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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : H05B 33/22, 33/28	A1	(11) International Publication Number: WO 94/14299 (43) International Publication Date: 23 June 1994 (23.06.94)
(21) International Application Number: PCT/US93/12139 (22) International Filing Date: 13 December 1993 (13.12.93) (30) Priority Data: 990,991 16 December 1992 (16.12.92) US (71) Applicant: UNITED TECHNOLOGIES CORPORATION [US/US]; United Technologies Building, Hartford, CT 06101 (US). (72) Inventors: BUDZILEK, Russell, A.; 417 Lake Avenue, Bridgeport, CT 06605 (US). MONARCHIE, Dominick, L.; 5 Wayfaring Road, Norwalk, CT 06851 (US). PODOBA, Myrosław; 87 High Hill Road, Wallingford, CT 06492 (US). SWATSON, Richard, R.; 21 Hedgehog Road, Trumbull, CT 06611 (US). (74) Agent: O'SHEA, Patrick, J.; United Technologies Corporation, Patent Department, United Technologies Building, Hartford, CT 06101 (US).		(81) Designated States: CA, JP, KR, RU, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>
(54) Title: SUNLIGHT VIEWABLE THIN FILM ELECTROLUMINESCENT DISPLAY (57) Abstract An AC thin film electroluminescent display panel includes a metal assist structure formed on and in electrical contact over each transparent electrode, and a light absorbing dark layer which combine to provide a sunlight viewable display panel.		

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Description

SUNLIGHT VIEWABLE THIN FILM ELECTROLUMINESCENT DISPLAY

Cross Reference to Related Applications

5 This application contains subject matter related to commonly assigned co-pending applications: Serial Number 07/897,210 filed June 11, 1992, entitled "Low Resistance, Thermally Stable Electrode Structure for Electroluminescent Displays"; Serial Number 07/990,322 designated attorney docket number N-1221, entitled
10 "Sunlight Viewable Thin Film Electroluminescent Display Having Darkened Metal Electrodes"; and Serial Number 07/989,672 designated attorney docket number N-1222, entitled "Sunlight Viewable Thin Film Electroluminescent Display Having A Graded Layer Of
15 Light Absorbing Material".

Technical Field

This invention relates to electroluminescent display panels and more particularly to reducing the reflection of ambient light to enhance the sunlight
20 viewability of the panels.

Background Art

Thin film electroluminescent (TFEL) display panels offer several advantages over older display technologies such as cathode ray tubes (CRTs) and
25 liquid crystal displays (LCDs). Compared with CRTs, TFEL display panels require less power, provide a larger viewing angle, and are much thinner. Compared

with LCDs, TFEL display panels have a larger viewing angle, do not require auxiliary lighting, and can have a larger display area.

Fig. 1 shows a prior art TFEL display panel. The TFEL display has a glass panel 10, a plurality of transparent electrodes 12, a first layer of a dielectric 14, a phosphor layer 16, a second dielectric layer 18, and a plurality of metal electrodes 20 perpendicular to the transparent electrodes 12. The transparent electrodes 12 are typically indium-tin oxide (ITO) and the metal electrodes 20 are typically Al. The dielectric layers 14, 18 protect the phosphor layer 16 from excessive dc currents. When an electrical potential, such as about 200 V, is applied between the transparent electrodes 12 and the metal electrodes 20, electrons tunnel from one of the interfaces between the dielectric layers 14, 18 and the phosphor layer 16 into the phosphor layer where they are rapidly accelerated. The phosphor layer 16 typically comprises ZnS doped with Mn. Electrons entering the phosphor layer 16 excite the Mn causing the Mn to emit photons. The photons pass through the first dielectric layer 14, the transparent electrodes 12, and the glass panel 10 to form a visible image.

Although current TFEL displays are satisfactory for some applications, more advanced applications require brighter higher contrast displays, larger displays, and sunlight viewable displays. One approach in attempt to provide adequate panel contrast under high ambient illumination is the use of a circular polarizer filter which reduces ambient reflected light. While this approach may provide reasonable contrast in moderate ambient lighting conditions, it also has a

number of drawbacks which include a high cost and a maximum light transmission of approximately 37%.

Disclosure of the Invention

5 An object of the present invention is to reduce the reflection of ambient light and enhance the contrast of a TFEL display to provide a sunlight viewable display.

Another object of the present invention is to provide a large TFEL display with enhanced contrast.

10 According to the present invention, a layer of light absorbing dark material is included within the layered structure of a TFEL display panel having low resistance transparent electrodes.

The present invention provides a TFEL display panel which is comfortably viewable in direct sunlight. Another feature of the present invention is, by employing a layer of light absorbing dark material in a TFEL display having low resistance electrodes (which allow the display to be driven at a faster rate),
20 larger display sizes with enhanced contrast such as those greater than thirty-six inches are now feasible.

These and other objects, features and advantages of the present invention will become more apparent in light of the following detailed description of a preferred embodiment thereof, as illustrated in the
25 accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a cross-sectional view of a prior art TFEL display;

30 Fig. 2 is a cross-sectional view of a TFEL display of the present invention;

Fig. 3 is graph of the composition of PrMnO_3 versus resistivity and dielectric constant;

Fig. 4 is an enlarged cross-sectional view of a single ITO line and an associated metal assist structure of Fig. 2;

Fig. 5 is a cross-sectional view of an alternate embodiment of an TFEL display of the present invention; and

Fig. 6 is a cross-sectional view of yet another alternative embodiment.

Best Mode for Carrying Out the Invention

In one embodiment of the present invention, a layer of light absorbing dark material is included in an electroluminescent display panel to reduce the reflection of ambient light impinging on the display panel.

Referring to Fig. 2, a metal assist structure 22 is in electrical contact with a transparent electrode 12 and extends for the entire length of the electrode 12. The metal assist structure 22 can include one or more layers of an electrically conductive metal compatible with the transparent electrode 12 and other structures in the TFEL display panel. To decrease the amount of light transmissive area covered by the metal assist structure 22, the metal assist structure should cover only a small portion of the transparent electrode 12. For example, the metal assist structure 22 can cover about 10% or less of the transparent electrode 12. Therefore, for a typical transparent electrode 12 that is about $250\text{ }\mu\text{m}$ (10 mils) wide, the metal assist structure 22 should overlap the transparent electrode by about $25\text{ }\mu\text{m}$ (1 mill) or less. Overlaps as small as

about 6 μm (0.25 mils) to about 13 μm (0.5 mils) are desirable. Although the metal assist structure 22 should overlap the transparent electrode 12 as little as possible, the metal assist structure should be as wide as practical to decrease electrical resistance. For example, a metal assist structure 22 that is about 50 μm (2 mils) to about 75 μm (3 mils) wide may be desirable. These two design parameters can be satisfied by allowing the metal assist structure 22 to overlap the glass panel 10 as well as the transparent electrode 12. With current fabrication methods, the thickness of the metal assist structure 22 should be equal to or less than the thickness of the first dielectric layer 16 to ensure that the first dielectric layer 16 adequately covers the transparent electrode 12 and metal assist structure. For example, the metal assist structure 22 can be less than about 250 nm thick. Preferably, the metal assist structure 22 will be less than about 200 nm thick, such as between about 150 nm and about 200 nm thick. However, as fabrication methods improve, it may become practical to make metal assist structures 22 thicker than the first dielectric layer 16.

The TFEL display panel also includes a layer of light absorbing dark material 24 to reduce the amount of ambient light reflected by the aluminum rear electrodes 20, and hence improve the display's contrast. The dark layer 24 should be in direct contact with the aluminum rear electrodes 20 and have a resistivity large enough to reduce electrical crosstalk between the rear electrodes 20, which is a result of leakage currents between the rear electrodes. Preferably, the dark material should have a resistivity

at least 10^8 ohms/cm. The layer of dark material 24 should also have a dielectric constant which is at least equal to or greater than the dielectric constant of the second dielectric 18, and preferably have a dielectric constant greater than seven. In order to provide a diffuse reflectance of less than 0.5%, the dark material should also have a light absorption coefficient of about 10^5 /cm.

Candidate materials for the layer of dark material 24 include Ge, CdTe, CdSe, Sb_2S_3 , GeN and $PrMnO_3$. The use of Ge has been marginally successfully and a more appropriate material may be GeN due to its higher breakdown threshold. $PrMnO_3$ in the proper composition has resistivity of greater than 10^8 ohms/cm, a dielectric constant between 200 and 300, and a light absorption coefficient of greater than 10^5 /cm at 500 nm. This combination of properties makes $PrMnO_3$ the preferred black layer material. Pr-Mn oxide films can be deposited using RF sputtering techniques with substrate temperatures ranging between 200-350 degree C in an Ar or Ar+O₂ atmosphere. Fig. 3 is an illustration of how the resistivity and dielectric constant of the $PrMnO_3$ can be tailored for the particular application by varying the composition of the Pr-Mn oxide film. Note that the extremely high dielectric constant achievable with $PrMnO_3$ as shown along a line 25, implies that $PrMnO_3$ can be utilized without having to significantly increase the display's threshold voltage.

Referring to Fig. 4, a preferred embodiment of the metal assist structure 22 is a sandwich of an adhesion layer 26, a first refractory metal layer 28, a primary conductor layer 30, and a second refractory metal layer 32. The adhesion layer 26 promotes the bonding of the

metal assist structure 22 to the glass panel 10 and transparent electrode 12. It can include any electrically conductive metal or alloy that can bond to the glass panel 10, transparent electrode 12, and first refractory metal layer 28 without forming stresses that may cause the adhesion layer 26 or any of the other layers to peel away from these structures. Suitable metals include Cr, V, and Ti. Cr is preferred because it evaporates easily and provides good adhesion.

Preferably, the adhesion layer 26 will be only as thick as needed to form a stable bond between the structures it contacts. For example, the adhesion layer 26 can be about 10 nm to about 20 nm thick. If the first refractory metal layer 28 can form stable, low stress bonds with the glass panel 10 and transparent electrode 12, the adhesion layer 26 may not be needed. In that case, the metal assist structure 22 can have only three layers: the two refractory metal layers 28, 32 and the primary conductor layer 30.

The refractory metal layers 28,32 protect the primary conductor layer 30 from oxidation and prevent the primary conductor layer from diffusing into the first dielectric layer 14 and phosphor layer 16 when the display is annealed to activate the phosphor layer as described below. Therefore, the refractory metal layers 28,32 should include a metal or alloy that is stable at the annealing temperature, can prevent oxygen from penetrating the primary conductor layer 30, and can prevent the primary conductor layer 30 from diffusing into the first dielectric layer 14 or the phosphor layer 16. Suitable metals include W, Mo, Ta, Rh, and Os. Both refractory metal layers 28,32 can be up to about 50 nm thick. Because the resistivity of

the refractory layer can be higher than the resistivity of the primary conductor 30, the refractory layers 28, 32 should be as thin as possible to allow for the thickest possible primary conductor layer 30.

5 Preferably, the refractory metal layers 28, 32 will be about 20 nm to about 40 nm thick.

The primary conductor layer 30 conducts most of the current through the metal assist structure 22. It can be any highly conductive metal or alloy such as Al, 10 Cu, Ag, or Au. Al is preferred because of its high conductivity, low cost, and compatibility with later processing. The primary conductor layer 30 should be as thick as possible to maximize the conductivity of the metal assist structure 22. Its thickness is 15 limited by the total thickness of the metal assist structure 22 and the thicknesses of the other layers. For example, the primary conductor layer 30 can be up to about 200 nm thick. Preferably, the primary conductor layer 30 will be about 50 nm to about 180 nm 20 thick.

The TFEL display of the present invention can be made by any method that forms the desired structures. The transparent electrodes 12, dielectric layers 14,18, phosphor layer 16 and metal electrodes 20 can be made 25 with conventional methods known to those skilled in the art. The metal assist structure 22 can be made with an etch-back method, a lift-off method, or any other suitable method.

The first step in making a TFEL display like the 30 one shown in Fig. 2 is to deposit a layer of a transparent conductor on a suitable glass panel 10. The glass panel can be any high temperature glass that can withstand the phosphor anneal step described below.

For example, the glass panel can be a borosilicate glass such as Corning 7059 (Corning Glassworks, Corning, NY). The transparent conductor can be any suitable material that is electrically conductive and has a sufficient optical transmittance for a desired application. For example, the transparent conductor can be ITO, a transition metal semiconductor that comprises about 10 mole percent In, is electrically conductive, and has an optical transmittance of about 85% at a thickness of about 200 nm. The transparent conductor can be any suitable thickness that completely covers the glass and provides the desired conductivity. Glass panels on which a suitable ITO layer has already been deposited can be purchased from Donnelly Corporation (Holland, MI). The remainder of the procedure for making a TFEL display of the present invention will be described in the context of using ITO for the transparent electrodes. One skilled in the art will recognize that the procedure for a different transparent conductor would be similar.

ITO electrodes 12 can be formed in the ITO layer by a conventional etch-back method or any other suitable method. For example, parts of the ITO layer that will become the ITO electrodes 12 can be cleaned and covered with an etchant-resistant mask. The etchant-resistant mask can be made by applying a suitable photoresist chemical to the ITO layer, exposing the photoresist chemical to an appropriate wavelength of light, and developing the photoresist chemical. A photoresist chemical that contains 2-ethoxyethyl acetate, n-butyl acetate, xylene, and xylol as primary ingredients is compatible with the present invention. One such photoresist chemical is AZ 4210

Photoresist (Hoechst Celanese Corp., Somerville, NJ).
AZ Developer (Hoechst Celanese Corp., Somerville, NJ)
is a proprietary developer compatible with AZ 4210
Photoresist. Other commercially available photoresist
5 chemicals and developers also may be compatible with
the present invention. Unmasked parts of the ITO are
removed with a suitable etchant to form channels in the
ITO layer that define sides of the ITO electrodes 12.
The etchant should be capable of removing unmasked ITO
10 without damaging the masked ITO or glass under the
unmasked ITO. A suitable ITO etchant can be made by
mixing about 1000 ml H₂O, about 2000 ml HCl, and about
370 g anhydrous FeCl₃. This etchant is particularly
effective when used at about 55°C. The time needed to
15 remove the unmasked ITO depends on the thickness of the
ITO layer. For example, a 300 nm thick layer of ITO
can be removed in about 2 min. The sides of the ITO
electrodes 12 should be chamfered, as shown in the
figures, to ensure that the first dielectric layer 14
20 can adequately cover the ITO electrodes. The size and
spacing of the ITO electrodes 12 depend on the
dimensions of the TFEL display. For example, a typical
12.7 cm (5 in) high by 17.8 cm (7 in) wide display can
have ITO electrodes 12 that are about 30 nm thick,
25 about 250 μ m (10 mils) wide, and spaced about 125 μ m (5
mils) apart. After etching, the etchant-resistant mask
is removed with a suitable stripper, such as one that
contains tetramethylammonium hydroxide. AZ 400T
Photoresist Stripper (Hoechst Celanese Corp.) is a
30 commercially available product compatible with the AZ
4210 Photoresist. Other commercially available
strippers also may be compatible with the present
invention.

After forming ITO electrodes 12, layers of the metals that will form the metal assist structure are deposited over the ITO electrodes with any conventional technique capable of making layers of uniform
5 composition and resistance. Suitable methods include sputtering and thermal evaporation. Preferably, all the metal layers will be deposited in a single run to promote adhesion by preventing oxidation or surface contamination of the metal interfaces. An electron
10 beam evaporation machine, such as a Model VES-2550 (Airco Temescal, Berkeley, CA) or any comparable machine, that allows for three or more metal sources can be used. The metal layers should be deposited to the desired thickness over the entire surface of the
15 panel in the order in which they are adjacent to the ITO.

The metal assist structures 22 can be formed in the metal layers with any suitable method, including etch-back. Parts of the metal layers that will become
20 the metal assist structures 22 can be covered with an etchant-resistant mask made from a commercially available photoresist chemical by conventional techniques. The same procedures and chemicals used to mask the ITO can be used for the metal assist
25 structures 22. Unmasked parts of the metal layers are removed with a series of etchants in the opposite order from which they were deposited. The etchants should be capable of removing a single, unmasked metal layer without damaging any other layer on the panel. A
30 suitable W etchant can be made by mixing about 400 ml H_2O , about 5 ml of a 30 wt% H_2O_2 solution, about 3 g KH_2PO_4 , and about 2 g KOH. This etchant, which is particularly effective at about 40°C, can remove about

40 nm of a W refractory metal layer in about 30 sec. A suitable Al etchant can be made by mixing about 25 ml H₂O, about 160 ml H₃PO₄, about 10 ml HNO₃, and about 6 ml CH₃COOH. This etchant, which is effective at room temperature, can remove about 120 nm of an Al primary conductor layer in about 3 min. A commercially available Cr etchant that contains HClO₄ and Ce(NH₄)₂(NO₃)₆ can be used for the Cr layer. CR-7 Photomask (Cyantek Corp., Fremont, CA) is one Cr etchant compatible with the present invention. This etchant is particularly effective at about 40°C. Other commercially-available Cr etchants also may be compatible with the present invention. As with the ITO electrodes 12, the sides of the metal assist structures 22 should be chamfered to ensure adequate step coverage.

The dielectric layers 14,18 and phosphor layer 16 can be deposited over the ITO lines 12 and metal assist structures 22 by any suitable conventional method, including sputtering or thermal evaporation. The two dielectric layers 14,18 can be any suitable thickness, such as about 80 nm to about 250 nm thick, and can comprise any dielectric capable of acting as a capacitor to protect the phosphor layer 16 from excessive dc currents. Preferably, the dielectric layers 14,18 will be about 200 nm thick and will comprise SiO_xN_x. The phosphor layer 16 can be any conventional TFEL phosphor, such as ZnS doped with less than about 1% Mn, and can be any suitable thickness. Preferably, the phosphor layer 16 will be about 500 nm thick. After these layers are deposited, the display should be heated to about 500°C for about 1 hour to anneal the phosphor. Annealing causes Mn atoms to

migrate to Zn sites in the ZnS lattice from which they can emit photons when excited.

After annealing the phosphor layer 16, metal electrodes 20 are formed on the second dielectric layer 18 by any suitable method, including etch-back or lift-off. The metal electrodes 20 can be made from any highly conductive metal, such as Al. As with the ITO electrodes 12, the size and spacing of the metal electrodes 20 depend on the dimensions of the display. For example, a typical 12.7 cm (5 in) high by 17.8 cm (7 in) wide TFEL display can have metal electrodes 20 that are about 100 nm thick, about 250 μ m (10 mils) wide, and spaced about 125 μ m (5 mils) apart. The metal electrodes 20 should be perpendicular to the ITO electrodes 12 to form a grid.

Fig. 5 shows an alternate embodiment of the present invention. In this embodiment, the image is viewed from the colored filter 38 side of the display, rather than the glass panel 10 side. The colored filter 38 allows a multicolored image, rather than a monochrome image to be produced. This alternative embodiment places the Al electrodes 20 on the glass panel 10, the layer of light absorbing dark material 24 on the Al electrodes 20, followed by the layer of first dielectric material 14 covering the layer of dark material 24. Phosphor layer 16 is placed between the layer of first dielectric material 14 and the layer of second dielectric material 18. A plurality of transparent electrodes 12 each incorporating the metal assist structure 22 illustrated in Fig. 4 are then placed on the layer of second dielectric material 18. A planarization layer 39 is placed over the non-covered portions of the second dielectric layer 18, the

transparent electrodes 12, and the metal assist structures 22 to create a planar surface onto which the color filter 38 such as a glass plate with adjacent red and green stripes is disposed. The planarization layer 5 39 may include materials such as spun-on-glass, a transparent polymer material, or a liquid glass. A person skilled in the art will know how to modify the method of making a TFEL display described above to make a display like that shown in Fig. 5. For example, a 10 person skilled in the art will know that the transparent electrodes 12 can be formed on the second dielectric layer 18 after the phosphor layer 16 is annealed.

Fig. 6 shows yet another alternative embodiment of 15 the present invention. The embodiment of Fig. 6 is similar to the embodiment of Fig. 2; the two embodiments differ primarily in that the position of the dark layer 24 and the second dielectric layer 18 are reversed. The remaining layers in the embodiment 20 illustrated in Fig. 6 incorporate the same or substantially the same materials as the embodiment in Fig. 2.

In addition to the embodiments shown in Figs. 2, 5, and 6, the TFEL display of the present invention can 25 have any other configuration that would benefit from the combination of low resistance electrodes and a light absorbing dark layer.

The present invention provides several benefits 30 over the prior art. For example, the combination of low resistance electrodes and a layer of light absorbing dark material make TFEL displays of all sizes capable of achieving higher contrast and higher brightness through an increased refresh rate. This

5 makes large TFEL displays, such as a display about 91
cm (36 in) by 91 cm feasible since low resistance
electrodes can provide enough current to all parts of
the panel to provide even brightness across the entire
panel, and the dark layer material reduces the
reflection of ambient light to improve the panel's
contrast. A display with low resistance electrodes and
a dark layer can be critical in achieving sufficient
contrast to provide a directly sunlight viewable thin
10 film electroluminescent display.

Although the invention has been shown and
described with respect to a preferred embodiment
thereof, it should be understood by those skilled in
the art that various other changes, omissions, and
15 additions may be made to the embodiments disclosed
herein, without departing from the spirit and scope of
the present invention.

We claim:

Claims

- 1 1. A sunlight viewable electroluminescent display
2 panel, comprising:
3 a glass substrate;
4 a plurality of parallel transparent electrodes
5 deposited on said glass substrate, each of said
6 transparent electrodes having a metal assist structure
7 formed on, and in electrical contact over, a portion of
8 said transparent electrodes;
9 a first dielectric layer deposited on said
10 plurality of transparent electrodes;
11 a layer of phosphor material deposited on said
12 first dielectric layer;
13 a second dielectric layer deposited on said layer
14 of phosphor material;
15 a layer of light absorbing dark material,
16 deposited on said second dielectric layer, for reducing
17 reflected light; and
18 a plurality of metal electrodes each deposited in
19 parallel over said layer of light absorbing dark
20 material.
- 1 2. The sunlight viewable electroluminescent display
2 panel of claim 1, wherein each of said metal assist
3 structures comprises a first refractory metal layer, a
4 primary conductor layer formed on the first refractory
5 layer, and a second refractory metal layer formed on
6 the primary conductor layer such that said first and
7 second refractory metal layers are capable of
8 protecting the primary conductor layer from oxidation
9 when the electroluminescent display is annealed to
10 activate said phosphor layer.

1 3. The sunlight viewable electroluminescent display
2 panel of claim 2 wherein said metal assist structure
3 covers about 10% or less of said transparent electrode.

1 4. The sunlight viewable electroluminescent display
2 panel of claim 2 wherein said layer of light absorbing
3 dark material is PbMnO_3 .

1 5. The sunlight viewable electroluminescent display
2 panel of claim 1 wherein said layer of light absorbing
3 dark material has a resistivity of least 10^8 ohms/cm.

1 6. The sunlight viewable electroluminescent display
2 panel of claim 1 wherein said layer of light absorbing
3 dark material has a dielectric constant of at least
4 seven.

1 7. The sunlight viewable electroluminescent display
2 panel of claim 1 wherein said layer of light absorbing
3 dark material has an absorption coefficient of about
4 $10^5/\text{cm}$.

1 8. The sunlight viewable electroluminescent display
2 panel of claim 1 wherein said layer of light absorbing
3 dark material is GeN.

1 9. The sunlight viewable electroluminescent display
2 panel of claim 2 wherein the edges of said metal assist
3 structure are chamfered.

1 10. The sunlight viewable electroluminescent display
2 panel of claim 9 wherein said layer of light absorbing
3 dark material is a distinct dark layer.

1 11. The sunlight viewable electroluminescent display
2 panel of claim 2, wherein said metal assist structure
3 further comprises an adhesion layer formed between said
4 first refractory metal layer and the transparent
5 electrode, wherein said adhesion layer is capable of
6 adhering to the transparent electrode and said first
7 refractory metal layer.

1 12. The sunlight viewable electroluminescent display
2 panel of claim 11 wherein said metal assist structure
3 covers about 10% or ⁸less of said transparent electrode.

1 13. The sunlight viewable electroluminescent display
2 panel of claim 12 wherein said layer of light absorbing
3 dark material is PbMnO_3 .

4 14. The sunlight viewable electroluminescent display
5 panel of claim 13 wherein said layer of light absorbing
6 dark material has a resistivity of least 10^8 ohms/cm.

1 15. The sunlight viewable electroluminescent display
2 panel of claim 14 wherein said layer of light absorbing
3 dark material has a dielectric constant of at least
4 seven.

1 16. The sunlight viewable electroluminescent display
2 panel of claim 15 wherein said layer of light absorbing
3 dark material has an absorption coefficient of about
4 $10^5/\text{cm}$.

1 17. The sunlight viewable electroluminescent display
2 panel of claim 16 wherein said layer of light absorbing
3 dark material is GeN .

1 18. The sunlight viewable electroluminescent display
2 panel of claim 17 wherein the edges of said metal
3 assist structure are chamfered.

1 19. The sunlight viewable electroluminescent display
2 panel of claim 18 wherein said layer of light absorbing
3 dark material is a distinct dark layer.

1 20. An inverse viewable sunlight viewable
2 electroluminescent display panel, comprising:
3 a glass substrate;
4 a plurality of metal electrodes each deposited in
5 parallel over said glass substrate;
6 a layer of light absorbing dark material formed
7 over each of said plurality of metal electrodes and
8 exposed portions of said glass substrate;
9 a first dielectric layer deposited on said layer
10 of light absorbing dark material;
11 a layer of phosphor material deposited on said
12 first dielectric layer;
13 a second dielectric layer deposited on said layer
14 of phosphor material; and
15 a plurality of parallel transparent electrodes
16 deposited on said second dielectric layer, each of said
17 transparent electrodes having a metal assist structure
18 formed on, and in electrical contact over a portion of
19 said transparent electrodes.

20 21. The sunlight viewable electroluminescent display
21 panel of claim 20 further comprising
22 a planarization layer deposited on each of said
23 plurality of parallel transparent electrodes and
24 exposed portions of said second dielectric material to

25 create a planar surface; and
26 a color filter on said planar surface.

1 22. The sunlight viewable electroluminescent display
2 panel of claim 20, wherein each of said metal assist
3 structures comprises a first refractory metal layer, a
4 primary conductor layer formed on the first refractory
5 layer, and a second refractory metal layer formed on
6 the primary conductor layer such that the first and
7 second refractory metal layers are capable of
8 protecting the primary conductor payer from oxidation
9 when the electroluminescent display is annealed to
10 activate said phosphor layer.

1 23. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said metal assist structure
3 covers about 10% or less of said transparent electrode.

1 24. The sunlight viewable electroluminescent display
2 panel of claim 23 wherein said layer of light absorbing
3 dark material is PrMnO_3 .

1 25. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said layer of light absorbing
3 dark material has a resistivity of least 10^8 ohms/cm.

1 26. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said layer of light absorbing
3 dark material has a dielectric constant of at least
4 seven.

1 27. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said layer of light absorbing
3 dark material has an absorption coefficient of about
4 $10^5/\text{cm}$.

1 28. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said layer of light absorbing
3 dark material is GeN.

1 29. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein the edges of said metal
3 assist structure are chamfered.

1 30. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said layer of light absorbing
3 dark material is a distinct dark layer.

1 31. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said layer of light absorbing
3 dark material is a graded layer of light absorbing dark
4 material.

1 32. The sunlight viewable electroluminescent display
2 panel of claim 31 wherein said graded layer of light
3 absorbing dark material comprises a nonstoichiometric
4 silicon nitride, SiN_x .

1 33. The sunlight viewable electroluminescent display
2 panel of claim 22, wherein said metal assist structure
3 further comprises an adhesion layer formed between said
4 first refractory metal layer and the transparent
5 electrode, and said adhesion layer is capable of
6 adhering to the transparent electrode and said first
7 refractory metal layer.

1 34. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said planarization layer
3 comprises a spun-on-glass material.

1 35. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said planarization layer
3 comprises a transparent polymer.

1 36. The sunlight viewable electroluminescent display
2 panel of claim 22 wherein said planarization layer
3 comprises liquid glass.

FIG.1 PRIOR ART

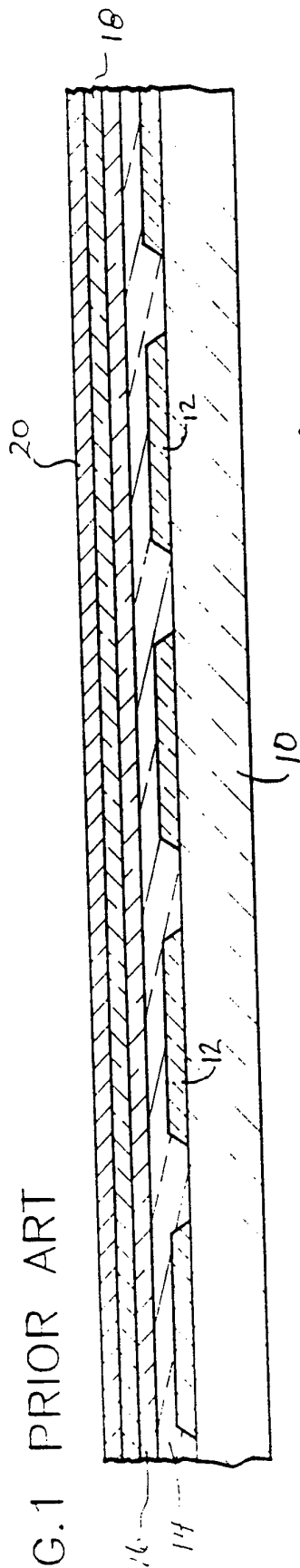


FIG.2

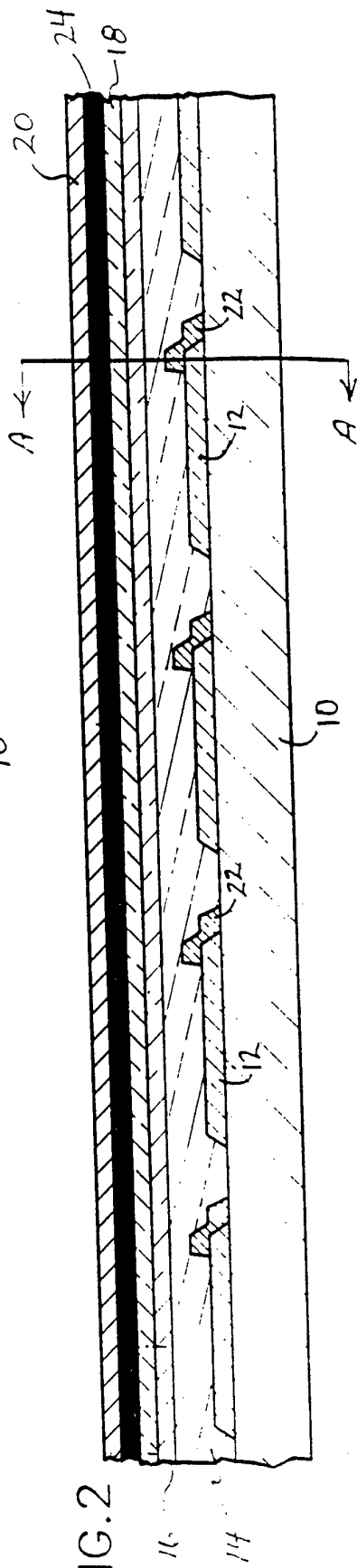
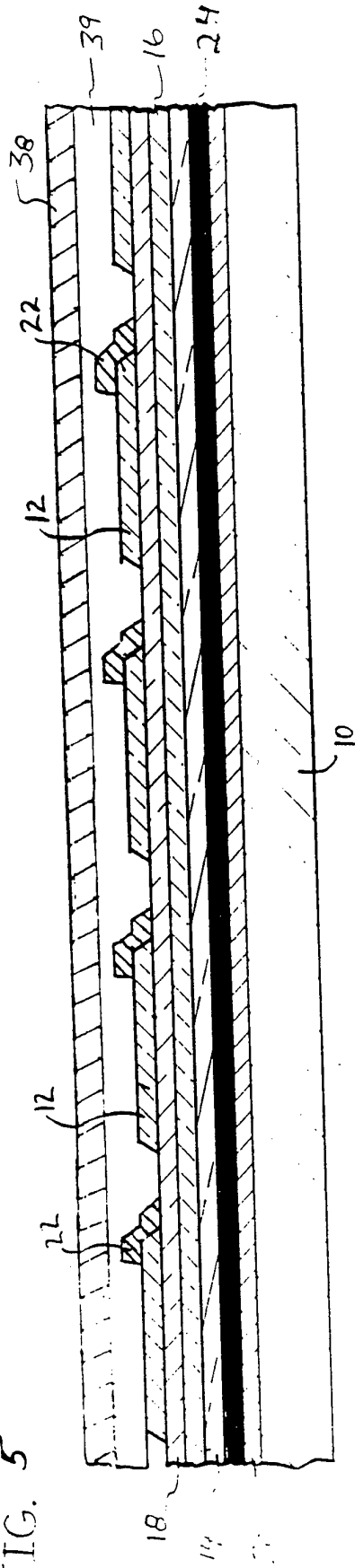
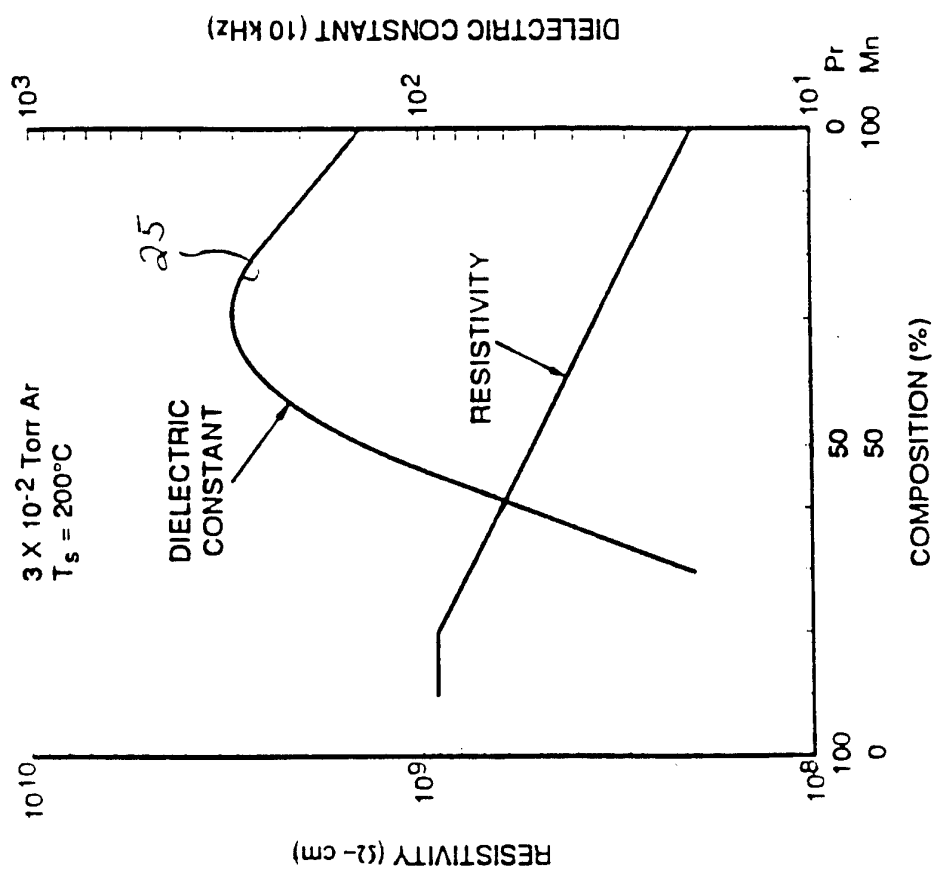


FIG. 5



FIG. 3

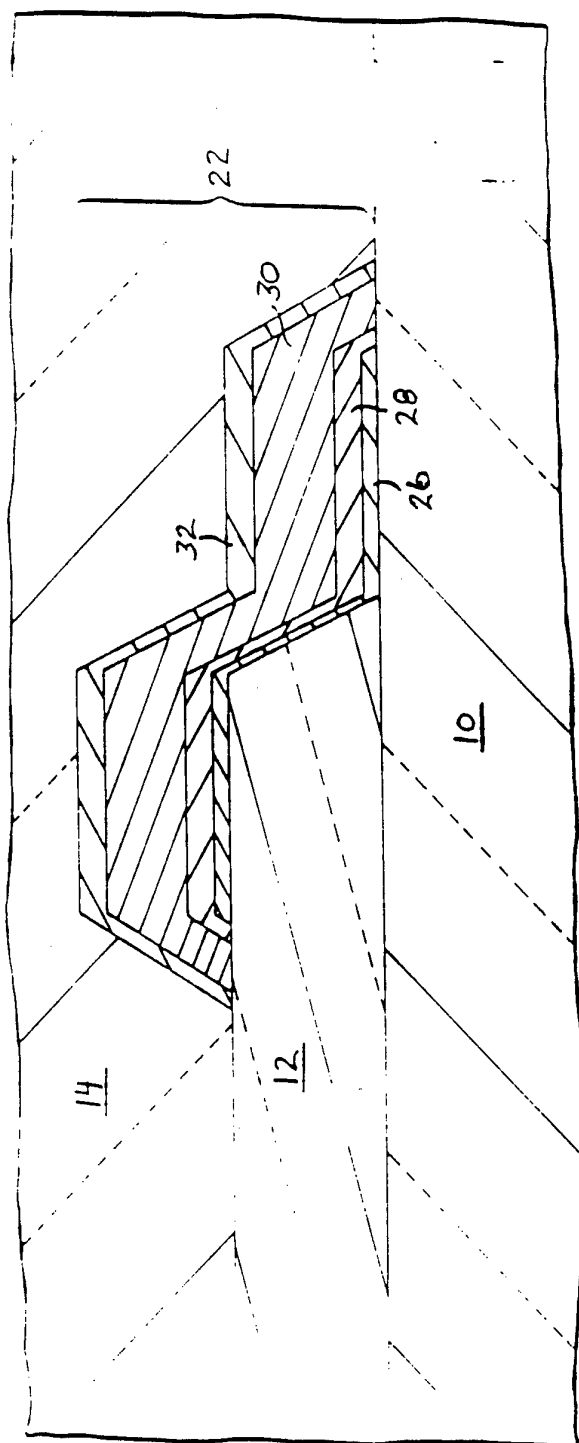
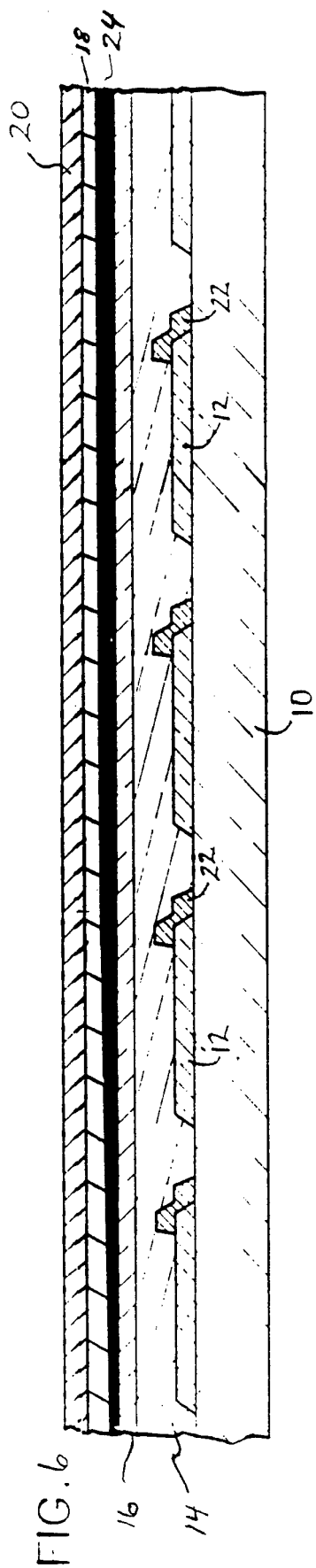


FIG. 4



INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 93/12139

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 H05B33/22 H05B33/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO,A,93 26139 (UNITED TECHNOLOGIES) cited in the application see page 10, line 22 - page 11, line 6; claims 1-44; figures 1-4; example 1 ---	1-3,9, 11,12, 18,19
X	JOURNAL OF THE ELECTROCHEMICAL SOCIETY vol. 138, no. 7, July 1991, MANCHESTER.US pages 2070 - 2075 O.J.GREGORY & AL 'fabrication of high-conductivity, transparent electrodes with trenched metal bus lines' --- -/--	1-3,9, 11,12, 18,22, 23,29



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

7 March 1994

Date of mailing of the international search report

25.03.94

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PROCEEDINGS OF THE SID vol. 31, no. 1 , 1990 , NEW YORK US pages 37 - 40 S.K.TIKU 'high-contrast dark field tfe display' ---	1,4-8, 10, 13-17, 19, 24-28, 30-32
A	EP,A,0 159 531 (MATSUSHITA ELECTRIC) 30 October 1985 see page 12, line 24 - page 14, line 4; claims 1-11 ---	1,4-7, 10,13-16
A	US,A,4 870 322 (T.MATSUDAIRA & AL) 26 September 1989 see claims 1-51 ---	1,8,10, 17,19
A	EP,A,0 483 783 (GOLDSTAR) 6 May 1992 see column 2, line 4-6; claims 1-12 ---	1,5,10, 14,19, 25,30-32
A	APPLIED OPTICS vol. 31, no. 1 , October 1992 , NEW YORK,US pages 5988 - 5996 J.A.DOBROWOLSKI & AL 'optical interference,contrast-enhanced electroluminescent device' -----	1,10

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. .onal Application No

PCT/US 93/12139

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		JP-A- 60200491	09-10-85
		JP-B- 63037477	26-07-88
		JP-B- 1048630	19-10-89
		JP-C- 1576329	24-08-90
		JP-A- 61029095	08-02-86
		DE-A- 3561435	18-02-88
		US-A- 4668582	26-05-87
US-A-4870322	26-09-89	NONE	
EP-A-0483783	06-05-92	NONE	