

Effects of the Nanometer-sized Bismuth Oxide Coating on Shadow Mask

Sang-Mun Kim* and Nam-Je Koh

Abstract

Nanometer-sized bismuth oxide with a diameter of about 80 nm was used as a new electron reflection material in a 29" Real Flat CPT. This bismuth oxide was well dispersed over pH8 in slurry. Spray coating was performed clearly and uniformly and was ensured that there was no clogging of shadow mask hole. Coating thickness was expressed to the brightness of chromaticity for the sprayed layer and was also well controlled during the spraying process. Doming was improved by about 10 % in spite of the similar coating weight in comparison with the average 3.5 ㎛ of the conventional bismuth oxide.

Keywords : nanometer-size, bnismuth oxide, doming, AK shadow mask, CRT

1. Introduction

Although competition among display device manufactures in the display market is influenced by the appearance of the various display devices including FPDs, we can not deny that CRT is still the most predominant product in TV market in terms of price and screen performance. In order to maintain its position in the TV market, CRT has been transformed into the slim typed CRT with invar shadow mask or the low cost CRT with AK shadow mask and these kinds of CRTs are being produced and sold in the world market today.

When AK shadow mask is applied to CRT, one of the big problems that exist in terms of the quality is the purity drift which is called doming. Doming refers to the mislanding of the electron beam that occur according to the change of working time. In particular, when screens are formed as shown in Fig. 1 and especially in Fig. 1 (c), the purity drift in partially brightened area becomes more and more severe due to the concentration of electron beam on the localized area where AK shadow mask is used on the CRT. This influences the temperature distribution on shadow mask causing discolorizing on the screen. To solve this kind of doming problem, several methods such as design of the shadow mask architecture or the optimization of screen design or the coating of the anti-doming material as Bi_2O_3, WO_3, PbO to occur the reflection of the electron beam are being applied to CRT. Most CRT makers, except Samsung SDI, are using the spray coating method in which the screen-printing method is used for anti-doming coating [1-7].

Let us consider the spray coating of bismuth oxide. Bismuth oxide is sprayed to the designated thickness in accordance with the index time in the production line. If the index time is decreased in order to increase of productivity,

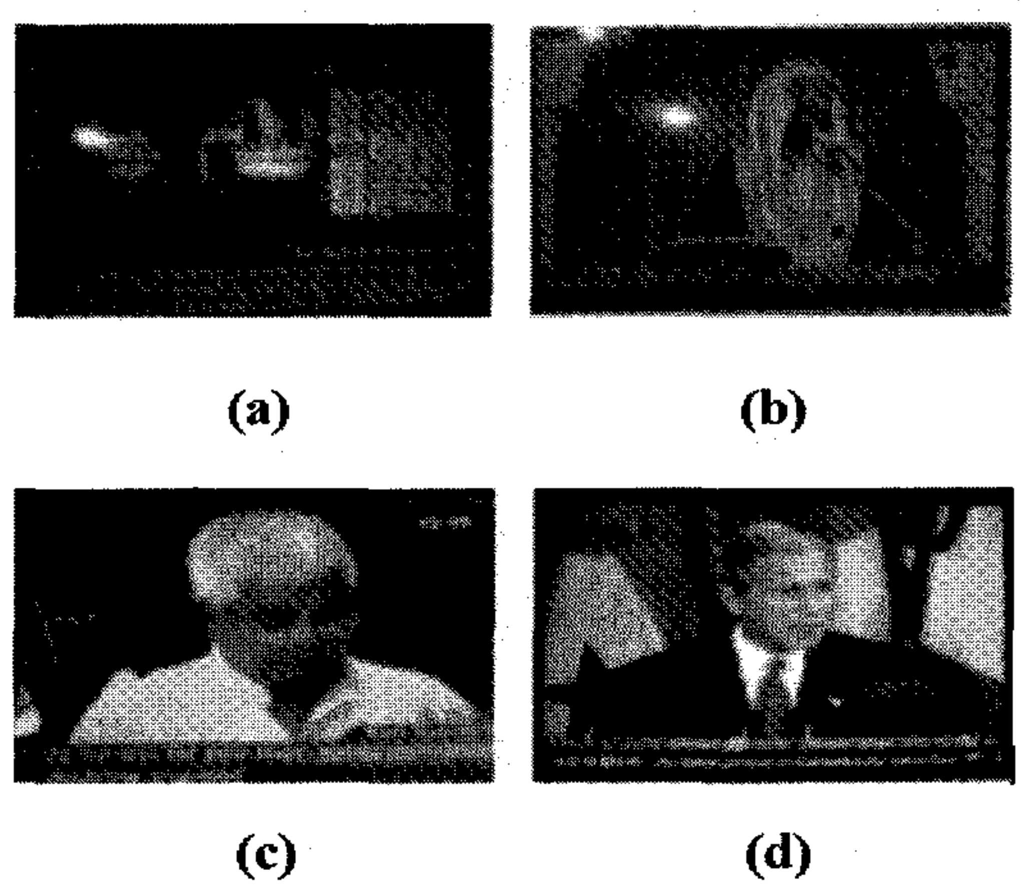

Fig. 1. Doming types to be requested for improvement of doming in CRT.
(a) Localized white state near edge side
(b) white bar state on both edge sides
(c) white state at inner portion in screen
(d) dark state at inner portion in screen

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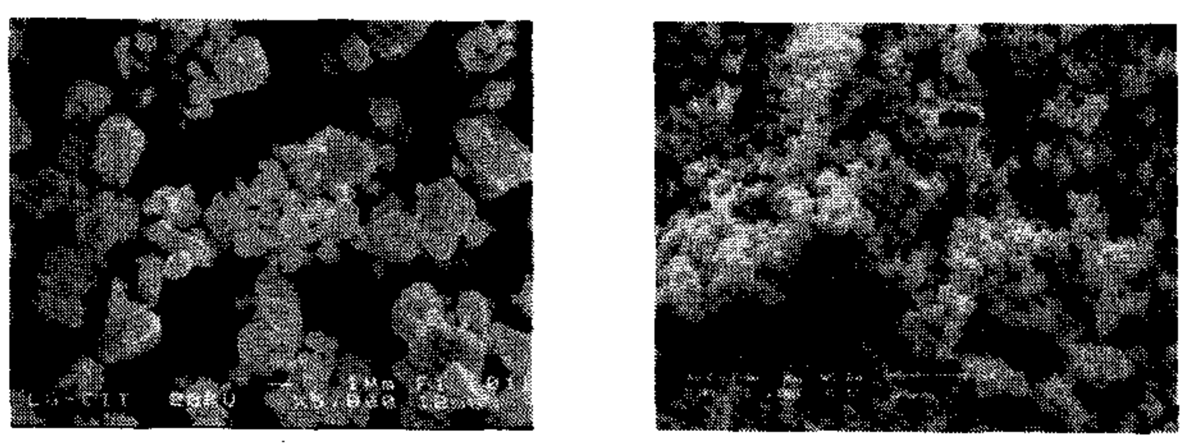
spray time is also decreased. As a result, the sprayed layer becomes thinner and is no longer more uniform, deteriorating the doming properties. Therefore, new methods to improve doming by spraying uniformly and thickly without the clogging of shadow mask hole in the given index time are needed. In this study, the nanometer-sized bismuth oxide was used to improve the spray uniformity and doming property.

2. Experiment

First, after an average of 3.5 μm of conventional bismuth oxide as shown in Fig. 2 (a) was dispersed in pure water, this bismuth oxide was grinded to the nanometer-sized bismuth oxide with a diameter of about 80 nm by the nano milling machine as shown in Fig. 2 (b). Potassium silicate ($K_2SiO_3nH_2O$) was used as the inorganic binder for slurry. Next, nanometer-sized bismuth oxide, potassium silicate and pure water were put into the vessel and mixed by ball milling machine for 2 hours. As a result, slurry with the nanometer-sized bismuth oxide was produced to the designated concentration of bismuth oxide.

The slurry was sprayed onto the inner surface of AK shadow mask to be welded on the inner side of the mask frame, hence producing CRT with the sprayed shadow mask was produced. Dispersion property for the nanometer-sized bismuth oxide was analyzed by using of the zeta potential meter (ELS-800, Otuska, Japan). Powder morphology was observed by scanning electron microscope (SEM, JSM-6360, JEOL, Japan). The degree of spray coating on shadow mask was observed by optical microscope (Optiphot-2, Nikon, Japan). The brightness of chromaticity for the coating layer as the expression of the relative coating thickness was measured by colorimeter (CM2002, Minolta, Japan) and was compared with the weight of the sprayed layer on shadow mask. Doming at window screen (hereinafter referred to as, "window doming") was measured by universal tester (MDU-7000, T&TS, Japan). The measuring condition is as follows. The emissive screen area had one forth of the effective screen size and was set at the center of CRT screen. The working condition was set at 450 μA and 30 kV. The window doming was measured at 30 mm off the center of the window screen edge in the screen center direction.



(a) Conventional Bi_2O_3 (b) Nano-sized Bi_2O_3

Fig. 2. SEM micrographs for bismuth oxides.

3. Results and discussion

Fig. 3 shows zeta potential of the bismuth oxide with variation of pH in water. Zeta potential was kept at the constant –60 mV and pH > 7. This result shows that the dispersion stability of the nanometer-sized bismuth oxide can be secured over pH = 7. Therefore after this, all of spray experiments were performed at pH = 10 as pH condition of slurry.

Spray coating thickness is very important in the process control. But it is very difficult to directly measure the sprayed coating thickness. Even though it may also be used to measure the coating weight in the meaning to control coating thickness, that is very troublesome in the course of production and is more and more uneasy in point of judging the coating uniformity. For these reasons, after we checked the coating weight and the chromaticity of the sprayed layer, we compared the coating weight with the brightness of the chromaticity to be measured for the layer. Chromaticity for product can be expressed to L.a.b color

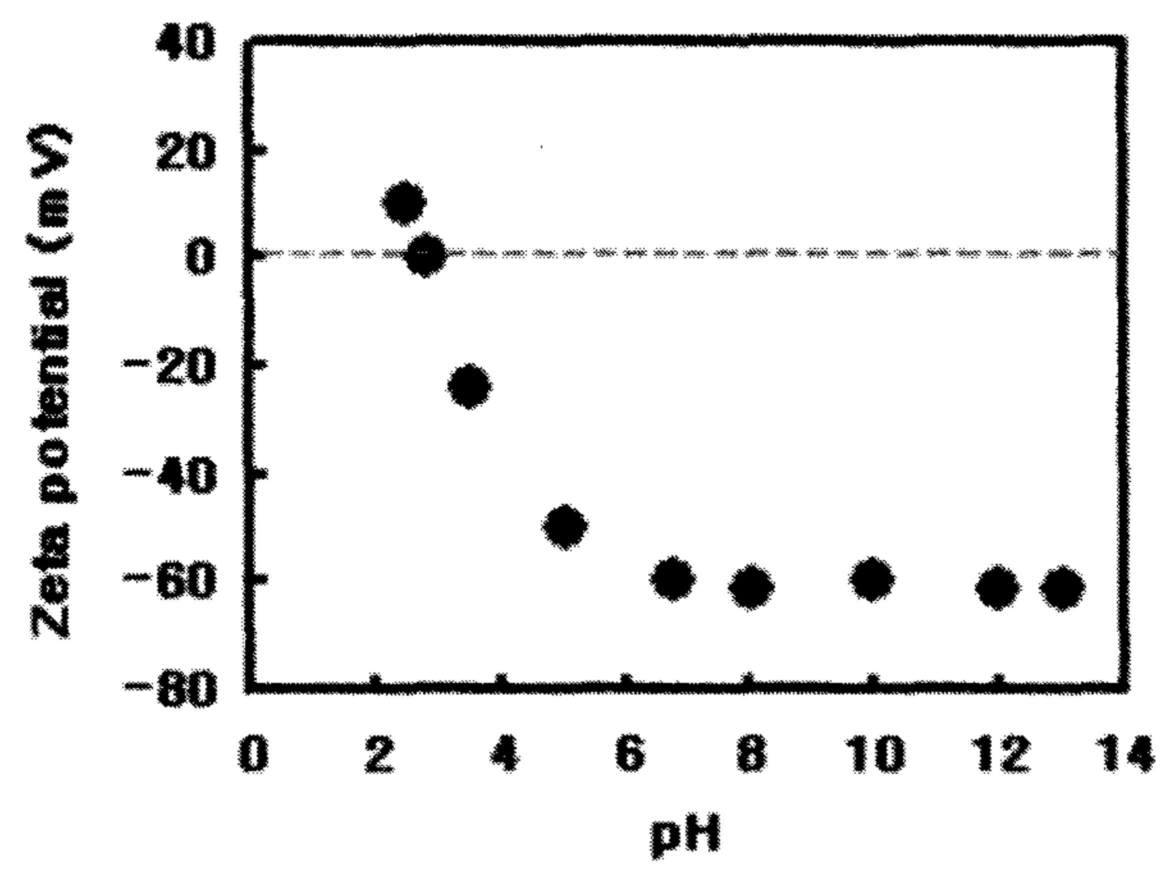


Fig. 3. Zeta potential for the nanometer-sized bismuth oxide in pure water with the variation of pH.

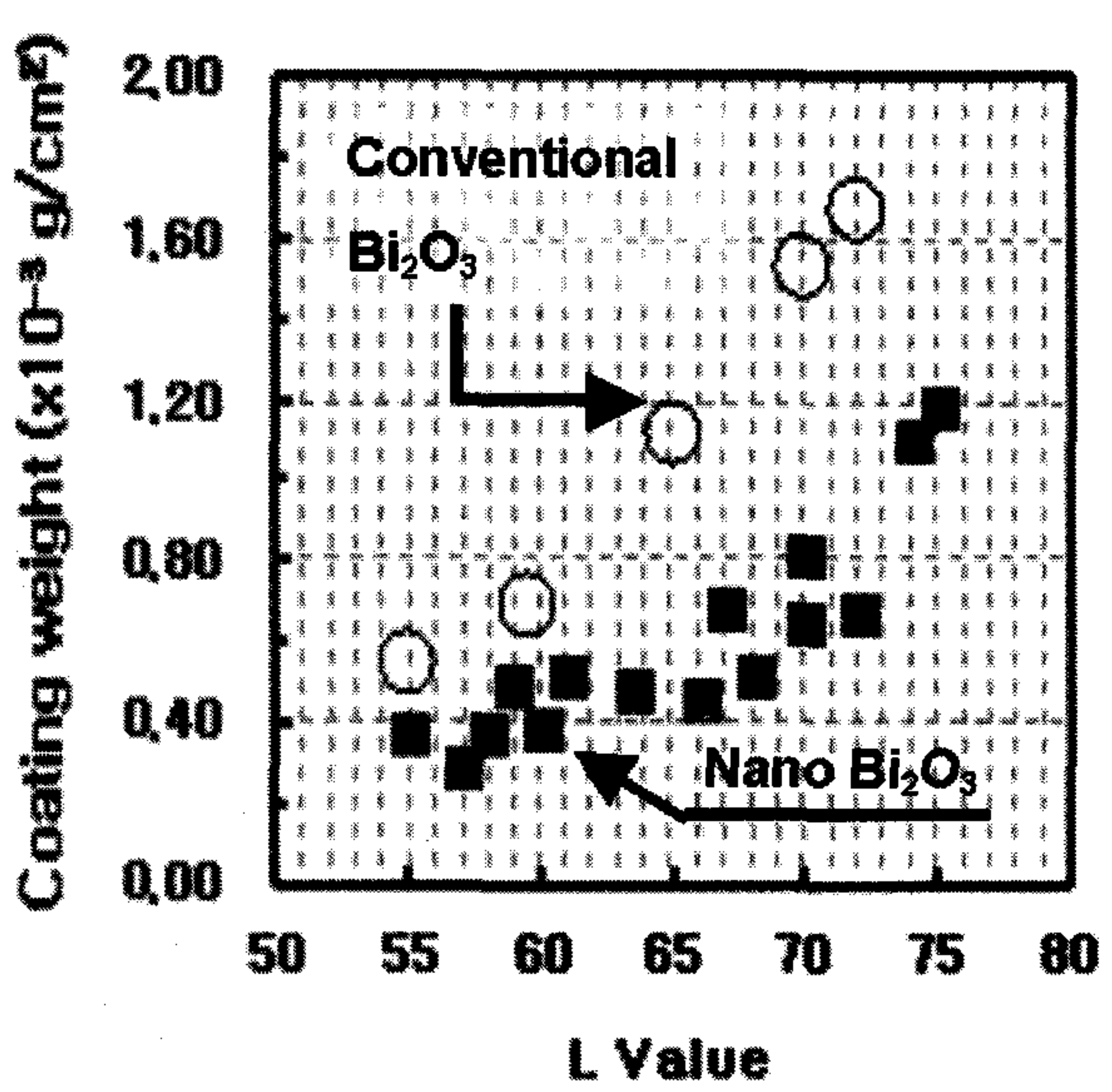


Fig. 4. The coating weight according to the brightness of chromaticity for the sprayed layer.

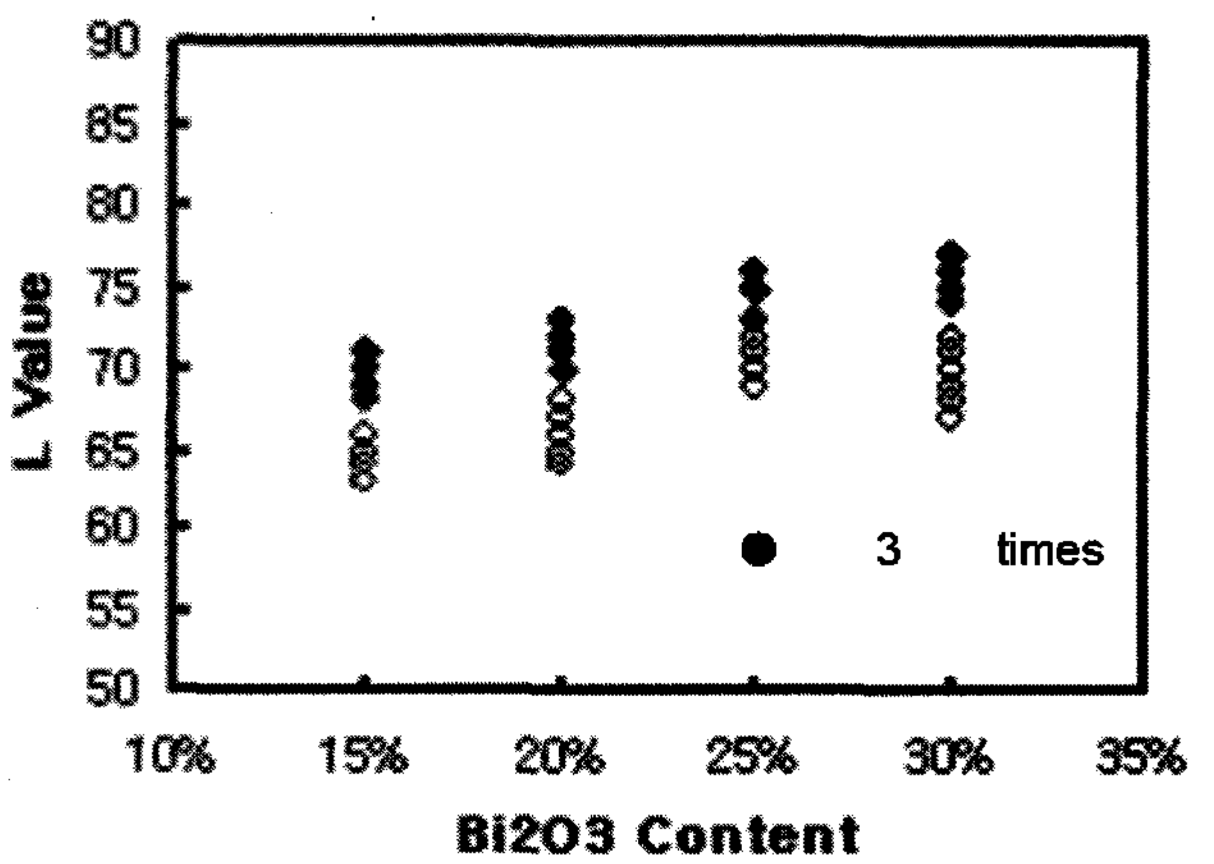
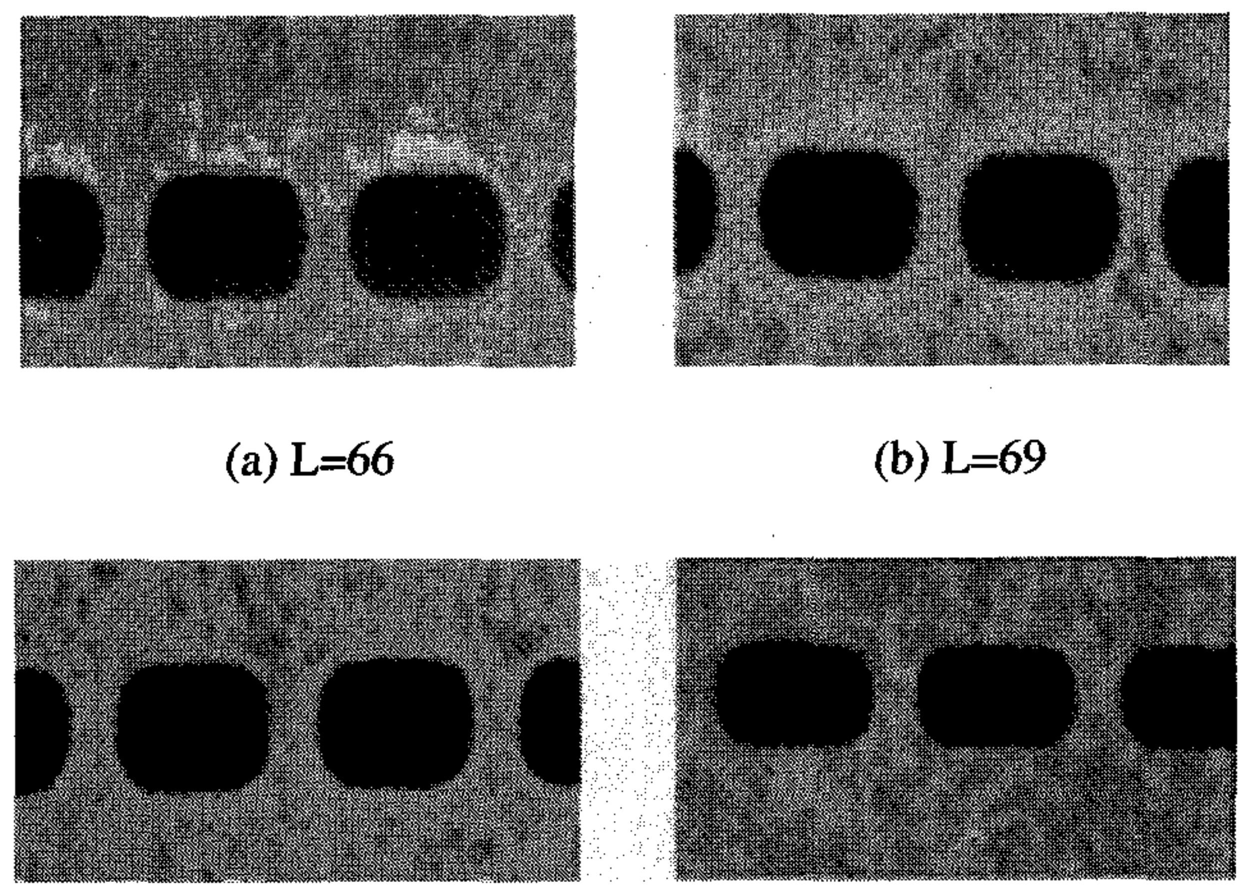


Fig. 5. Brightness of the chromaticity at the sprayed layer with concentration of bismuth oxide in slurry.

coordinate system in general. Here, L means the brightness of chromaticity, and a or b means axis of color coordinate.

The chromaticity was measured as follows. After white light was illuminated on the surface of the sprayed layer, the chromaticity of the reflected light for the layer was checked and the chromaticity was expressed to L.a.b color coordinate system. Then we could properly control the brightness in the production line thereafter. It is believed that this is good method because we can determine the coating uniformity and the degree of the spray coating, and also control the spray process by this method.

Fig. 4 shows the relation between L value and the



(a) L=66 (b) L=69

(c) L=72 (d) conventional Bi_2O_3 L=62

Fig. 6. Optical micrographs for the shadow mask to be coated with bismuth oxides.

coating weight for the sprayed layer on AK shadow mask. Coating weight is increased with L value. In case of the conventional bismuth oxide, L value is generally controlled up to 55~62 and then the coating weight is between 0.6 and 0.8 mg/cm^2. If the L value of the sprayed layer for the nanometer-sized bismuth oxide are estimated on the basis of the coating weight of the conventional bismuth oxide at that time, it can be known L value of the nanometer-sized bismuth oxide layer is among 65~75. It is believed that this is due to the increase of the light reflection that occur as a result of the increase of specific area when bismuth oxide was changed to the nanometer-sized particle.

Fig. 5 shows the measurement results of the brightness of the chromaticity at the sprayed layer according to the concentration of the bismuth oxide in slurry. The spray time was 10sec/1 time. It can be seen that the L value above 65 is secured at the concentration of the bismuth oxide above 20 % in the slurry as shown in Fig. 5. The sprayed amount of the slurry is changed by spray time, based on which the L value is decided. Accordingly it is necessary that a proper concentration of the bismuth oxide in slurry is set taking in account of the spray time in the CRT process.

Fig. 6 shows the microphotographs for the surface of the sprayed layer. Although the weight of the bismuth oxide for the samples to be sprayed with the nanometer-sized bismuth oxide in Fig. 6 (a)~(c) is similar to that of the conventional bismuth oxide, it means that they have been sprayed more uniformly as shown in Fig. 4 and Fig. 6. It can be seen that the nanometer-sized bismuth oxide is more

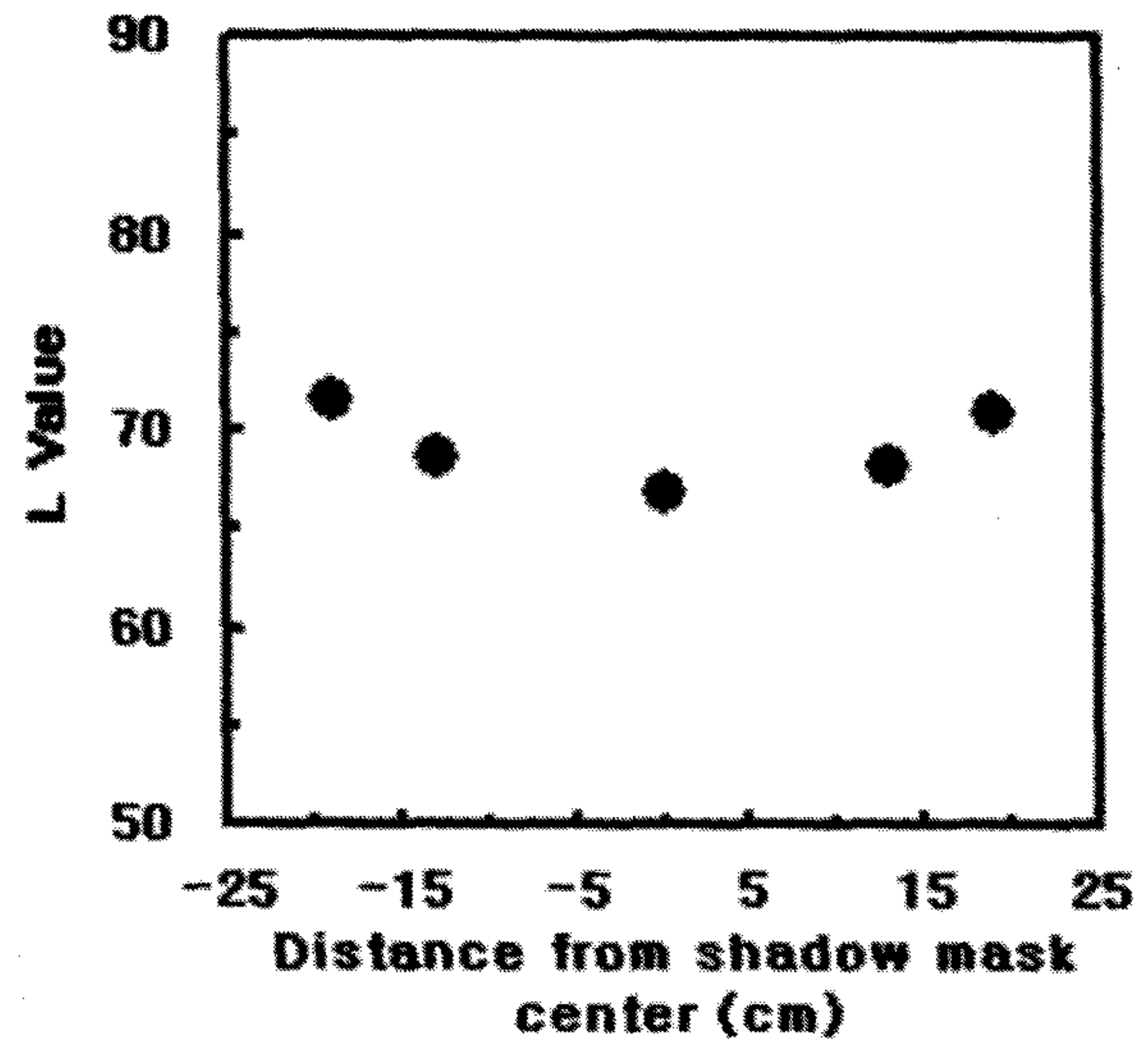


Fig. 7. Brightness of the chromaticity for the sprayed layer on shadow mask.

densely sprayed around shadow mask hole in particular.

It is thought that nanometer-sized bismuth oxide has been accumulated around the shadow mask hole as a result of the bismuth oxide going through the shadow mask hole when bismuth oxide was sprayed at high air pressure. We believe that this result has a favorable effect on the doming of shadow mask because the impacted electron can be better reflected around the shadow mask hole.

Fig. 7 shows the variation for the L value to be measured from the center of the shadow mask to both edge directions after spray coating for CRT production. Though the center area of shadow mask is, generally, not sensitive to doming, the curvature of shadow mask change and mask doming is also very sensible at these areas where are located from both areas to be from about 10 cm off the center to the both edge. As shown Fig. 7, it can be seen that the nanometer-sized bismuth is more thickly and densely sprayed at the side area and L value exists among 68 and 73. This means the shadow mask is favorable to doming at these areas.

Fig. 8 shows the tendency of window doming with the variation of L value. As L values change from 55 to 65, window doming decreases rapidly. But window doming nearly changes at the L value among 65 and 80 as can be seen in Fig. 8. This result indicates that electron reflection had increased owing to the increase in the coating thickness up to L value = 65 and the increase of the electron reflection discontinues when the L value exceeds 65 owing

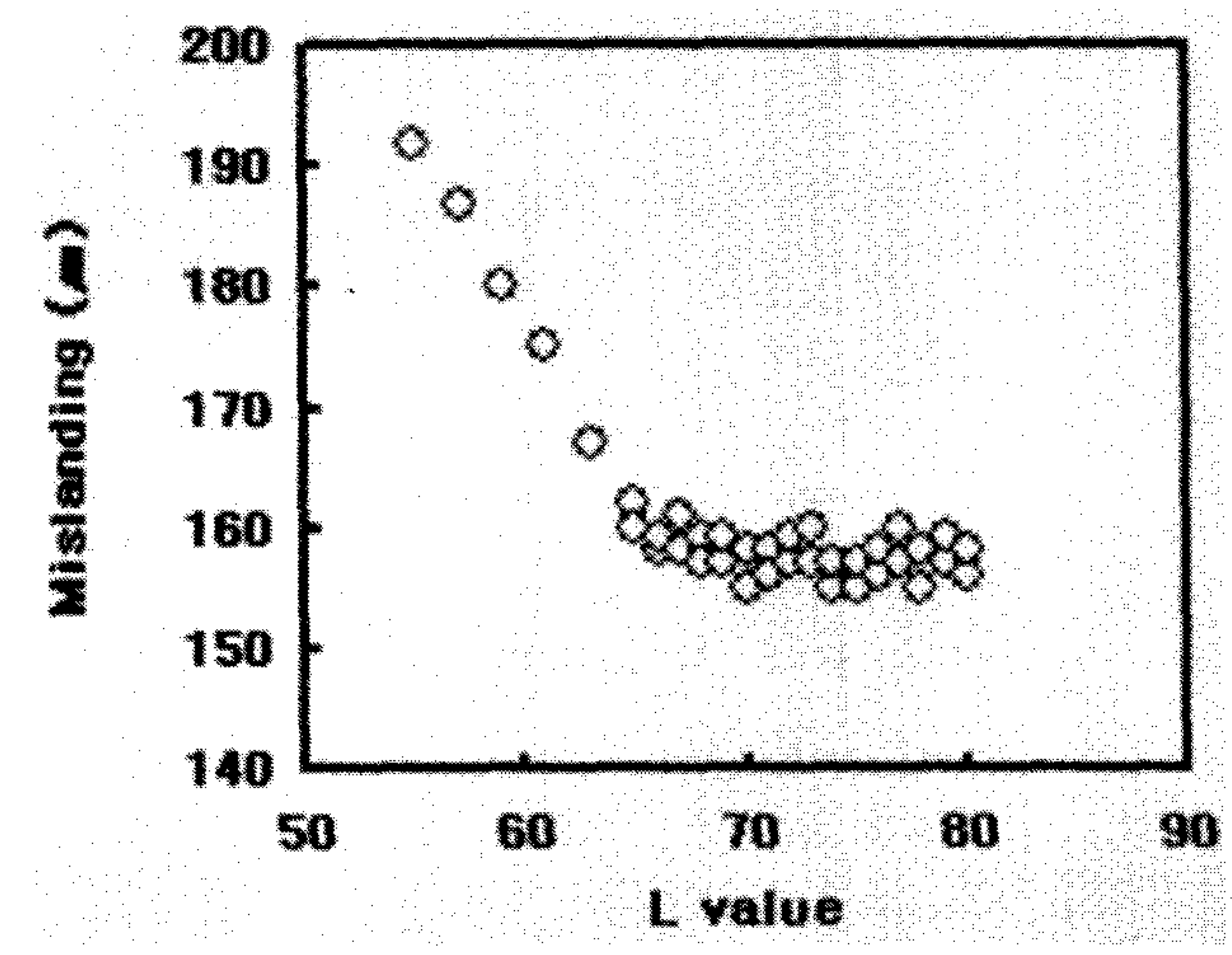


Fig. 8. Window doming with the variation of the brightness of chromaticity of the layer.

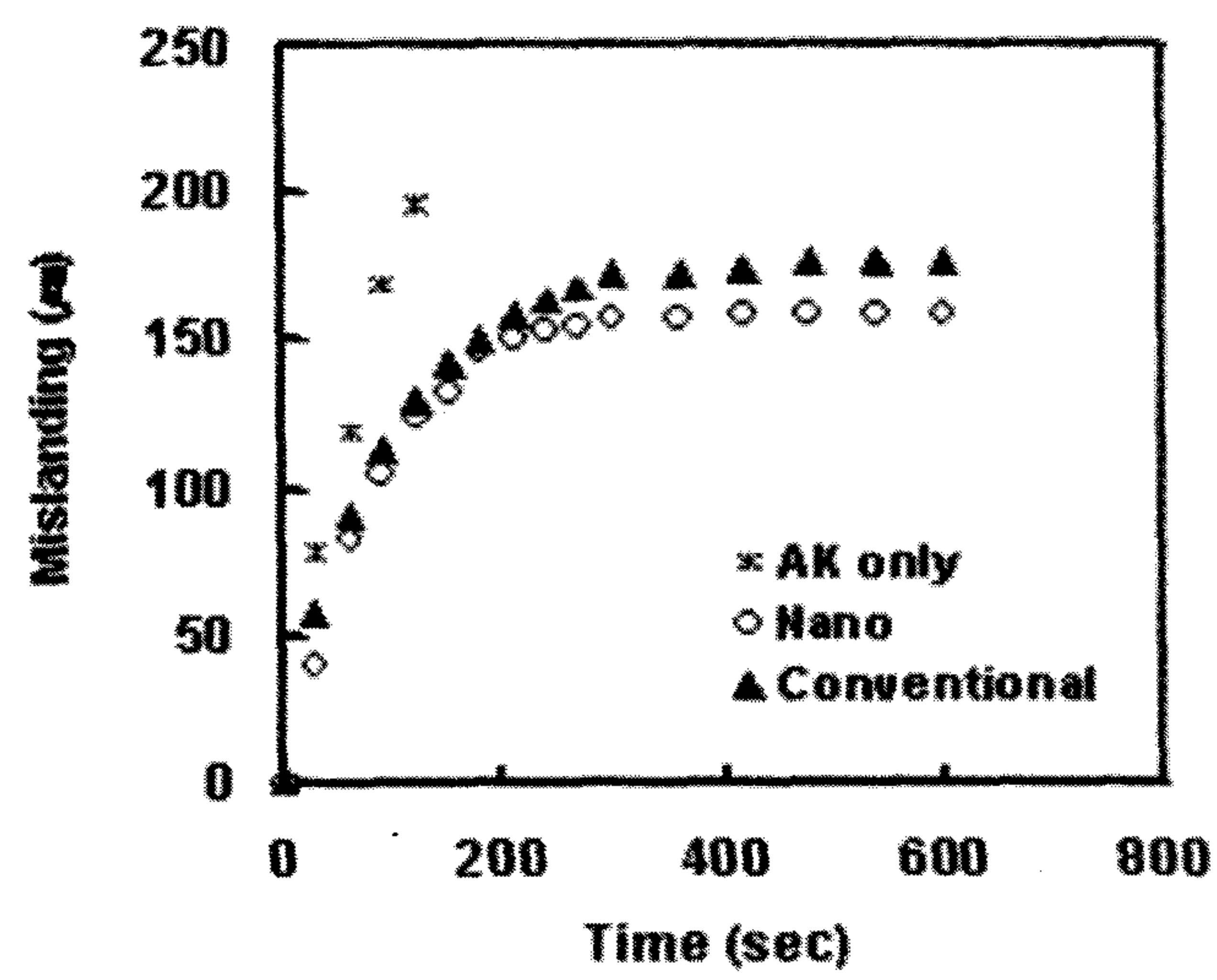


Fig. 9. Window doming with the variation of the working time in CRT.

to the dense and thick coating.

Fig. 9 shows widow doming to be measured with varying working time. In case of the uncoated AK shadow mask, it is impossible to measure the window doming after the 60 sec time mark because the variation of window doming is too large to measure the mislanding of the electron beam in CRT.

Though nanometer-sized bismuth oxide with similar coating weight with that of the conventional bismuth oxide was sprayed, window doming is better by about 10 ㎛ in CRT.

4. Conclusions

Nanometer-sized bismuth oxide was applied to the flat 29"CPT with AK shadow mask in this study. The following conclusions could be drawn.

1. Superior dispersion can be achieved at pH = 7 of pH condition for slurry including bismuth oxide.

2. Coating thickness and uniformity can be properly controlled by measuring the brightness of the chromaticity at L.a.b coordinate system for the coating layer.

3. Concentration of the nanometer-sized bismuth oxide in slurry for spray can be properly controlled in consideration of the spray time in the CRT process without clogging of shadow mask hole.

4. Superior window doming occurs in comparison to the conventional bismuth oxide.

5. References

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