Display device and a method for producing the same

Anzeigevorrichtung und Herstellungsverfahren

Dispositif d'affichage et son procédé de fabrication

(84) Designated Contracting States:
DE GB

(30) Priority: 06.04.1992 JP 83551/92
24.07.1992 JP 198161/92

(43) Date of publication of application:
13.10.1993 Bulletin 1993/41

(73) Proprietor: Matsushita Electronics Corporation
Kadoma-shi, Osaka 571 (JP)

(72) Inventors:
- Arimoto, Nozomu
  Takatsuki City, 569 (JP)
- Hayama, Hidekazu
  Moriguchi City, 570 (JP)
- Takahashi, Toshihide
  Takatsuki City, 569 (JP)

- Tohda, Hitoaki
  Asahi-ku, Osaka City, 535 (JP)

(74) Representative: Dr. Elisabeth Jung
Dr. Jürgen Schirndewahn Dipl.-Ing. Claus
Gernhardt
Postfach 40 14 68
D-80714 München (DE)

(56) References cited:
EP-A- 0 131 341
EP-A- 0 263 541
EP-A- 0 372 488
US-A- 4 945 282

- PATENT ABSTRACTS OF JAPAN vol. 14, no. 252 (E-934)(4195) 30 May 1990 &
- SID INTERNATIONAL SYMPOSIUM: DIGEST OF
  TECHNICAL PAPERS 1989, LOS ANGELES US
  pages 270 - 273 YOSHISHIGE ENDO '16.3:
  Combined antistatic and antireflection coating
  for CRTs'

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention.)
Description

FIELD OF THE INVENTION AND RELATED ART STATEMENT

1. FIELD OF THE INVENTION

The present invention generally relates to a display device and a method for producing such display device. In particular, the present invention is concerned with the display device, such as a cathode ray tube (CRT) or a plasma display panel, having a face panel which has both functions of anti-static charging and reduced reflection.

DESCRIPTION OF THE PRIOR ART

When an outer light from the room lamp and the like impinges on and is reflected from an outer surface of the glass face panel of the display device such as the CRT, an image produced on the screen of the display device becomes illegible. When a charge is accumulated on the outer surface of the face panel, it becomes liable to attract dust particles hence to make the image obscure and besides induce the hazard of an electric shock.

In order to cope with such circumstances, it has been a conventional practice to roughen the outer surface of the face panel by a chemical or mechanical means and render the outer surface to perform an irregular reflection of the outer light. Another conventional measure is to deposit an electrically-conductive thin film composed of stannic oxide (SnO₂) or the like, on the outer surface of the face panel to make it anti-static charging.

The above-mentioned reflection reducing means can prevent the undesirable reflection of the outer light of the face panel by the provision of a multiplicity of the minute convex and concave spots of the outer surface of the face panel. The means, however, have a disadvantage such that the light emitted from light emission means for producing the display is also reflected irregularly on the roughened surface, thereby deteriorating the resolution of the display device and the glossiness of the face panel is also lost.

JP-A-2 072 549 discloses a display device according to the prior art portion of claim 1 comprising a glass substrate, on which a transparent conductive film mainly composed of SnO₂ and In₂O₃ is provided, and an uneven film mainly composed of SiO₂ is further provided on the transparent conductive film. Thereby a reflection-electricitication preventive film is formed, wherein the uneven film provides a levelling-off action for preventing a reflection of light.

OBJECT AND SUMMARY OF THE INVENTION

It is therefore the primary object of the present invention to provide a display device that can overcome the above-mentioned disadvantages inherent to the prior art devices.

It is another object of the present invention to provide a method for producing the above-mentioned display device.

These objects are achieved by a display device according to claim 1 and a method according to claim 4.

In this display device, the electrically-conductive thin film comprises at least one number selected from the group consisting of stannic oxide (SnO₂), indium sesquioxide (In₂O₃), titanium dioxide (TiO₂) and zirconium dioxide (ZrO₂), or of a mixture of these compounds with silicon dioxide (SiO₂).

The third layer of uneven exposed surface is composed essentially of silicon dioxide (SiO₂) or magnesium fluoride (MgF₂).

By configuring the face panel of the display device as described in claim 4, an anti-static effect can be obtained by the electrically-conductive transparent thin film and a remarkable anti-dazzling effect can also be obtained by the interference film and the irregular reflection film. Adequately selected irregular reflection does not deteriorate the required resolution of the displayed image, and maintains a moderate glossiness of the face panel. Further, since the irregular reflection layer has a multiplicity of the fine concave and convex spots or regions on its surface, there is another advantage in that no stain such as finger print is adhered to the outer surface of the face panel.

While the novel features of the present invention are set forth particularly in the appended claims, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features thereof, from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of an essential part of the face panel of the display device built in accordance with an embodiment of the present invention.

FIG. 2 is a side cross-sectional view illustrating the spin-coating process, as a step of the production method in accordance with the present invention.

FIG. 3 is an enlarged plan view of the exposed surface of the face panel of the display device built in accordance
with the present invention.

FIG. 4 is a view for illustrating the optical characteristics of the display device built in accordance with the present invention.

It will be recognized that some or all of the Figures are schematic representations for purposes of illustration and do not necessarily depict the actual relative sizes or locations of the elements shown.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following paragraphs, the present invention will be described in more detail with reference to the preferred embodiments shown in the attached drawings.

In FIG. 2, the face panel 2 is one for a 47 cm (17 inch) type color cathode ray tube and is mounted, through a rubber cushion 1b, on a rotating table 1 which is enclosed in a painting booth 3 equipped with a nozzle 4 for injecting a solution for deposition. The outer surface of the face panel 2 has already been finished by polishing with a buffing tool impregnated with a grinding agent such as cerium oxide, washing with deionized water, drying as well as air blowing for removing the dust.

The rotating table 1 is permitted to rotate around an axis in together with the face panel 2 at a rate of revolution of approximately 100 rpm. A volatile solution containing stannic oxide and silica is applied on the center of the outer surface of the face panel 2 by dripping through the nozzle 4 for injecting the solution, rotating the face panel and keeping its outer surface at a temperature of about 40°C. The solution supplied by dripping on the above-mentioned outer surface extends from its center to its periphery by the rotation, which is continued for about 30 seconds, whereby an uniform film of the solution is formed by the spin-coating.

At the end of this step, the above-mentioned dripping is stopped but the rotation is still continued for about 80 second at a halved rate, i.e., about 50 rpm. During this rotation, the film forming material in the solution is dried by maintaining the temperature of the outer surface of the face panel 2 at a temperature of about 50°C with a planer heater, infrared lamp or the like means. It is convenient for preventing the mixing of the film forming material with that of a second layer, which will be described later. The employed volatile solution is obtained by dissolving a polymer of an alkyl silicate and fine powder of stannic oxide (SnO₂) in an alcoholic solvent.

In the above-mentioned manner, the first layer 5 of the thickness t₁ of about 80 nm having a high refractive index (n₁) is formed on the outer surface of the face panel 2 as shown by FIG. 1. Next, in order to give a low reflecting function to the face panel 1, the second layer 6 having a low refractive index (n₂) is formed on the surface of the first layer 5. As the film forming material for the second layer 6, one obtained by dissolving only the alkyl silicate polymer is employed; and thereon, another film of an uniform thickness t₂ of about 70 nm is formed by the spin-coating; and the drying is made as mentioned in the above. Although the employed conditions for the deposition of the second layer 6 are similar to those employed in forming the first layer 5, the temperature kept during the drying, as the final step, is set at 60 -- 80°C. Besides the material to make SiO₂, a material to form MgF₂ may similarly be used.

Then, the face panel 2 dismounted from the rotating table 1 is transferred to a spray coating process, and a third layer 7 is formed on the surface of the second layer 6 by known spray coating. And the coated film is finished by heating at 400 -- 450°C for about 20 min. By this heat treatment, the first layer 5, the second layer 6 and the third layer 7 are all baked firmly on the surface of the face panel 2.

The third layer 7 has a fine crater-like uneven configuration on its exposed surface, and its concave regions 9 wherein the average thickness is t₃ constitute an interference film together with the second layer 6 as well as the first layer 5. On the other hand, the convex regions 8 around the crater-like concave regions 9 reflect the outer light irregularly. Preferable range of the thickness t₃ is between 5 nm and 60 nm. This will be discussed later. The outer light impinging on the concave regions 9 is reflected with reduced intensity resulting from the interference as shown by the dotted arrow in FIG.1, while the light impinging on the convex regions 8 is reflected irregularly. In FIG. 1, there is also shown a film 10 of a fluorescent material provided on the inner side of the face panel.

FIG. 3 is an enlarged plan view of the crater-like uneven surface configuration (specular glossiness (defined in Japanese Industrial Standard JIS Z 8471): 75), wherein there are the convex regions 8 surrounding the concave regions 9. When each of the convex regions 8 is connected to others, and each area of surrounded by the convex regions is reduced, the specular glossiness is reduced. In case of such low specular glossiness, the irregular reflection is relatively high, while the effect of reduction of the undesirable reflection by the optical interference decreases. A preferable result is obtainable for the specular glossinesses in a range of 65 -- 85.

The above-mentioned interference film reduces the reflection of the lights of room lighting by fluorescent lamp, outside light from the window and the like; and the above-mentioned convex regions reflect these lights irregularly. The surface electric resistance of this film is 1 KΩ --- 1 MΩ (per square), and this value is sufficient for performing the anti-static function. Furthermore, the above-mentioned interference film is grounded through a periphery guard metal band surrounding the outer periphery of the face panel 2.

Provided that film thicknesses of the first layer, the second layer and the third layer are t₁, t₂ and t₃, respectively,
wavelength of the outer light is \( \lambda \) and refractive index of the face panel is \( n_g \), then an ideal condition to make the reflection light zero is obtainable by fulfilling the following equations:

\[
\frac{n_1}{n_2} = \frac{\lambda}{4}
\]

and

\[n_2 \cdot (t_2 + t_3) = \frac{\lambda}{4}.
\]

where the following relation holds concerning the surface reflectance \( R \) of the face panel:

\[
R = \left( \frac{n_2^2 \cdot n_g \cdot n_1^2}{n_2^2 \cdot n_g \cdot n_1^2 + \frac{\lambda^2}{4}} \right)^2 = 0.
\]

Therefore, it is required to satisfy the following formula:

\[
\frac{n_1}{n_2} = \sqrt{n_g}.
\]

In an actual case, wherein \( n_g = 1.54 \), \( n_1 = 1.82 \) and \( n_2 = 1.47 \), the value of \( R \) is obtained as \( R = 5.3 \times 10^{-6} \) (%), and thus the reflectance \( R \) at the outer surface of the face panel becomes approximately zero. In order to make the reflectance close to zero for the light of the wavelength of 555 nm at which the spectral luminous efficiency becomes maximum, a condition becomes \( t_1 = 76 \) nm, \( t_2 + t_3 = 94 \) nm, because \( n_1 \cdot \lambda/4 \) and \( n_2 \cdot (t_2 + t_3) = \lambda/4 \). Since the average thickness \( t_2 \) of the concave regions \( 9 \) of the third layer is about \( 20 \) nm, when the thickness \( t_1 \) of the first layer \( 5 \) is set to \( 76 \) nm and the thickness \( t_2 \) of the second layer \( 6 \) is set to \( 74 \) nm, a value of the reflectance of the surface becomes close to zero.

In the foregoing embodiment, the first layer is formed by the spin-coating with the film forming material of the volatile solution containing both the stannic oxide and silica, but the first layer may alternatively be a layer containing only stannic oxide (SnO_2). The film forming material employed for the first layer may be at least one member selected from stannic oxide (SnO_2), indium sesquioxide (In_2O_3), titanium dioxide (TiO_2) and zirconium dioxide (ZrO_2), or a mixture of these compounds with silicon dioxide (SiO_2), and the first layer may be deposited by means of the chemical vapor deposition (CVD) instead of the spin coating.

In case of forming the first layer from SnO_2, the thicknesses of the respective layers to make the surface reflectance \( R \) zero is obtained by a different ideal condition from that of the foregoing case. In this different condition, the surface reflectance \( R \) for the refractive index \( n_g \) of the face panel is given by the following formula:

\[
R = \frac{X}{1+X}
\]

where, \( X \) is represented by the following formula:

\[
X = 0.385 \left( \left( \frac{n_2}{n_1} - 0.649 \right) \sin g_1 \cdot \sin g_2 - 0.351 \cos g_1 \cos g_2 \right)^2
\]

\[+ \left( \left( \frac{1}{n_2} - \frac{n_2}{\lambda/4} \right) \cos g_1 \cdot \sin g_2 + \left( \frac{1}{n_1} - \frac{n_1}{\lambda/4} \right) \sin g_1 \cos g_2 \right)^2 \]

where, \( g_1 \) and \( g_2 \) are represented by the following formulae:

\[g_1 = \frac{2\pi}{\lambda} \left( t_1 + t_2 \right), \quad g_2 = \frac{2\pi}{\lambda} n_2 \left( t_2 + t_3 \right).\]

And, by rearranging the above formulae by substituting as \( X = 0 \) for \( R = 0 \), the conditions represented by the following formulae are obtained:

\[
\tan^2 g_1 = n_1 \left( 0.54 \times \left( \frac{1.54 - n_2^2}{1.54n_2^2 - n_1^2} \right) \right)^2
\]

\[\tan^2 g_2 = n_2 \left( 0.54 \times \left( \frac{1.54 - n_1^2}{1.54n_2^2 - n_1^2} \right) \right)^2 \]

The conditions for \( R = 0 \) in the case of \( n_1 = 2.0 \) and \( n_2 = 1.47 \) are

\[\tan^2 g_1 = 0.81,\]
\[
\tan^2 \theta = 6.87, \\
\eta_1 t_1 = 64 \text{ nm and} \\
\eta_2 (t_2 + t_3) = 170 \text{ nm}.
\]

From these, the following values are obtained:

\[
\begin{align*}
t_1 & = 52 \text{ nm}, \\
t_2 + t_3 & = 116 \text{ nm}, \\
t_2 & = 96 \text{ nm and} \\
t_3 & = 20 \text{ nm}.
\end{align*}
\]

Referring now to FIG. 4, dots show a result of the glossiness measurement for the crater-like uneven exposed surfaces. The measurement is made by employing a mirror-finished surface specular glossiness measurement apparatus in accordance with JIS Z 8741 (Japanese Industrial Standard No. Z 8741). During this measurement, the incident angle of the light to the surface of the sample is fixed to 60 degree. For better understanding of the effect of the crater-like uneven exposed surface of the third layer deposited on the interference film, the measurements are made for both the layers with and without the interference film. And the correlation between the layers with the interference films and the layers without the same is shown in the figure.

As clearly shown by this measurement, the glossiness 80 of the surface without the interference film corresponds to the glossiness 53 of the surface with the interference film; and the difference 27 between them represents the reflection reducing effect.

In the foregoing embodiment, the first layer is formed by the spin-coating with the film forming material of the volatile solution containing stannic oxide and silica though, the first layer may alternatively be a layer containing only stannic oxide (SnO₂). Further, although the second layer 6 and the third layer 7 are formed by employing a solution obtained by dissolving a polymer of alkyl silicates in an alcoholic solvent, at least one of the second layer 6 and the third layer 7 may alternatively be a mixture obtained by dissolving or dispersing at least one of the polymer of alkyl silicates and fine powder of magnesium fluoride (MgF₂) in the alcoholic solvent. For MgF₂ having the refractive index of 1.38, apart from the value 1.4 of SiO₂, the effect and advantage similar to these of the foregoing embodiments can also be obtained in this case.

**Claims**

1. A display device comprising:

   a glass face panel (1);
   a first layer (5) of an electrically-conductive transparent thin film, deposited on an outer surface of said glass face panel;
   a second layer (6) of a transparent thin film deposited on said first layer (5);
   wherein a large number of concave regions (9) and a large number of convex regions (8) form an irregular reflection surface,
   characterized in that
   a third layer (7) is deposited on said second layer (6), said third layer (7) comprises said concave and convex regions,
   said concave regions (9) have flat faces; and
   said flat faces form an interference film together with said first (5) and second layers (6).

2. A display device according to claim 1, wherein said electrically-conductive thin film comprises: at least one member selected from the group consisting of stannic oxide (SnO₂), indium sesquioxide (In₂O₃), titanium dioxide (TiO₂) and zirconium dioxide (ZrO₂), or of a mixture of these compounds with silicon dioxide (SiO₂).

3. A display device according to claim 1 or 2, wherein said third layer of uneven exposed surface is composed essentially of silicon dioxide (SiO₂) or magnesium fluoride (MgF₂).

4. A method for producing a display device which has a glass face panel (1), comprising

   depositing a first layer (5) of an electrically conductive transparent thin film on an outer surface of said glass face panel (1); and
EP 0 565 026 B1

depositing a second layer (6) of a transparent thin film consisting essentially of a material selected from a group including silicon dioxide (SiO₂) on said first layer (5) of electrically conductive transparent thin film, wherein the most outer layer with respect to said glass face panel (1) is an irregular reflection film so as to have a large number of crater-like concave regions and convex regions; wherein a large number of convex regions form an irregular reflection surface, characterized in that said first layer (5) is deposited by means of a spin-coating, a chemical vapor deposition (CVD), a dip-coating or spray coating, said second layer (6) is deposited by means of spin-coating, a dip-coating or spray coating, said group further including magnesium fluoride (MgF₂), a third layer (7) consisting essentially of silicon dioxide (SiO₂) or magnesium fluoride (MgF₂) is deposited on said second layer (6) by means of spray coating; and a large number of said crater-like concave regions have flat faces to form an interference film together with said first and second layers.

Patentansprüche

1. Anzeigevorrichtung, umfassend:
   eine Glasfrontplatte (1);
   eine erste Schicht (5) aus elektrisch leitendem transparenten Dünnfilm, abgesetzt auf einer Außenfläche der Glasfrontplatte;
   eine zweite Schicht (6) aus einem transparenten Dünnfilm, abgesetzt auf der ersten Schicht (5);
   wobei eine große Anzahl konkaver Bereiche (9) und eine große Anzahl konvexer Bereiche (8) eine unregelmäßige Reflexionsfläche bilden,
   dadurch gekennzeichnet, daß
   eine dritte Schicht (7) auf der zweiten Schicht (6) abgesetzt ist, die dritte Schicht (7) die konkaven und konvexen Bereiche umfaßt,
   die konkaven Bereiche (9) flache Vorderseiten aufweisen; und
   die flachen Vorderseiten einen Interferenzfilm zusammen mit der ersten (5) und zweiten Schicht (6) bilden.

2. Anzeigevorrichtung nach Anspruch 1, bei der der elektrisch leitende Dünnfilm umfaßt: wenigstens ein Element, ausgewählt aus der Gruppe bestehend aus Zinn (IV)-Oxid (SnO₂), Indiumsesquioxid (In₂O₃), Tlindioxid (TIO₂) und Zirkondioxid (ZrO₂) oder einer Mischung dieser Zusammensetzungen mit Siliciumdioxid (SiO₂).

3. Anzeigevorrichtung nach Anspruch 1 oder 2, bei der die dritte Schicht in der unebenen exponierten Oberfläche im wesentlichen aus Siliciumdioxid (SiO₂) oder Magnesiumfluorid (MgF₂) besteht.

4. Verfahren zur Herstellung einer Anzeigevorrichtung, die eine Glasfrontplatte (1) aufweist, umfassend, daß:
   eine erste Schicht (5) aus elektrisch leitendem transparenten Dünnfilm auf einer Außenfläche der Glasfrontplatte (1) abgesetzt wird; und
   eine zweite Schicht (6) aus transparentem Dünnfilm, bestehend im wesentlichen aus einem Material, ausgewählt aus einer Gruppe, enthaltend Siliciumdioxid (SiO₂) auf der ersten Schicht (5) aus elektrisch leitendem transparenten Dünnfilm abgesetzt wird, wobei die äußerste Schicht in bezug auf die Glasfrontplatte (1) ein unregelmäßiger Reflexionsfilm ist, so daß er eine große Anzahl kratertartiger konkaver Bereiche und konvexer Bereiche aufweist; wobei eine große Anzahl konvexer Bereiche eine unregelmäßige Reflexionsfläche bildet, dadurch gekennzeichnet, daß
   die erste Schicht (5) mittels Schleuderbeschichtung, einer chemischen Gashphasenabscheidung (CVD), einer Tauchbeschichtung oder einer Sprühbeschichtung abgesetzt wird, die zweite Schicht (6) mittels Schleuderbeschichtung, Tauchbeschichtung oder Sprühbeschichtung abgesetzt wird,
   wobei die Gruppe weiter Magnesiumfluorid (MgF₂) umfaßt,
   wobei eine dritte Schicht (7), bestehend im wesentlichen aus Siliciumdioxid (SiO₂) oder Magnesiumfluorid (MgF₂), auf der zweiten Schicht (6) mittels Sprühbeschichtung abgesetzt wird; und
   eine große Anzahl der kratertartigen konkaven Bereiche flache Vorderseiten aufweisen, um einen Interferenzfilm
Revisions

1. Dispositif d'affichage comprenant :
   un panneau de face en verre (1);
   une première couche (5) d'un fin film transparent conducteur de l'électricité, déposée sur la surface extérieure dudit panneau de face en verre;
   une seconde couche (6) d'un fin film transparent déposée sur ladite première couche (5);
   dans lequel un grand nombre de zones concaves (9) et un grand nombre de zones convexes (8) forment une surface irrégulière réfléchissante,
   caractérisé en ce que :
   une troisième couche (7) est déposée sur ladite seconde couche (6), ladite troisième couche (7) comprend lesdites zones concaves et convexes,
   lesdites zones concaves (9) ont des faces plates; et
   lesdites faces plates forment un film d'interférence avec lesdites première (5) et seconde (6) couches.

2. Dispositif d'affichage selon la revendication 1, dans lequel ledit fin film conducteur de l'électricité comprend : au moins un élément choisi dans le groupe constitué de l'oxyde stannique (SnO₂), du sesquioxyde d'indium (In₂O₃), du dioxyde de titane (TiO₂) et du dioxyde de zirconium (ZrO₂), ou d'un mélange de ces composés avec du dioxyde de silicium (SiO₂).

3. Dispositif d'affichage selon la revendication 1 ou 2, caractérisé en ce que ladite troisième couche de la surface irrégulière exposée est constituée essentiellement de dioxyde de silicium (SiO₂) ou de fluorure de magnésium (MgF₂).

4. Procédé de fabrication d'un dispositif d'affichage qui comporte un panneau de face en verre (1), comprenant les étapes consistant à :
   déposer une première couche (5) d'un fin film transparent conducteur de l'électricité sur la surface extérieure dudit panneau de face en verre (1); et
   déposer une seconde couche (6) d'un fin film transparent constitué essentiellement d'un matériau choisi dans un groupe comprenant le dioxyde de silicium (SiO₂) sur ladite première couche (5) du fin film transparent conducteur de l'électricité,
   dans lequel la couche la plus à l'extérieur par rapport audit panneau de face en verre (1) est un film ir régulier réfléchissant de façon à avoir un grand nombre de zones concaves analogues à un cratère et de zones convexes; où un grand nombre de zones convexes forment une surface irrégulière réfléchissante,
   caractérisé en ce que :
   ladite première couche (5) est déposée au moyen d'un revêtement par rotation, d'une déposition en phase gazeuse par procédé chimique (CVD), d'un revêtement par immersion ou d'un revêtement par projection,
   ladite seconde couche (6) est déposée au moyen d'un revêtement par rotation, d'un revêtement par immersion ou d'un revêtement par projection,
   ledit groupe comportant en outre du fluorure de magnésium (MgF₂),
   une troisième couche (7) constituée essentiellement de dioxyde de silicium (SiO₂) ou de fluorure de magnésium (MgF₂) est déposée sur ladite seconde couche (6) au moyen d'un revêtement par projection; et
   un grand nombre desdites zones concaves analogues à un cratère présentent des faces plates pour former un film d'interférence avec lesdites première et seconde couches.
FIG. 4

Glossiness of the exposed uneven surface (with the interference film) vs. Glossiness of the exposed uneven surface (without the interference film).