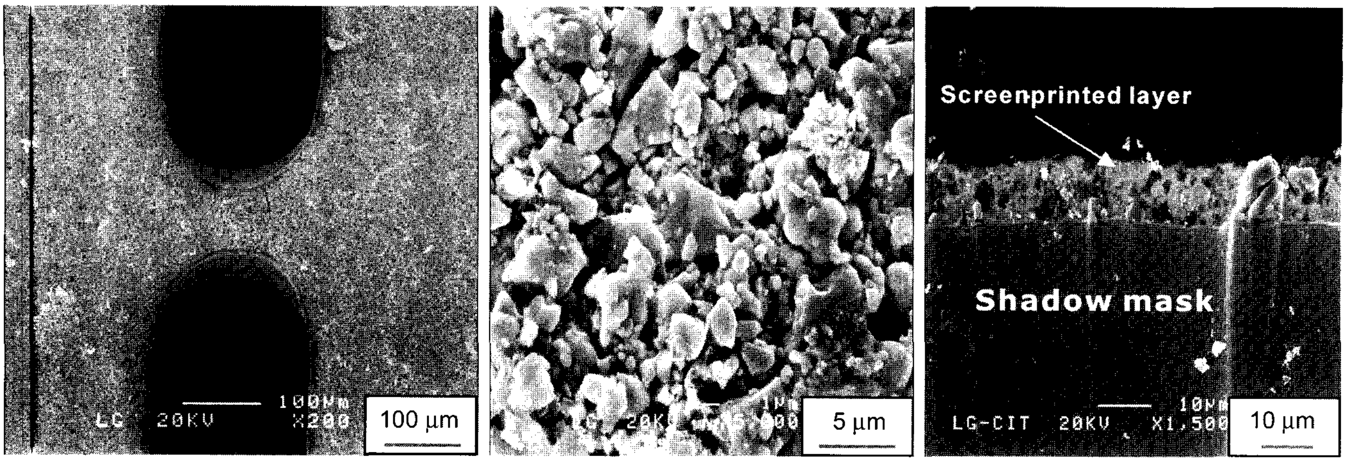


Fig. 2. Viscosity of paste with the lead tungsten oxides for the screen-printing on shadow mask.



(a) The screen-printed shadow mask (b) The surface of the screen-printed layer (c) The crossed section of the screen-printed layer

Fig. 3. SEM photographs of the screen-printed shadow mask.

has almost no deformation after screen-printing.

The microstructures of the printed layer with the lead tungsten oxides on shadow mask are shown in Fig. 3. The screen-printed layer has apparently good shape as shown in Fig 3. The screen-printed layer is microscopically composed of many sponge-like pores and aggregated particles. It has about 10 µm thickness which is much thicker than conventional sprayed Bi_2O_3 layer of 2~3 µm. So it is thought the printed layer has the thickness enough to have the electron reflecting effect in CRT.

Fig. 4 shows the back scattered coefficients of the incident electron to the screen-printed layer with the lead tungsten oxides on shadow mask.

The back scattered coefficients can be obtained by the following equation.

$$B\,C = \frac{I_b}{I_i}$$

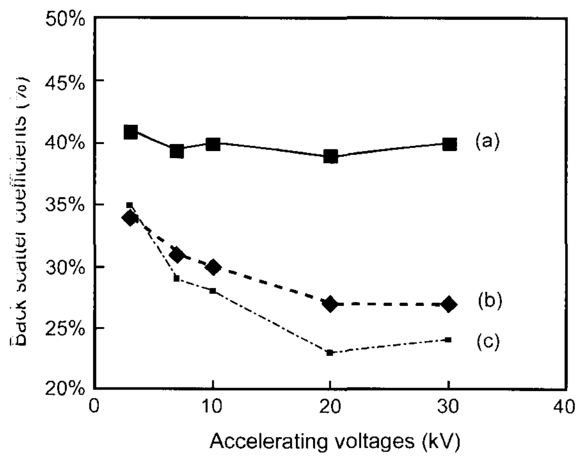


Fig. 4. The back scattered coefficient of electron for shadow mask; (a) as screen-printed with the lead tungsten oxides, (b) as blackened, and (c) as unblackened.

where B.C is the back scattered coefficient, I_i is the current of incident electron and I_b is the current detected by the back scattered electron through the grid of the secondary electron detector in vacuum chamber.

The back scattered coefficients of the printed shadow mask with the lead tungsten oxides show about 40% for the primary current and are more higher than those of the blackened shadow mask and show the much smaller variance in spite of increasing accelerating voltage of electron from 3 kV to 30 kV, but the blackened shadow masks which was made from the alumium killed steel show the decreasing tendencies in the back scattering of electrons, though the back scattered coefficients of the blackened shadow mask were higher than those of the unblackened shadow mask. These results are due to the electron reflecting on the printed layer with the lead tungsten oxides.

Fig. 5 shows the mislanding properties of CRT with the shadow mask screen-printed with the lead tungsten oxide paste. It was reported that the shadow mask heated up to around 80°C and the mislanding was rapidly increased to the maximum point within 3 min after operation and was slowly decreased due to the heating and thermal expansion

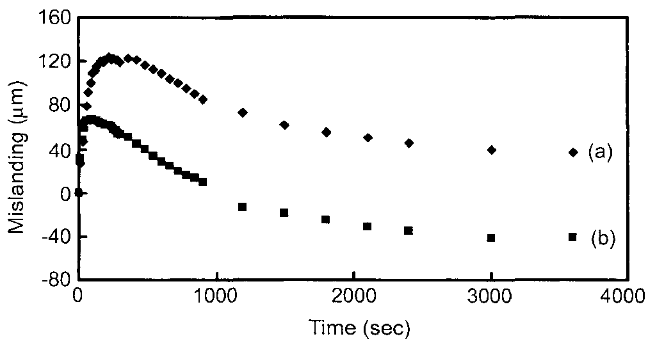


Fig. 5. The mislanding of electron beam in CRT with the screen-printed electron reflecting layer on shadow mask; (a) as blackened and (b) as screen-printed.

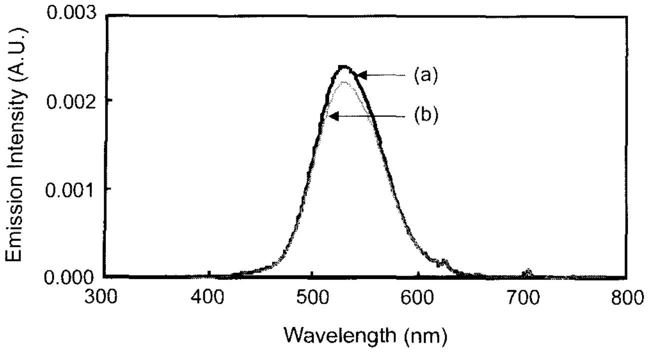


Fig. 6. Green emitted cathodoluminescence spectra of CRT with the lead tungsten oxide coated shadow mask; (a) as screen-printed and (b) as blackened.

of the materials to be in contact with shadow mask.[4,5]

The mislanding tendencies well corresponded with the previously reported resultes but the mislanding property of CRT with the screen-printed shadow mask was reduced about 45% in comparison with CRT which has the only blackened shadow mask from Fig. 5. It was thougtht that this result was epochal in making allowance for the previously reported conventional spray method which had 20~30% of reduction effect in mislanding.[6-8]

Fig. 6 is the results of the measurement for green emitted spectra by cathodoluminescence.

The emission intensity of cathodoluminescence measured from CRT which has the shadow mask screen-printed with paste made from the lead tungsten oxides was higher than that measured from CRT with the blackened shadow mask as shown in Fig. 6. Emission intensity means brightness of screen. Compared with CRT with the blackened shadow mask, the brightness of screen is improved as a result of the screen-printing on shadow mask.

By use of emission spectra of Fig. 6 and the color matching function, we calculate the color coordinate of CIE1931. As a result, the green color coordinate of CRT with the printed shadow mask shows x=0.282 and y=0.606, that of CRT with unprinted shadow mask shows x=0.285 and y=0.601. The color purity of x=0.282 and y=0.606 was better than that of x=0.285 and y=0.601. Therefore the brightness of screen and the color purity were improved by the screen-printing of the paste with the lead tungsten oxides on shadow mask.

Fig. 7 shows the property of thermal expansion for materials. The hights of measured samples were 3 mm. The thermal expansion coefficient of the baked paste with lead tungsten oxide at 450°C for 2 h, was similar to that of the blackened shadow mask as shown in Fig. 7. This means that it enable to minimize the misfit of thermal expansion between the shadow mask and the electron reflecting layer with lead tungsten oxide.

So the electron reflecting layer with the lead tungsten oxides has a good joining to shadow mask and the thermal peeling of the electron reflecting layer is not nearly occurred on shadow mask in CRT.

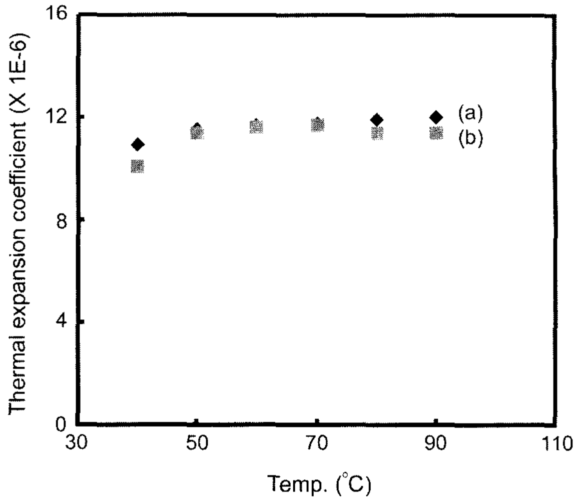


Fig. 7. Variation in the thermal expansion coefficient of the materials with temperature; (a) as blackened shadow mask and (b) as baked paste with the lead tungsten oxides.

Though the thermal deformation of length at the unprinted shadow mask is about 10 μm from 40°C to 80°C in CRT from Fig. 7, the mislanding of the electron beam due to doming was about 125 μm from Fig. 5. This means that doming is largely occurred due to the curvature of shadow mask.

It was reported that in case of the shadow mask with the electron reflection layer, the increase of temperature at shadow mask was reduced due to the electron reflecting effect and thermal deformation of shadow mask is reduced, so the mislanding of electron beam was reduced.[9,10]

4. Conclusions

On the purpose to reduce the doming property of CRT, the lead tungsten oxides as the new electron reflecting materials was prepared and was applied to the shadow mask with the electron reflecting layer by using the screen-sprinting method.

As a result, the following conclusion was reached.

The prepared lead tungsten oxides showed the crystal phases of $PbWO_4$ or Pb_2WO_5 which have the higher density than that of WO_3.

The electron reflecting layer of about 10 μm was screen-printed on shadow mask without clogging mask hole by using the paste which had the high viscosity above 50000 cps. This layer was shown the microstructure with many sponge-like pores and the aggregated particles and had the similar thermal expansion coefficient to the only blackened shadow mask. So the doming property of CRT with the the lead tungsten oxides screen-printed layer on shadow mask wad reduced about 45% owing to the back scattering of the electron in comparison with CRT which had the only blackened shadow mask.

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