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## (54) Thin film semiconductor device and liquid crystal display unit, and fabrication methods thereof

Dünnschicht-Halbleitervorrichtung, FlüssigkristallAnzeigeeinheit und deren Herstellungsverfahren

Dispositif semi-conducteur à couches minces et unité d'affichage à cristaux liquides et leurs procédés de fabrication

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- PATENT ABSTRACTS OF JAPAN vol. 011, no. 376 (E-563), 8 December 1987 (1987-12-08) -& JP 62 143469 A (HITACHI LTD), 26 June 1987 (1987-06-26)
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## Description

### BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to a thin film semiconductor device and a liquid crystal display unit, and fabrication methods thereof. In particular, the present invention concerns a gate interconnection structure and a light shield structure for thin film transistors integrated on a thin film semiconductor.

**[0002]** Thin film semiconductors, on each of which thin film transistors and pixel electrodes are integrated, are being widely used for substrates for driving liquid crystal display units. In particular, a thin film semiconductor device built in a liquid crystal display unit for a projector is essential to have a light shield structure for shielding thin film transistors from intensive light coming from a liquid source of the projector. One example of such a liquid crystal display unit is shown in FIG. 5. As shown in this figure, the liquid crystal display unit uses a thin film transistor for driving each pixel electrode 8. The thin film transistor is typically composed of a high temperature polysilicon TFT; however, it may be composed of a low temperature polysilicon TFT or an amorphous silicon TFT. The liquid crystal display unit shown in the figure is disclosed, for example, in Japanese Patent Laid-open No. Hei 2000-131716. As shown in the figure, the liquid crystal display unit includes a substrate 1 (quartz for supporting TFTs) having TFTs 7 as pixel transistors and a counter substrate 2, with liquid crystal 3 held between the substrate 1 and the counter substrate 2. The counter substrate 2 has a counter electrode 6.

**[0003]** Referring to FIG. 5, the substrate 1 has a pixel electrode 8 in an upper layer portion, and a TFT (thin film transistor, which has a top gate structure herein) in a lower layer portion. The TFT 7 is used as a switching element for driving the pixel electrode 8. The TFT 7 has, as an active layer, a semiconductor thin film 10 which is made from first layer polysilicon. A gate electrode G is formed on the semiconductor thin film 10 via a gate insulating film 11 made from  $\text{SiO}_2$ . The gate electrode G is made from second layer polysilicon. The TFT 7 has a source region S and a drain region D on both sides of the gate electrode G. LDD regions 71 and 72 are formed at end portions of the source and drain regions, respectively. Extraction electrodes 12A and 12B are connected to the source region S and the drain region D, respectively. Each of the extraction electrodes 12A and 12B is made from an aluminum based material such as aluminum. The extraction electrode 12A is electrically connected to the source region S of the TFT 7 via a contact hole SCN, and the extraction electrode 12B is electrically connected to the drain region D of the TFT 7 via a contact hole DCN.

**[0004]** The semiconductor thin film 10 includes an auxiliary capacitance (Cs) 13. The auxiliary capacitance (Cs) 13 is formed by holding a dielectric film made from, for example,  $\text{SiO}_2$  forming the gate insulating film 11 be-

tween the first layer polysilicon forming the semiconductor thin film 10, that is, the TFT 7, and the second layer polysilicon forming a semiconductor thin film 14, that is, the gate electrode G.

**[0005]** Light shield layers 4M and 4P are formed in an intermediate layer portion between the upper layer portion having the pixel electrode 8 and the lower layer portion having the TFT 7. The light shield layers 4M and 4P are located on the counter substrate 2 side with respect to the TFT 7, that is, on the light coming side, and therefore, they are called "upper side light shield layers". That is to say, the upper side light shield layers herein are composed of the mask shield layer 4M and the pad shield layer 4P. With the aid of the two upper side light shield layers (mask shield layer 4M and pad shield layer 4P) and the extraction electrodes 12A and 12B (each of which is made from aluminum herein) overlapped to the upper side light shield layers, the overall pixel region except for a pixel opening is shielded from light coming from the counter substrate 2 side. Each of the mask shield layer 4M and the pad shield layer 4P is made from a conductive material, for example, a metal such as Ti. The mask shield layer 4M is continuously patterned along the row direction (cross direction) of the pixels, and shields the TFT at least partially from external light. The pad shield layer 4P is patterned discretely for each pixel, and contributes to the contact with the pixel electrode 8. To be more specific, the pixel electrode 8 is connected to the pad shield layer 4P via contact hole PCN. The pad shield layer 4P is connected to the extraction electrode 12B via a contact hole JCN. The extraction electrode 12B is, as described above, connected to the drain region D of the TFT 7 via the contact hole DCN. By providing the mask shield layer 4M and the pad shield layer 4P and the extraction electrodes 12A and 12B overlapped to the shield layers 4M and 4P, the overall pixel region except for the pixel opening can be shielded from light coming from the counter substrate side.

**[0006]** On the other hand, a light shield layer 5 is formed on a portion, opposed to the counter substrate 2 side, of the pixel transistor portion. This light shield layer 5 is called "lower light shield layer". At least the end portions of the source and drain of the pixel transistor 7, and the LDD regions 71 and 72 are formed at the end portions of the source and drain thus shielded from external light. In general, the lower light shield layer 5 is made from a silicide of a refractory metal, such as WSi and has a thickness of 200 nm.

**[0007]** To satisfy recent strong demands toward higher luminance of a liquid crystal projector, the liquid crystal panel of the type shown in FIG. 5 has been required to be improved in terms of its transmittance. At the same time, the liquid crystal panel shown in FIG. 5 has been required to keep a high image quality even under a condition with a large quantity of light coming from a light source for a projector. To meet these market requirements for the liquid crystal panel of the type shown in FIG. 5, there have been adopted a method (1) of improv-

ing the transmittance by increasing the pixel opening rate, and a method (2) of keeping a high image quality by increasing the area of an auxiliary capacitance (Cs). The methods (1) and (2), however, are essentially inconsistent with each other. Namely, if the auxiliary capacitance (Cs) is increased, the pixel opening rate is reduced. The reason why the methods (1) and (2) have been simultaneously adopted is due to the fact that there has been a margin of the layout of pixels. However, along with tendency toward higher definition of a liquid crystal projector, it has been difficult to realize the layout of pixels with such a margin, and it has become impossible to achieve higher pixel opening rate on the basis of the related art pixel structure.

**[0008]** FIG. 6 is a schematic plan view of the prior art liquid crystal display unit shown in FIG. 5, particularly, one pixel region of the liquid crystal display unit. As shown in the figure, the liquid crystal display unit includes a plurality of signal interconnections 12 and gate interconnections crossing the signal interconnections 12. Pixels are provided at crossing points between the signal interconnections extending to column direction (longitudinal direction) and the gate interconnections extending in the row direction (cross direction). As described above, the pixel includes the pixel electrode, the thin film transistor for driving the pixel electrode, and the light shield band (light shield layer) for shielding the thin film transistor from external light. The thin film transistor has, as the active layer, the semiconductor thin film 10. The source region of the semiconductor thin film 10 is connected to the signal interconnection 12 via the contact hole SCN; the drain region thereof is connected to the pixel electrode (not shown) via the contact hole DCN; and the gate electrode G thereof is formed as part of the gate interconnection. In addition, the gate interconnection is formed of the semiconductor thin film (made from second layer polysilicon) 14 different from the semiconductor thin film (made from first layer polysilicon) 10. The pixel also includes the auxiliary capacitance 13. The auxiliary capacitance 13 has such a stacked structure that the dielectric thin film being the same as the gate insulating film is held between the semiconductor thin film (first layer polysilicon) 10 and the semiconductor thin film (second layer polysilicon) 14. The semiconductor thin film 10 forming the lower electrode of the auxiliary capacitance 13 exhibits the same potential as that of the drain of the thin film transistor, and the semiconductor thin film 14 forming the upper electrode of the auxiliary capacitance 13 is connected to the upper side extraction electrode (not shown) made from aluminum via a contact hole CCN. The extraction electrode is further connected to the upper side mask shield layer via a contact hole MCN. The pixel electrode (not shown) is connected to the drain region D of the thin film transistor via the contact holes PCN, JCN and DCN. As shown in the figure, the gate electrode G is formed of the semiconductor thin film 14 (second layer polysilicon) which extends in the cross direction, to form the gate interconnection. Part of the semiconductor thin film 14, which is

taken as the upper electrode of the auxiliary capacitance 13, exhibits a potential different from that of the gate interconnection. Accordingly, although both the gate interconnection and the upper electrode of the auxiliary capacitance 13 are formed of the same semiconductor thin film 14, they are required to be electrically separated to each other with a specific gap (GAP) put therebetween. That is to say, in this pixel structure, since the gate interconnection and the upper electrode of the auxiliary capacitance 13 are disposed in parallel to each other, the gap (GAP) must be provided therebetween, with a result that the pixel opening rate is reduced. To improve the pixel operating rate, as is easily understood, it is effective to form the gate interconnection and the upper electrode of the auxiliary capacitance 13 as separate layers; however, the prior art structure shown in FIG. 6 has failed to examine such a layout of the gate interconnection and the upper electrode of the auxiliary capacitance 13.

**[0009]** FIG. 7 is a graph showing a relationship between a pixel opening rate and the area of the auxiliary capacitance (Cs) in the prior art structure shown in FIG. 6. As the pixel opening rate is increased, the area of the auxiliary capacitance is sacrificed and is significantly reduced. This is because the gate interconnection and the upper electrode of the auxiliary capacitance (auxiliary capacitance interconnection) are formed of the same layer and are disposed in parallel to each other. Such a parallel layout of the gate interconnection and the auxiliary capacitance interconnection makes it difficult to improve the pixel opening rate while ensuring the area of the auxiliary capacitance.

**[0010]** Further information pertaining to the prior art can be found in JP 08-234239 which discloses, for the purpose of lowering the resistance of wiring patterns by utilizing light shield patterns, a display device having a display substrate with pixels arranged in a matrix form, a transparent counter substrate joined to this display substrate interposing a prescribed spacing and liquid crystals held in the spacing therebetween. Pixel electrodes, transistor elements and capacitor elements disposed every pixel are formed on the display substrate. Gate wiring patterns and auxiliary wiring patterns are formed for electrical connection of the individual transistor and capacitor elements. The wiring patterns consist of semiconductor films having a relatively high resistance. Further, light shielding patterns consisting of metallic films having a relatively low resistance are formed for a black matrix in the peripheries of the individual pixel electrodes. Contact parts are formed and the light shielding patterns are electrically connected to either of the gate wiring patterns and the auxiliary wiring patterns to lower the resistance of the wiring patterns.

**[0011]** JP 62-143469 teaches, for the purpose of reliably preventing a decrease in OFF resistance and for preventing the production of a floating capacity, a thin-film transistor wherein light-shielding films are electrically connected to a gate electrode for providing them with the same potential. In particular, it teaches a thin-film trans-

sistor wherein lower and upper light-shielding films are formed in a size large enough to cover the most part of the side of a data line of a gate electrode. A conductive metal is deposited within a through hole said that the lower light-shielding film, the data line and the upper light-shielding film are electrically connected with each other by means of the conductive metal. According to such a construction, the films are held at the same potential as those of the gate electrode and the data line and therefore no floating capacity is produced there. Further, since the gate electrode is connected to the power supply line, any noises applied thereto will be easily absorbed. The light-shielding films disclosed in this document do not extend across pixel boundaries.

**[0012]** JP 01-177020 teaches, for the purpose of lowering the resistance of a gate bus wiring and for improving an image grade, an active matrix display device wherein a light shielding film is brought into contact with the gate bus wiring of a transistor thereby making double wirings. In particular, it teaches that the light shielding film that shields the projection of incident light to allow transmission of a liquid crystal to a semiconductor thin film is formed in said film. In addition, the light shielding film is brought into contact with the gate bus wiring. Since the light shielding film shields the irradiation of the incident light to the semiconductor thin film and, therefore, the decrease of the resistance of the thin-film transistor which has the thin film as a part of the constitution is prevented. Since the gate bus wiring is double-wired, the resistance of the gate bus wiring is lowered. The large-size active matrix display device having the high image grade is thereby obtained. In accordance with the teachings of this document, the part of the light shielding film located beneath the gate of the thin film transistor is disjunct from the remainder of the light shielding film and is moreover not electrically connected to said gate.

**[0013]** EP 0 997 769 teaches a liquid crystal display device as so constructed that the scattered or reflected incident rays and even the return rays are prevented from entering the transistor part. The device is free from the problem of photoelectric current leakage. The device comprises an active substrate with a pixel transistor TFT thereon and a counter substrate that faces the active substrate via liquid crystal therebetween, wherein light-shielding layers (upper light-shielding layer, and lower light-shielding layer) are formed to be adjacent to the side of the pixel transistor part that faces the counter substrate and adjacent to the side thereof that faces opposite to the counter substrate and wherein the upper light-shielding layer and the lead electrode shield the entire region except the pixel openings from the incident rays that enter the device through the counter substrate. In a second embodiment thereof, the lower light-shielding layer is connected to the gate in every stage. In a third embodiment thereof, the lower light-shielding layer is spaced for each pixel unit and the respective lower light-shielding layers are separately connected to the gate in each pixel. In all embodiments, the gate line interconnects the gates

of at least two adjacent pixels.

## SUMMARY OF THE INVENTION

- 5 **[0014]** The present invention provides a thin film semiconductor device in accordance with independent claim 1. Preferred embodiments of the invention are reflected in the dependent claims.
- 10 **[0015]** The claimed invention can be better understood in view of the embodiments of a thin film semiconductor device described hereinafter. In general, the described embodiments describe preferred embodiments of the invention.
- 15 **[0016]** An object of the present invention is to improve a pixel opening rate of a thin film semiconductor device used as a drive substrate of an active matrix type liquid crystal display unit while ensuring light protection of the thin film semiconductor device.
- 20 **[0017]** To achieve the above object, a preferred embodiment provides a thin film semiconductor device including: a plurality of signal interconnections and a plurality of gate interconnections crossing the signal interconnections, and pixels disposed at crossing points between the signal and gate interconnections, the signal and gate interconnections and the pixels being provided on an insulating substrate; wherein each of the pixels includes at least a pixel electrode, a thin film transistor for driving the pixel electrode, and a light shield band for shielding the thin film transistor from external light; and
- 25 a source of the thin film transistor is connected to one of the signal interconnections, a drain of the thin film transistor is connected to the pixel electrode, and a gate electrode of the thin film transistor is connected to one of the gate interconnections. This thin film semiconductor device is characterized in that the light shield band is formed of a first conductive layer, and at least part of the light shield band is used as the gate interconnection; the gate electrode is formed of a second conductive layer different from the first conductive layer; and the first conductive layer used for the gate interconnection is electrically connected to the second conductive layer forming the gate electrode within each pixel region.
- 30 **[0018]** Preferably, the second conductive layer forming the gate electrodes is separated from each other for each pixel region, and each of the separated parts of the second conductive layer is electrically connected to the first conductive layer used for the gate interconnection in each pixel region.
- 35 **[0019]** Preferably, the first conductive layer forming the gate interconnection is separated from each other for each pixel region, and each of the separated parts of the first conductive layer is electrically connected to the second conductive layer forming the gate electrode within each pixel region.
- 40 **[0020]** Preferably, the light shield band is composed of two conductive layers for shielding the thin film transistor from above and below, and one of the two conductive layers is used as the first conductive layer for the

gate interconnection.

**[0021]** Preferably, the light shield band is composed of a single conductive layer for shielding the thin film transistor from either above or below, and the single conductive layer is used as the first conductive layer for the gate interconnection.

**[0022]** Preferably, each of the pixels includes an auxiliary capacitance composed of a dielectric substance held between a pair of upper and lower electrodes in order to hold signal charges written from the signal interconnection into the pixel electrode via the thin film transistor; and one of the pair of upper and lower electrodes is formed of the same layer as the second conductive layer forming the gate electrode.

**[0023]** With these configurations, the light shield band for shielding the thin film transistor from external light is formed of the first conductive layer, and at least part of the light shield band is used as the gate interconnection. On the other hand, the gate electrode is formed of the second conductive layer different from the first conductive layer, and is electrically connected to the light shield band within each pixel region. By making use of the light shield layer as the gate interconnection as described above, it is not required to form the gate interconnection and the auxiliary capacitance interconnection with the same layer. For example, by using the lower light shield layer as the gate interconnection, the auxiliary capacitance interconnection formed of the same layer as that forming the gate electrode can be overlapped on the gate interconnection. Since it is not required to ensure the gap (GAP) between the gate interconnection and the auxiliary capacitance interconnection which are made from the same layer, the pixel opening rate can be correspondingly improved.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0024]**

FIG. 1 is a schematic plan view of a liquid crystal display unit of a preferred embodiment;

FIG. 2 is a schematic sectional view of the liquid crystal display unit shown in FIG. 1;

FIGS. 3A and 3B are each an equivalent circuit diagram of one pixel region, wherein FIG. 3A shows the circuit of the liquid crystal display unit shown in FIGS. 1 and 2, and FIG. 3B shows the circuit of a reference example;

FIGS. 4A to 4D are schematic views each showing an electrical connection relationship between a pixel electrode and a light shield layer in the liquid crystal display unit of a preferred embodiment;

FIG. 5 is a sectional view showing one example of a prior art liquid crystal display unit;

FIG. 6 is a plan view of the prior art liquid crystal display unit shown in FIG. 5; and

FIG. 7 is a graph showing a relationship between a pixel opening rate and the area of an auxiliary ca-

pacitance.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

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**[0025]** Hereinafter, a preferred embodiment of the present invention will be described in detail with reference to the accompanying drawings. FIG. 1 is a schematic plan view showing one example of a liquid crystal display unit of the present invention, particularly, only one pixel region of the liquid crystal display unit. In particular, this figure shows a planar configuration of a thin film semiconductor device on the drive substrate side of the liquid crystal display unit. The thin film semiconductor device includes, on an insulating substrate, a plurality of signal interconnections 12 and a plurality of gate interconnections crossing the signal interconnections 12, and pixels disposed at crossing points between the signal and gate interconnections. It is to be noted that in the figure, there is shown only one pixel disposed at a crossing point between one signal interconnection 12 extending in the longitudinal direction and one gate interconnection extending in the cross direction. Each pixel includes at least a pixel electrode (not shown), a thin film transistor for driving the pixel electrode, and a light shield layer (light shield band) 5 for shielding the thin film transistor from external light. The thin film transistor includes a semiconductor thin film (made from first layer polysilicon) 10 formed as a device region on the lower side light shield layer 5. A source of the thin film transistor is connected to the signal interconnection 12 via a contact hole SCN. A drain of the thin film transistor is connected to the pixel electrode (not shown) via contact holes DCN, JCN and PCN. A gate electrode G of the thin film transistor is connected to the gate interconnection. It is to be noted that the gate electrode G is formed of another semiconductor thin film (made from second layer polysilicon) 14 disposed over the semiconductor thin film (made from first layer polysilicon) 10.

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**[0026]** According to features of the present invention, the light shield layer 5 is formed of a first conductive layer, and at least part of the light shield layer 5 is fused as the gate interconnection; the gate electrode G is formed of a second conductive layer (that is, the semiconductor thin film 14 heavily doped with an impurity) different from the first conductive layer; and the first conductive layer used for the gate interconnection and the second conductive layer (semiconductor thin film 14) forming the gate electrode G are electrically connected to each other via a contact hole GCN within each pixel region. In summary, according to the present invention, the layer forming the gate electrode G is different from the layer forming the gate interconnection, and both the gate electrode G and the gate interconnection are three-dimensionally connected to each other via the contact hole GCN within each pixel region. As a further feature of the present invention, the second conductive layer (semiconductor thin film 14) for forming the gate electrodes G is separated

from each other for each pixel, and each of the separated parts (gate electrodes G) of the second conductive layer is electrically connected to the first conductive layer (light shield layer 5) used for the gate interconnection within each pixel region.

**[0027]** The pixel includes an auxiliary capacitance 13 in addition to the above-described thin film transistor and pixel electrode. The auxiliary capacitance 13 functions to hold signal charges written from the signal interconnection 12 into the pixel electrode via the thin film transistor so as to keep an image quality. The auxiliary capacitance 13 has a stacked structure in which a dielectric substance is held between a pair of upper and lower electrodes. The upper electrode of the auxiliary capacitance 13 is formed of the same layer as the second conductive layer (semiconductor thin film 14) forming the gate electrode G. The lower electrode of the auxiliary capacitance 13 is formed of the same layer as the semiconductor thin film 10. The dielectric substance of the auxiliary capacitance 13 is formed of the same insulating film as a gate insulating film held between the pair of upper and lower electrodes 14 and 10. As is apparent from the figure, the auxiliary capacitance 13 can be overlapped to the light shield layer 5 forming the gate interconnection. As a result, according to the structure of the present invention, the pixel opening rate can be significantly enlarged as compared with the related art structure. Such a structure of the present invention is realized by replacing part of the gate interconnection, which has been the same layer as the layer forming the gate electrode G, with a different layer, that is, the light shield layer 5. To be more specific, the gate interconnection is formed of the lower light shield layer 5 made from WSi for example, and the gate electrode G is formed of the semiconductor thin film 14 (made from second layer polysilicon) like the related art structure. The gate interconnection and the gate electrode G are electrically connected to each other via the contact hole GCN. On the other hand, the upper electrode of the auxiliary capacitance 13 is formed of the semiconductor thin film 14 (made from the second layer polysilicon) which is the same layer as that forming the gate electrode G. Since the layer forming the gate interconnection is different from the layer forming the upper electrode (auxiliary capacitance interconnection) of the auxiliary capacitance 13, the auxiliary capacitance 13 can be formed over the light shield layer 5 forming the gate interconnection, to thereby significantly improve the pixel opening rate.

**[0028]** FIG. 2 is a sectional view, taken on line X-X of FIG. 1, showing a structure of the liquid crystal display unit. Referring to this figure, the liquid crystal display unit includes a pair of substrates 1 and 2 jointed to each other with a specific gap held therebetween, and liquid crystal 3 held in the gap. One substrate 1 has, as described above, the plurality of signal interconnections 12 and the plurality of gate interconnections crossing the signal interconnections 12, and the pixels disposed at crossing points between the signal and gate interconnections. The

other substrate (counter substrate) 2 has an electrode (counter electrode) 6 facing to respective pixels.

**[0029]** The lower light shield layer 5 is formed on the surface of the lower substrate 1, and the thin film transistor and the auxiliary capacitance 13 are formed thereon via an insulating film 9. The thin film transistor has a top gate structure in which the gate electrode G is disposed on the semiconductor thin film 10 of a dual structure via a gate insulating film 11. As described above, the gate electrodes G are separated from each other for each pixel region, and each gate electrode G is electrically connected to the light shield layer 5 serving as the gate interconnection via the contact hole GCN. On the other hand, the auxiliary capacitance 13 is composed of the lower semiconductor thin film 10, the upper semiconductor thin film 14, and the gate insulating film 11 held therebetween. As is apparent from the figure, the upper electrode of the auxiliary capacitance 13 and the gate electrode G are formed of the same semiconductor thin film (made from second layer polysilicon) 14. The thin film transistor and the auxiliary capacitance 13 configured as described above are covered with an interlayer insulating film. The signal interconnection 12 and an extraction electrode 12C are formed on the interlayer insulating film. Each of the signal interconnection 12 and the extraction electrode 12C is made from aluminum, and the surfaces thereof are covered with a planarization film. An upper light shield layer 4 is formed on the planarization film. In this way, according to this embodiment, the light shield band for shielding the thin film transistor from external light is composed of two conductive layers for shielding the thin film transistor from above and below, and one of the two conductive layers is used as the first conductive layer for the gate interconnection. Alternatively, the light shield band may be composed of a single conductive layer for shielding the thin film transistor from either above or below, and the single conductive layer be used as the first conductive layer for the gate interconnection. In this embodiment, the upper electrode of the auxiliary capacitance 13 is electrically connected to the extraction electrode 12C via a contact hole CCN. The extraction electrode 12C is further electrically connected to the upper light shield layer 4 via a contact hole MCN. With this connection, a specific potential is applied to the upper electrode of the auxiliary capacitance 13. The upper light shield layer 4 is covered with a protective film, and a pixel electrode (not shown) is formed thereon.

**[0030]** A method of fabricating the liquid crystal displays unit according to the present invention will be described with reference to FIG. 2. The liquid crystal display unit includes the pair of the substrates 1 and 2 jointed to each other with the specific gap put therebetween, and the liquid crystal 3 held in the gap. To fabricate such a liquid crystal display unit, a plurality of signal interconnections 12 and a plurality of gate interconnections crossing the signal interconnections, and pixels disposed at the crossing points between the signal and gate interconnections are formed on one substrate 1, and an elec-

trode 6 is formed on the other substrate 2 in such a manner as to face to respective pixels. At least a pixel electrode, a thin film transistor for driving the pixel electrode, and a light shield band 5 for shielding the thin film transistor from external light are formed in each pixel region. A source of the thin film transistor is connected to the signal interconnection 12, a drain thereof is connected to the pixel electrode, and a gate electrode G thereof is connected to the gate interconnection. In this case, the light shield band 5 is formed of a first conductive layer, and at least part of the light shield band is used for the gate interconnection. The gate electrode G is formed of a second conductive layer 14 different from the first conductive layer. The first conductive layer used for the gate interconnection is electrically connected to the second conductive layer 14 forming the gate electrode G via a contact hole GCN within each pixel region. In this embodiment, the light shield band is composed of two conductive layers for shielding the thin film transistor from above and below, and one light shield band 5 is used as the first conductive layer for the gate interconnection. An auxiliary capacitance 13 is formed in each pixel region by holding a gate insulating film 11 as a dielectric substance between a pair of upper and lower electrodes (10, 14) in order to hold signal charges written from the signal interconnection 12 into the pixel electrode via the thin film transistor. One of the pair of the upper and lower electrodes is formed of the same layer as the second conductive layer 14 forming the gate electrode G.

**[0031]** FIGS. 3A and 3B are schematic diagrams each showing an equivalent circuit for one pixel, wherein FIG. 3A shows the circuit of the liquid crystal display unit of the present invention, and FIG. 3B shows the circuit of the reference example. In the reference example shown in FIG. 3B, the lower light shield layer 5 is not taken as part of the gate interconnection and is connected to the ground potential. In such a configuration, a parasitic transistor due to the metal light shield layer 5 occurs in the LDD region as shown circles depicted by dotted lines. Since the potential of the light shield layer 5 is fixed, that is, usually grounded, to act in the direction of usually turning off the parasitic transistor. To prevent the above inconvenience, it is impossible to reduce the concentration of an impurity of the LDD region by a specific value or more. However, along with the tendency to increase the quantity of light, it has been required to reduce the concentration of an impurity of the LDD region to about one-third the present impurity concentration in order to improve the image quality.

**[0032]** In the configuration shown in FIG. 3A, although a parasitic transistor due to the metal light shield layer 5 occurs like the reference example, the potential of the light shield layer 5 is usually kept at a value equal to a gate potential via the contact hole GCN. Accordingly, the turn on/off of the parasitic transistor surrounded by dotted lines is perfectly synchronized with the substantive thin film transistor. As a result, it is possible to significantly reduce the concentration of an impurity in the LDD region,

and hence to improve the image quality. In addition, an image signal Vsig supplied to the signal interconnection 12 is written from the source region S of the thin film transistor TFT into the pixel electrode via the drain region D. In the figure, a potential written in the pixel electrode is designated by character Vpxl, and a potential applied to the gate electrode G of the thin film transistor is designated by character Vg.

**[0033]** FIGS. 4A to 4D are schematic views each showing a connection relationship between the gate electrode G and the light shield layer 5 serving as the gate interconnection. FIG. 4A schematically shows the connection relationship according to the embodiment shown in FIG. 1, in which pixel electrodes G are separated from each other for each pixel region and the light shield layer 5 forming the gate interconnection extends through the pixels. Each of the separated gate electrodes G is electrically connected to the lower light shield layer 5 via the corresponding contact hole GCN. The multi-layer structure formed by overlapping the metal thin layer, the semiconductor thin film layer, and the like to each other causes a side reaction of increasing a deformed amount of the substrate. This exerts adverse effect on control in assembly and mounting steps of a panel. In particular, it has been revealed that the continuous formation of the gate interconnection formed of the semiconductor thin film (made from second layer polysilicon) along the cross direction of the panel becomes a large cause of deformation of the substrate. On the contrary, according to the present invention, as schematically shown in FIG. 4A, the gate electrodes G made from second layer polysilicon are separated from each other for each pixel region, with a result that the deformed amount of the substrate can be reduced. Further, since the gate electrode G is not used as the interconnection unlike the related art structure, the thickness of the gate electrode G can be made small. This is effective to further reduce the deformed amount of the substrate.

**[0034]** In the connection relationship shown in FIG. 4B, not only the gate electrodes G but also the lower light shield layers 5 for forming the gate interconnection are separated from each other for each pixel region. The separated gate electrodes G and lower light shield layers 5 are sequentially, electrically connected to each other via contact holes GCN of the number of two pieces for each pixel. Since the lower light shield layers 5 are also separated from each other, it is possible to further reduce the deformed amount of the substrate.

**[0035]** In the connection relationship shown in FIG. 4C, the light shield layers 5 are separated from each other for each pixel region, but the gate electrode G extends through the pixels. In the connection relationship shown in FIG. 4D, each of the gate electrode G and the lower light shield layer 5 extends through the pixels, and both the gate electrode G and the lower light shield layer 5 are connected to each other via contact holes GCN provided for each pixel region. With this configuration, even if one of the upper and lower two conductive layers is

disconnected, the electric conduction can be ensured by the other one of the conductive layers, to thereby obtain a merit of preventing occurrence of a failure.

**[0036]** As described above, according to the present invention, the pixel opening rate can be improved by making use of the light shield layer as the gate interconnection. Also it is possible to realize a double-gate structure in which the semiconductor thin film as an active layer of the thin film transistor is held, from above and below, between the light shield layer serving as the gate interconnection and the gate electrode, and hence to increase the design margin of the thin film transistor. For example, the double-gate structure is effective to reduce the concentration of an impurity of the LDD region and hence to correspondingly lower leakage of light from the thin film transistor. Further, by separating the gate electrodes or light shield layers serving as the gate interconnection from each other for each pixel region, it is possible to suppress the deformation of the substrate.

**[0037]** While the preferred embodiment of the present invention has been described using the specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the scope of the following claims.

## Claims

### 1. A thin film semiconductor device comprising:

a plurality of signal interconnections (12) and a plurality of gate interconnections crossing said signal interconnections;

pixels disposed at crossing points between said signal and gate interconnections, each of said pixels including at least a pixel electrode, a thin film transistor for driving said pixel electrode and an auxiliary capacitor (13) for holding signal charges written from said signal interconnection into said pixel electrode via said thin film transistor, each of said thin film transistors comprising a source, a drain and a gate electrode (G) and each of said auxiliary capacitors comprising a first (14) and a second electrode (10), said second electrode (10) being connected to said drain;

a first conductive light shield layer (5) formed on an insulating substrate (1) and configured and adapted for shielding said thin film transistors from external light from below;

wherein  
said sources are connected to a respective signal interconnection;  
said drains are connected to a respective

pixel electrode:

said gate electrodes are formed in a third conductive layer (14) different from said first conductive light shield layer;  
said first electrodes are formed in said third conductive layer;

#### **characterized by**

a second conductive light shield layer configured and adapted for shielding said thin film transistors from light from above, wherein

said second electrodes are mutually distinctly formed in a semiconductor layer formed intermediate said first conductive light shield layer and said third conductive layer,

said first electrodes are further connected to said second conductive light shield layer; and

said gate interconnections are formed in said first conductive light shield layer;  
said gate electrodes are mutually distinctly formed in said third conductive layer; and  
said first electrodes are mutually distinctly formed in said third conductive layer.

### 2. The thin film semiconductor device of claim 1, wherein

said gate interconnections are mutually distinctly formed in said first conductive light shield layer; and comprising:

contact holes configured and adapted for electrically contacting each of said gate interconnections with a respective two of said gate electrodes and each of said gate electrodes with a respective two of said gate interconnections.

### 3. A liquid crystal display unit comprising:

a pair of substrates (1.2) jointed to each other with a specific gap held therebetween, and liquid crystal (3) held in said gap; and  
a thin film semiconductor device in accordance with any of the preceding claims, wherein one (1) of said pair of substrates constitutes said insulating substrate; and  
the other (2) of said pair of substrates has an electrode (6) facing to respective pixels.

## Patentansprüche

### 1. Dünnschicht-Halbleitervorrichtung, mit:

mehreren Signalverbindungen (12) und mehreren Gate-Verbindungen, die die Signalverbindungen kreuzen;

- Pixeln, die an Kreuzungspunkten zwischen den Signal- und den Gate-Verbindungen angeordnet sind, wobei jedes der Pixel wenigstens eine Pixelelektrode, einen Dünnschichttransistor, um die Pixelelektrode anzusteuern, und einen Hilfskondensator (13), um von den Signalverbindungen in die Pixelelektrode über den Dünnschichttransistor geschriebene Signalladungen zu halten, enthält, wobei jeder Dünnschichttransistor eine Source-, eine Drain- und eine Gate-Elektrode (G) aufweist und wobei jeder der Hilfskondensatoren eine erste Elektrode (14) und eine zweite Elektrode (10) aufweist, wobei die zweite Elektrode (10) mit dem Drain verbunden ist; und
- einer ersten leitenden Lichtabschirmungsschicht (5), die auf einem isolierenden Substrat (1) gebildet ist und konfiguriert und ausgelegt ist, um die Dünnschichttransistoren vor äußerem Licht von unten abzuschirmen; wobei
- die Sources mit einer entsprechenden Signalverbindung verbunden sind;
- die Drains mit einer entsprechenden Pixelelektrode verbunden sind;
- die Gate-Elektroden in einer dritten leitenden Schicht (14), die von der ersten leitenden Lichtabschirmungsschicht verschieden ist, gebildet ist; und
- die ersten Elektroden in der dritten leitenden Schicht gebildet sind;
- gekennzeichnet durch**
- eine zweite leitende Lichtabschirmungsschicht, die konfiguriert und ausgelegt ist, um die Dünnschichttransistoren vor Licht von oben abzuschirmen, wobei
- die zweiten Elektroden voneinander verschieden in einer Halbleiterschicht gebildet sind, die zwischen der ersten leitenden Lichtabschirmungsschicht und der dritten leitenden Schicht gebildet ist,
- die ersten Elektroden ferner mit der zweiten leitenden Lichtabschirmungsschicht verbunden sind;
- die Gate-Verbindungen in der ersten leitenden Lichtabschirmungsschicht gebildet sind;
- die Gate-Elektroden voneinander verschieden in der dritten leitenden Schicht gebildet sind; und
- die ersten Elektroden voneinander verschieden in der dritten leitenden Schicht gebildet sind.
2. Dünnschicht-Halbleitervorrichtung nach Anspruch 1, wobei
- die Gate-Verbindungen voneinander verschieden in der ersten leitenden Lichtabschirmungsschicht gebildet sind; ferner mit:
- Kontaktlöchern, die konfiguriert und ausgelegt
- sind, um zwischen jeder der Gate-Verbindungen und zwei entsprechenden Gate-Elektroden und zwischen jeder der Gate-Elektroden und zwei entsprechenden Gate-Verbindungen einen elektrischen Kontakt herzustellen.
3. Flüssigkristallanzeigeeinheit, mit:
- einem Paar von Substraten (1, 2), die miteinander über einen bestimmten dazwischen aufrechterhaltenen Spalt verbunden sind, wobei der Flüssigkristall (3) in dem Spalt gehalten wird; und
- einer Dünnschicht-Halbleitervorrichtung nach einem der vorhergehenden Ansprüche, wobei eines (1) der beiden Substrate das isolierende Substrat bildet; und
- das andere (2) der beiden Substrate eine Elektrode (6), die entsprechenden Pixeln zugewandt ist, besitzt.

### Revendications

- 25 1. Dispositif à semi-conducteur à couche mince comprenant :
- une pluralité d'interconnexions de signal (12) et une pluralité d'interconnexions de grille coupant lesdites interconnexions de signal ; des pixels disposés aux points d'intersection entre lesdites interconnexions de signal et de grille, chacun desdits pixels comprenant au moins une électrode de pixel, un transistor à couche mince pour exciter ladite électrode de pixel et un condensateur auxiliaire (13) pour contenir les charges de signal écrites depuis ladite interconnexion de signal dans ladite électrode de pixel via ledit transistor à couche mince, chacun desdits transistors à couche mince comprenant une source, un drain et une électrode de grille (G) et chacun desdits condensateurs auxiliaires comprenant une première (14) et une deuxième électrode (10), ladite deuxième électrode (10) étant raccordée audit drain ; une première couche pare-lumière conductrice (5) formée sur un substrat isolant (1) et configurée et adaptée pour protéger lesdits transistors à couche mince contre la lumière externe provenant de dessous ; où lesdites sources sont raccordées à une interconnexion de signal respective ; lesdits drains sont raccordés à une électrode de pixel respective ; lesdites électrodes de grille sont formées dans une troisième couche conductrice (14) différente de ladite première couche pare-lumière

conductrice ;  
 lesdites premières électrodes sont formées dans ladite troisième couche conductrice ;  
**caractérisé par**  
 une deuxième couche pare-lumière conductrice 5  
 configurée et adaptée pour protéger lesdits transistors à couche mince contre la lumière de dessus, où  
 lesdites deuxières électrodes sont mutuellement formées distinctement dans une couche 10  
 semi-conductrice formée entre ladite première couche pare-lumière conductrice et ladite troisième couche conductrice,  
 lesdites premières électrodes sont en outre racordées à ladite deuxième couche pare-lumière 15  
 conductrice ; et  
 lesdites interconnexions de grille sont formées dans ladite première couche pare-lumière conductrice ;  
 lesdites électrodes de grille sont mutuellement 20  
 formées distinctement dans ladite troisième couche conductrice ; et  
 lesdites premières électrodes sont mutuellement formées distinctement dans ladite troisième couche conductrice. 25

2. Dispositif semi-conducteur à couche mince de la revendication 1, dans lequel  
 lesdites interconnexions de grille sont mutuellement formées distinctement dans ladite première couche 30  
 pare-lumière conductrice ; et comprenant :

des trous de contact configurés et adaptés pour mettre en contact électriquement chacune desdites interconnexions de grille avec deux respectives desdites électrodes de grille et chacune desdites électrodes de grille avec deux respectives desdites interconnexions de grille. 35

3. Unité d'affichage à cristaux liquides comprenant : 40

une paire de substrats (1, 2) assemblés mutuellement avec un écartement spécifique maintenu entre eux, et un cristal liquide (3) contenu dans ledit écartement ; et 45  
 un dispositif à semi-conducteur à couche mince selon l'une quelconque des revendications précédentes, où  
 un (1) de ladite paire de substrats constitue ledit substrat isolant ; et 50  
 l'autre (2) de ladite paire de substrats a une électrode (6) faisant face aux pixels respectifs.

FIG.1

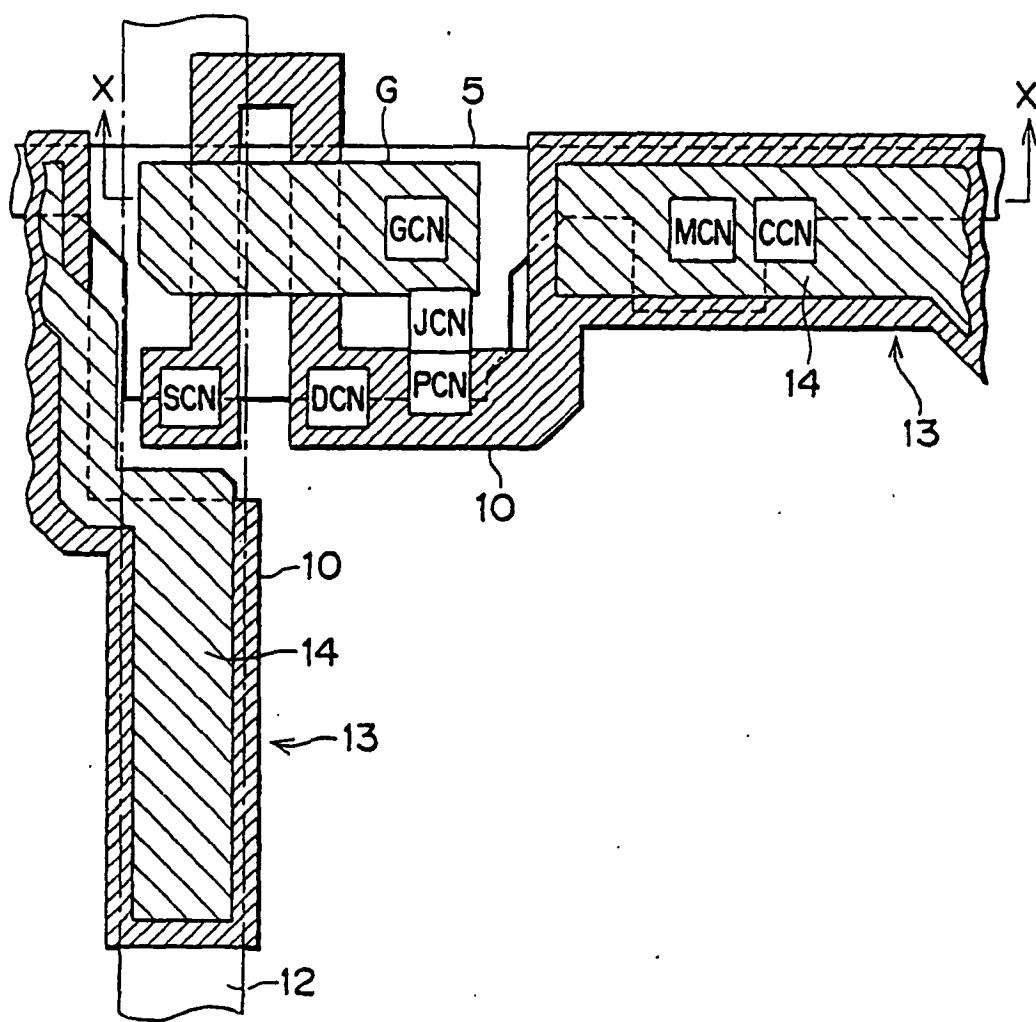


FIG. 2

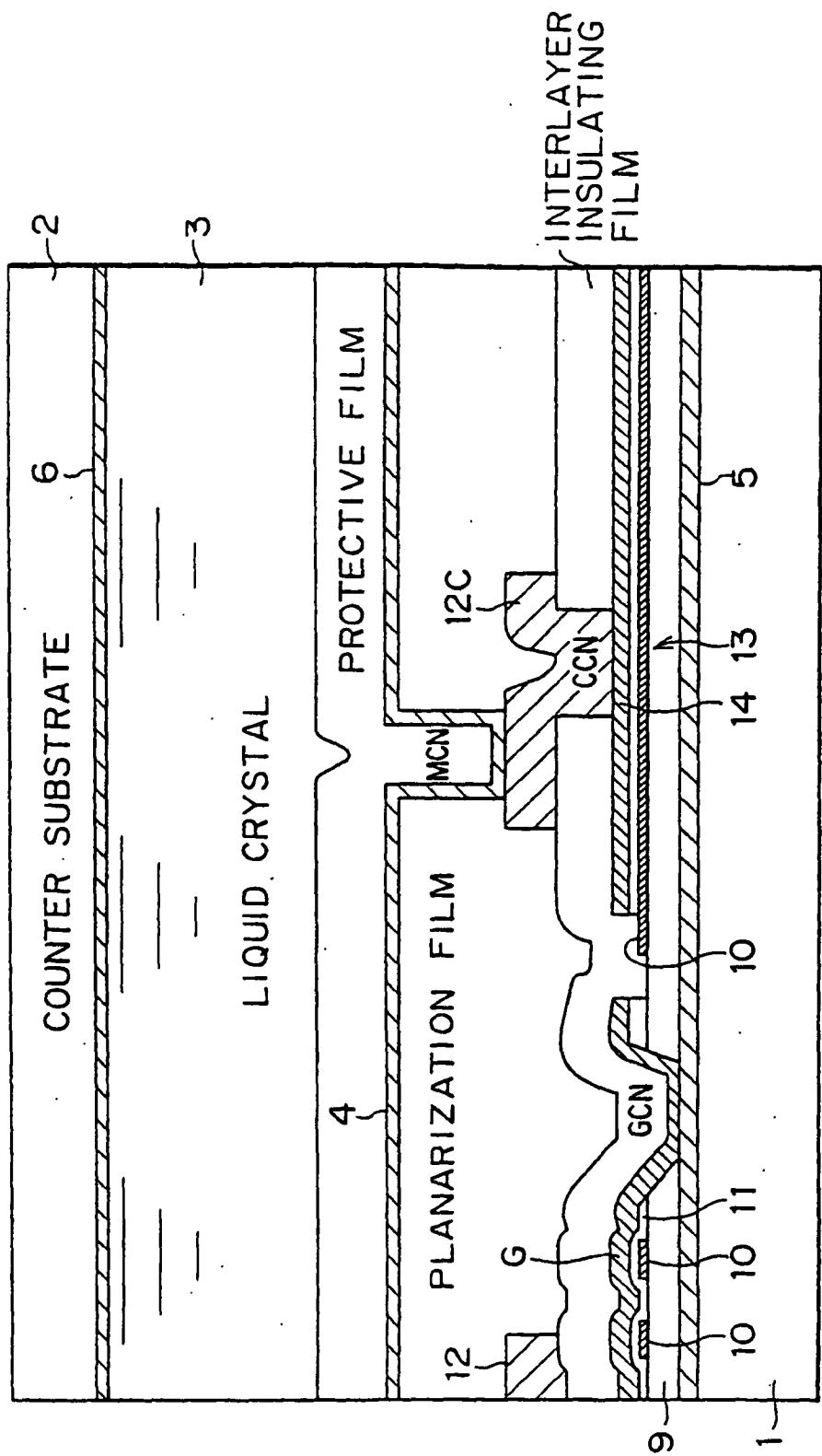


FIG. 3A

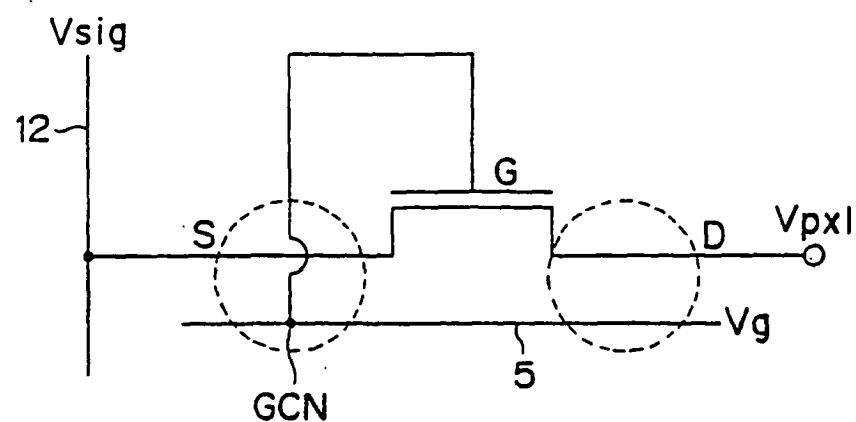


FIG. 3B

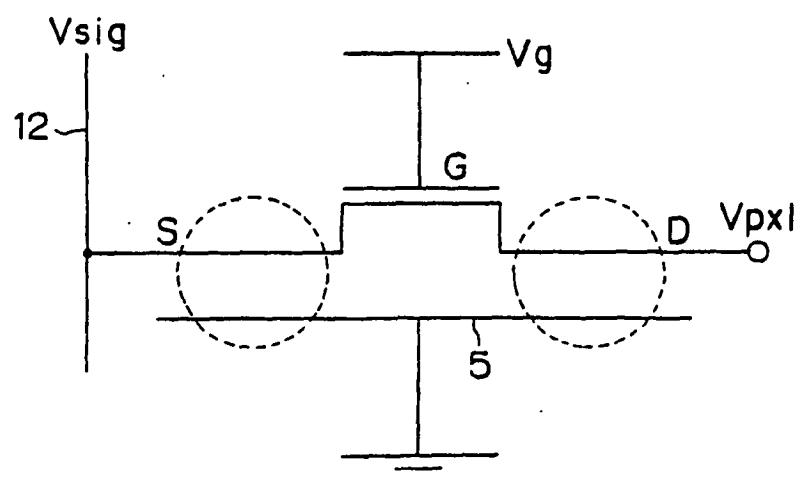


FIG. 4A

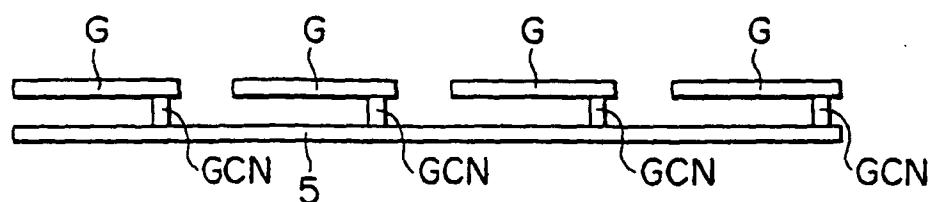


FIG. 4B

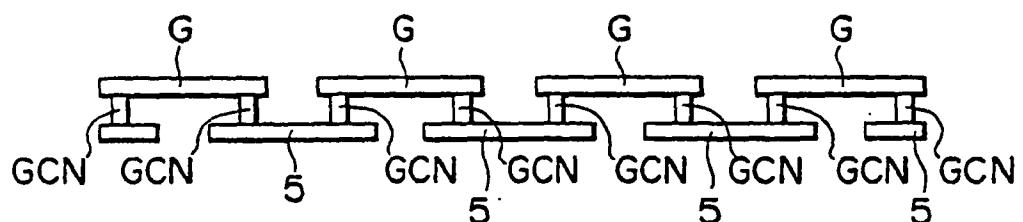


FIG. 4C

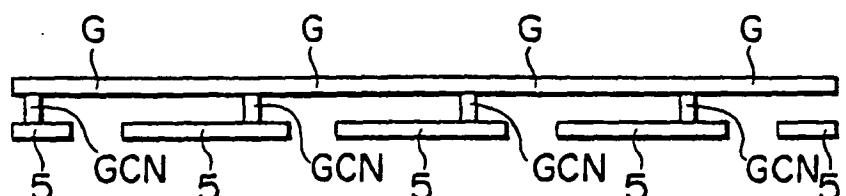


FIG. 4D

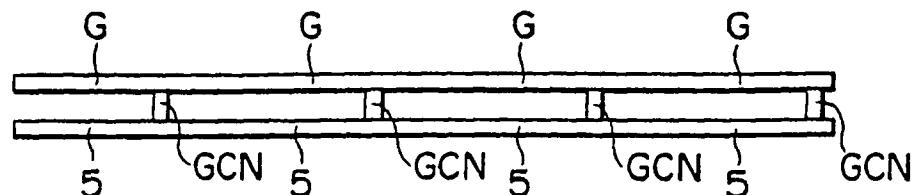


FIG. 5

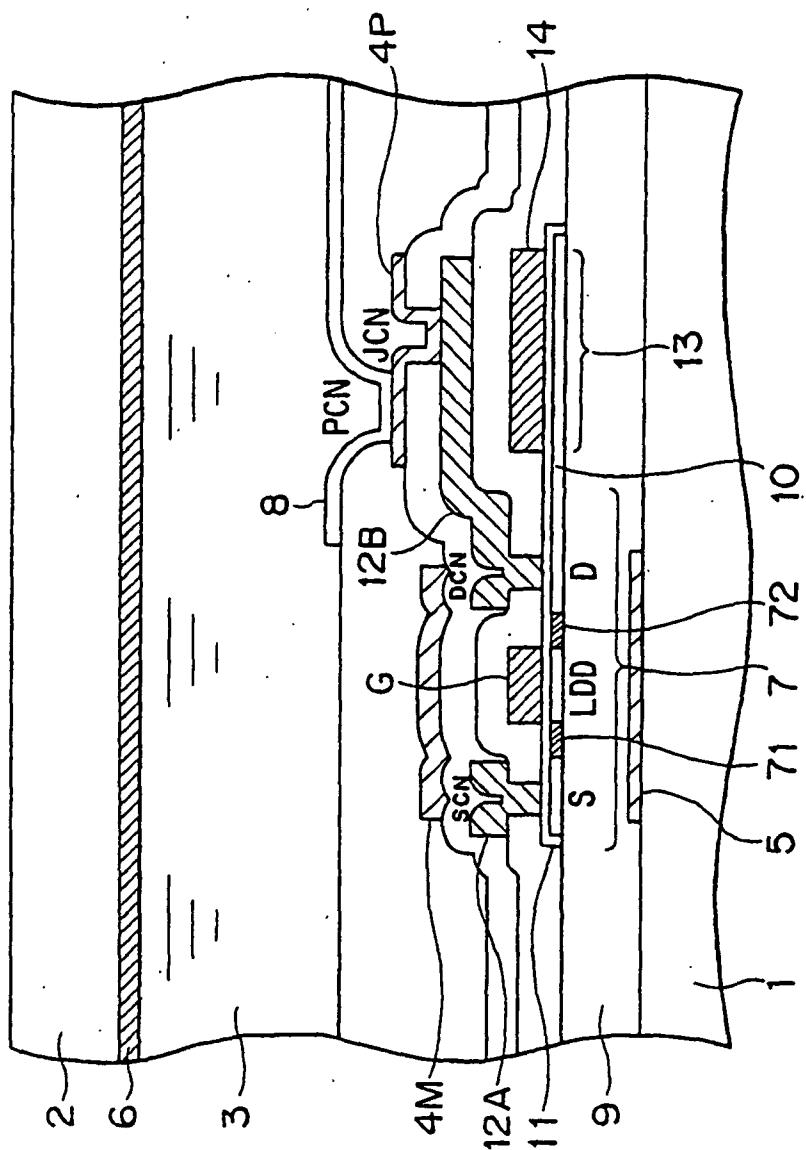


FIG. 6

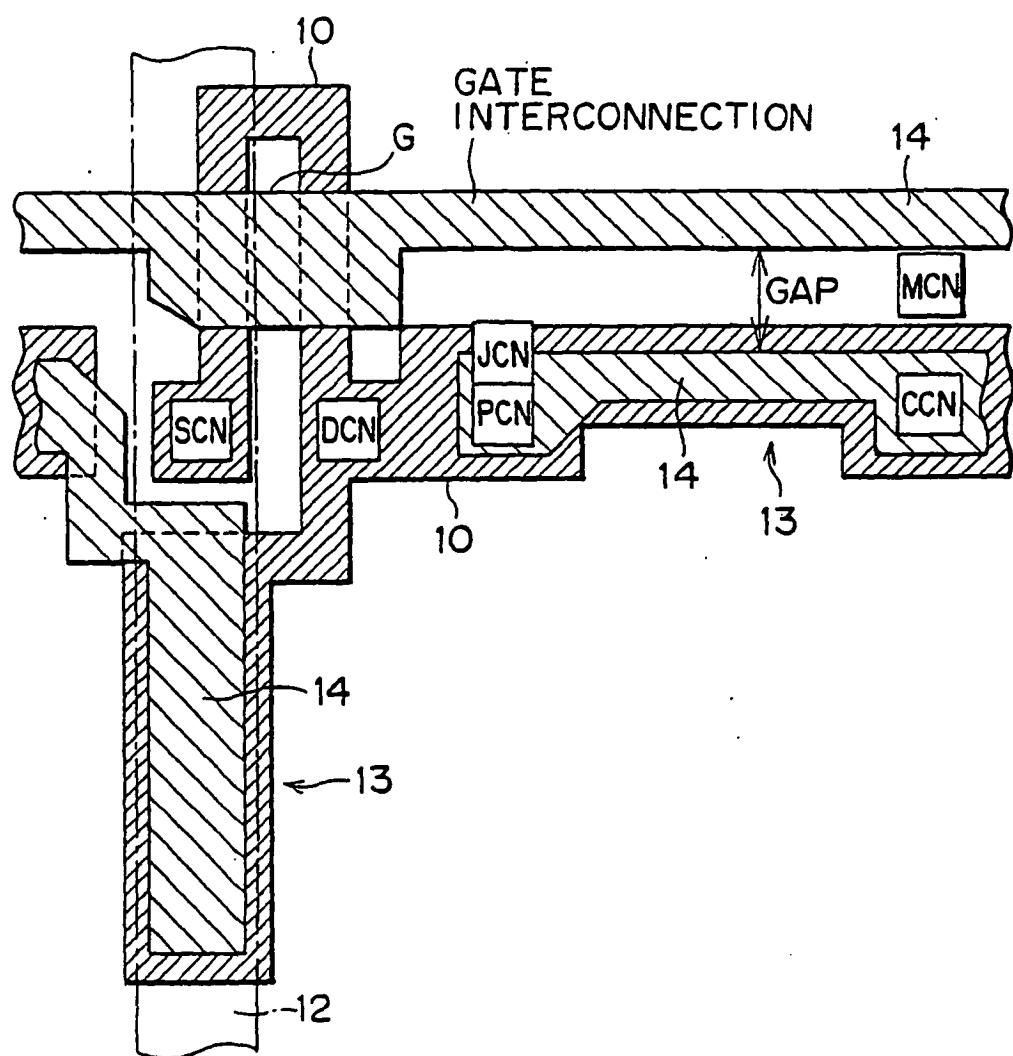
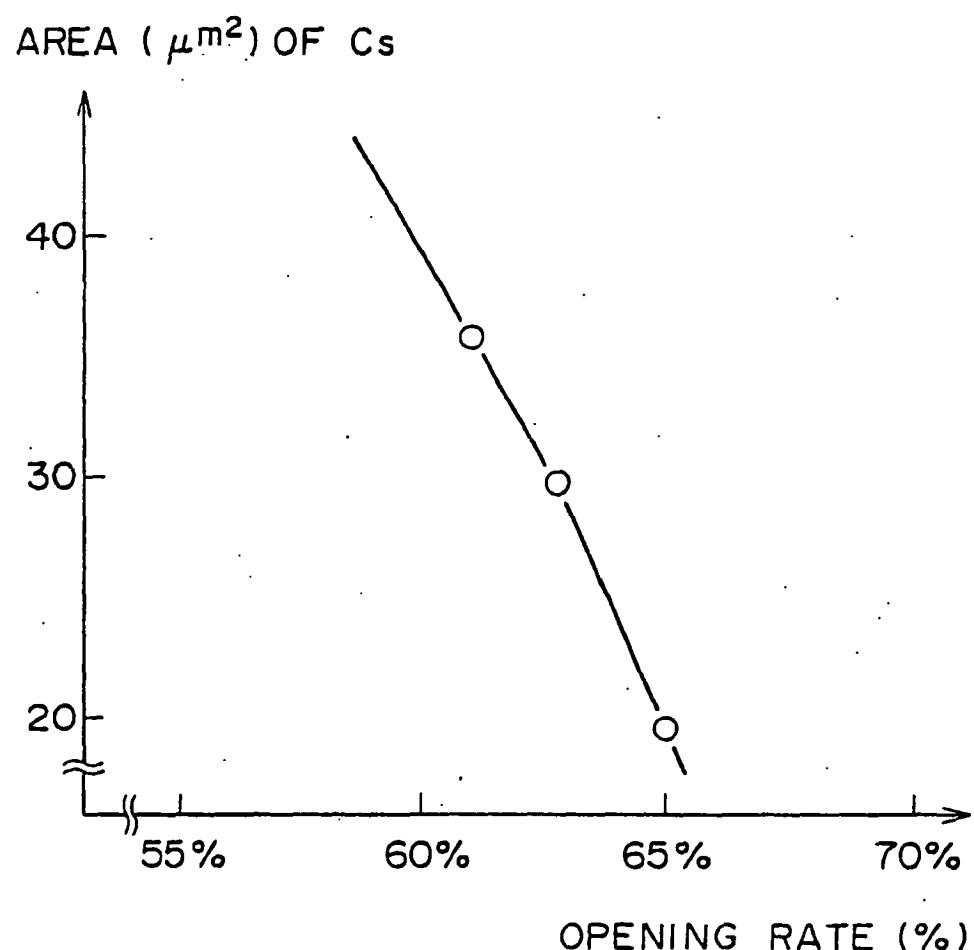


FIG. 7



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP HEI2000131716 B [0002]
- JP 8234239 A [0010]
- JP 62143469 A [0011]
- JP 1177020 A [0012]
- EP 0997769 A [0013]

专利名称(译)	薄膜半导体器件和液晶显示单元及其制造方法		
公开(公告)号	<a href="#">EP1180716B1</a>	公开(公告)日	2011-12-28
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[标]申请(专利权)人(译)	索尼公司		
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优先权	2000242170 2000-08-10 JP		
其他公开文献	EP1180716A2 EP1180716A3		
外部链接	<a href="#">Espacenet</a>		

## 摘要(译)

薄膜半导体器件包括在绝缘基板上彼此交叉的多个信号和栅极互连。像素设置在信号和栅极互连之间的交叉点处。每个像素至少具有像素电极，用于驱动像素电极的薄膜晶体管，以及用于屏蔽薄膜晶体管免受外部光影响的遮光带。薄膜晶体管的源极连接到信号互连，其漏极连接到像素电极，并且其栅极连接到栅极互连。遮光带由第一导电层形成，并且遮光带的至少一部分用作栅极互连。栅电极由与第一导电层不同的第二导电层形成。用于栅极互连的第一导电层经由接触孔电连接到在每个像素区域内形成栅电极的第二导电层。因此，改善了用作有源矩阵型液晶显示单元的驱动基板的薄膜半导体器件的像素开口率。

FIG. 1

