The effects of the filter layer with $CoAl_2O_4$ on inner face of CRT Panel.

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Abstract

Nanosize cobalt aluminate($CoAl_2O_4$) power as filter layer was coated to improve the color purity and contrast performances on inner face of CRT panel. We simulated color properties by measuring the transmittance and thickness of the coated filter layer. Contrast performance could be improved and color gamut was also changed because of the selective light absorption of filter layer at 580~605 nm.

1. Introduction

According to development of information technology, many kinds of display devices recently have appeared like CRT, Organic LED, Inorganic LED, TFT-LCD, PDP, FED. The recommended screen properties in these display devices are superior brightness, its uniformity, higher contrast, better color purity and wider color gamut. CTR is well known as display device with the best screen performance. CRT based on screen performance and HDTV technology will be developed to slim CRT and will remain hereafter for a long time.

To be this, good color reproducibility and higher contrast as screen performance are requested in CRT. [1]~[8] In this study, It is reported the effects of the filter layer coated with $CoAl_2O_4$ on inner face of CRT panel by using the technique of color simulation.

2. Experiment

3 weight percentage of the particulate nanosize cobalt aluminate($CoAl_2O_4$) sol including silica as inorganic binder was used. This sol was spined out on soda lime glass and was dried. As a result, filter layer with cobalt aluminate was formed. Clear CPT panel with 12.0 micrometer of thickness was chosen for color simulation. Scanning electron microscopy (JSM-6300, JEOL, Japan) was used for evaluation of the particle size in filter layer. Transmittances of the filter layer and CPT panel were measured by use of UV spectrophotometer (UV2100, Shimadzu, Japan), cathodoluminescence of R,G,B phosphor was measured by colorimeter(PR650, Photo Research , U.S.A).

3. Results and Discussion

Figure 1 shows SEM micrograph for the cobalt aluminate powder on the filter layer.

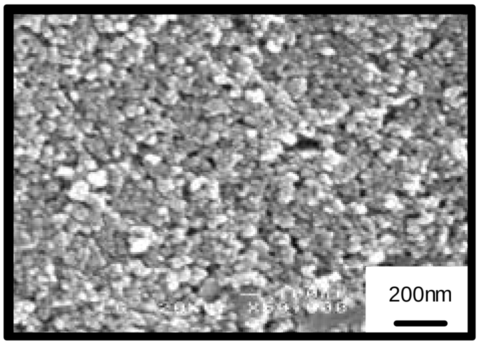

Figure 1. SEM micrograph for the cobalt aluminate powder on the filter layer.

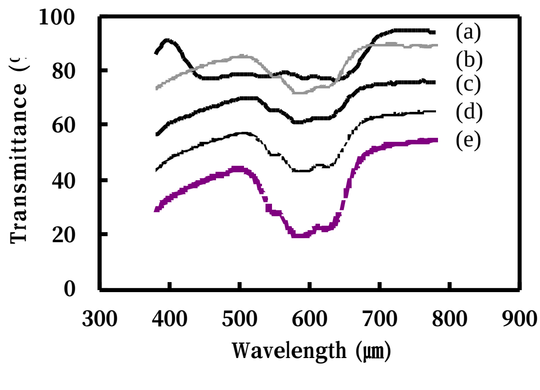

Figure 2. The transmittance for the panel with inner filter layer made of cobalt aluminate.

(a) as-received celar panel, (b) t = 0.6 μm, (c) t = 1.1 μm, (d) t = 1.8 μm, (e) t = 3.5 μm

It can be known that the particles are simular to spherical shape and have about 70 nm in size as shown in Figure 1.

Figure 2 shows the results simulated for the transmittance when filter layer was formed in inner face of panel. Transmittance was calculated as follows.

Transmittance = $T_{Panel} \times T_{Filter}$

T_{Panel} : Transmittance of panel

T_{Filter}: Transmittance of filter layer

$= T_{sodalime\ glass\ coated\ with CoAl_2O_4} / T_{sodalime\ glass}$

$T_{sodalime\ glass\ coated\ with CoAl_2O_4}$:

Transmittance of sodalime glass with filter layer

$T_{sodalime\ glass}$: Transmittance of sodalime glass

Clear panel shows about 79% of the light transmission property which is very sensible to human eyes at the range of 445 ~ 650 nm as Figure 2 (a). When cobalt aluminate inner filter layer is formed on inner face of CRT panel, decrease of panel transmittance is shown at the range of 505 ~ 680 nm, the highest decrease in transmittance is shown at the range of 580 ~ 605 nm which is the boundary between range of green and range of red color and shows orange color as shown in Figure 3(b) ~ (f). It is thought that selective light absorption at special wavelength range such as 500 ~ 680nm is a distinctive feature of filter layer with cobalt aluminate.

Figure 3 shows the results simulated for the cathodoluminescence of CRT when filter layers were formed on inner face of panel.

Cathodoluminescence spectra were calculated as follows.

Spectrum = $S_{phosphor} \times T_{panel\ with\ filter}$

$S_{phosphor}$: Emission spectrum of phosphor

$T_{panel\ with\ filter}$: Transmittance of panel with filter layer.

From Figure 3, as the thicknesses of filter layer increase, the emission intensities that mean each brightness of R, G, B color decrease as a whole. The shoulders of spectrum especially are shifted from 530 nm to 515 nm and green peaks at the range between 705 ~ 710 nm decrease in case of green spectrum as shown in Figure 3(b). Those are because the transmittance of panel decreased owing to the selective light absorption of filter layer at the special range of wavelength as shown Figure 2.

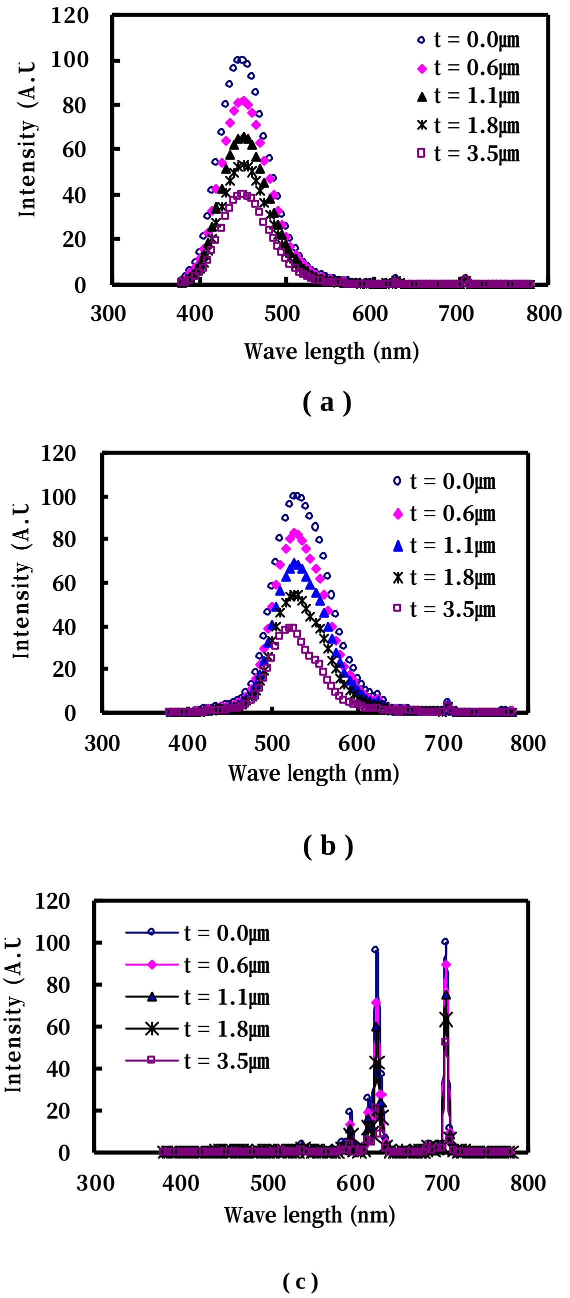

Figure 3. The emission spectra according to the coated thickness of cobalt aluminate in CRT. (a) Blue (b) Green (c) Red

Figure 4 shows the results simulated for the change of chromaticity coordinate when CRT with filter layers works.

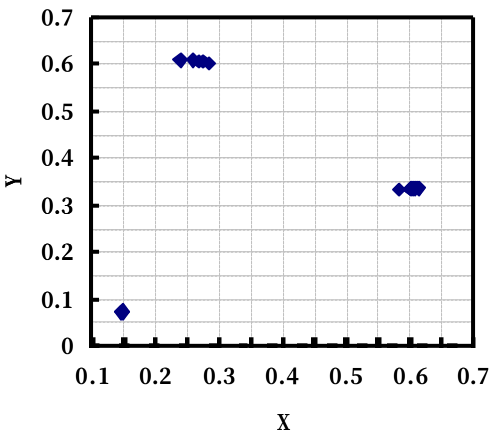

Figure 4. The change of chromaticity coordinate according to the thickness of filter layer in CIE 1931 chromaticity diagram.

Chromaticity coordinate was calculated as follows.

$\mathbf{x} = X / (X+Y+Z)$

$\mathbf{y} = Y / (X+Y+Z)$

$$X = \sum_{i=380}^{780} S(\lambda)x(\lambda)T_{panel*Filter} * \frac{100}{\sum_{i=380}^{780} S(\lambda)y(\lambda)}$$

$$Y = \sum_{i=380}^{780} S(\lambda)y(\lambda)T_{panel*Filter} * \frac{100}{\sum_{i=380}^{780} S(\lambda)y(\lambda)}$$

$$Z = \sum_{i=380}^{780} S(\lambda)z(\lambda)T_{panel*Filter} * \frac{100}{\sum_{i=380}^{780} S(\lambda)y(\lambda)}$$

S(λ) : Each emission intensity of R,G,B phosphor ×i_k of each R,G,B cathode in CRT.

x(λ), y(λ), z(λ) : Color matching function in XYZ color system

$\mathbf{T_{panel*filter}}$ **:** Transmittance of the panel coated with filter layer composed of cobalt aluminate.

Once filter layers are formed on the inner face of panel, chromaticity coordinates for blue color nearly don't change but those for green color are shifted to pure green and those for red color show the changes to be shifted to white red as shown in Figure 5. It is also thought that it's owing to the selective light absorption of filter layer at orange color range between 580 ~ 605 nm.

Figure 5 shows the schematic figure about the reflectance of incident light from outdoors into panel.

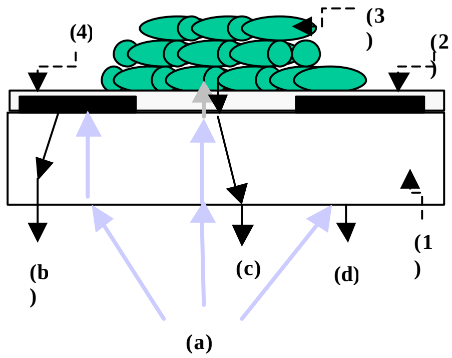

Figure 5. Schematic figure for the reflected light from the CRT screen.

(a) Incident light from outdoors (200 lx)

(b) Light reflected from black matrix

(c) Light reflected from phosphor

(d) Light reflected from panel face

(1) Panel (2) Black matrix(BM)

(3) Phosphor (4) Inner filter layer

It can be known that the reflection of incident light into screen occurs on panel face, black matrix, inner filter layer and phosphor coating as shown in Figure 5.

In that case, contrast of CRT can be calculated as follows.

Contrast = (Average brightness + Total reflected light) / Total reflected light

Total reflected light

= Reflected light at BM + Reflected light at Phosphor layer + Reflected light at Panel face

Reflected light at BM

$= (L/\pi * 0.2919) * (1 - R_{Glass}) * T^2_{panel} * R_{BM} *$

$* PBMA$

Reflected light at Phosphor layer

$= (L/\pi * 0.2919) * (1 - R_{Glass}) * T^2_{panel} * T^2_{filter}$

$* R_{Phosphor} * (1 - PBMA)$

Reflected light at Panel face $= (L/\pi * 0.29) * 0.045$

Phosphor reflectance

= (Red phosphor reflectance + Green phosphor reflectance + Blue phosphor reflectance)/3 0.61

R_{Glas} : Reflectance of glass surface

R_{BM} : Reflectance of graphite layer

$R_{Phosphor}$: Reflectance of phosphor

L : Brightness of outdoor light (lux)

PBMA : Percentage of black matrix area in screen.

Here 45FL was taken as average brightness, the unit of L is lux, ($1Lux = 1/\pi\ cd/m^2 = 0.2919/\pi\ FL$), we take 200 lux as L value, R_{BM} measured by colorimeter(CS-1000,Minolta) is 0.057, , "1-PBMA" is generally called as screen transmission and we took 0.4 as the value of PBMA, R_{Glass} is taken as 0.045.

Figure 6 shows the changes of contrast simulated by using above equations.

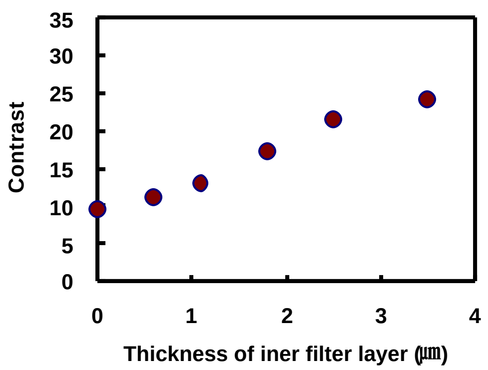

Figure 6. The change of contrast according to the coated thickness of cobalt aluminate($CoAl_2O_4$) in CRT.

The contrast increases as thickness of filter layer increases. That is because total reflected light decreases due to light absorption of filter layer.

4. Conclusions

70 nm of cobalt aluminate was used in forming filter layer on inner face of panel. As results, transmittance of panel and brightness of CRT were decrease with increase of thickness of filter layer, the chromaticity coordinates of the green and red color changed and contrast was increased as thickness of filter layer increases. These were owing to the selective light absorption of filter layer with cobalt aluminate at orange color range between 580 ~ 605 nm.

5. References

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