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DESCRIPTION

TFT SUBSTRATE, LIQUID CRYSTAL DISPLAY USING THE SAME,
AND ITS MANUFACTURING METHOD

Technical Field

The present invention relates to a TFT substrate, a liquid crystal display using the same and a method for manufacturing the TFT substrate.

Technical Background

Flat panel displays such as a liquid crystal display (LCD), an organic EL display, etc., have prevailed as mainstream displays for cellular phones, PDAs, portable personal computers, laptop computers and television receivers owing to their display performances and energy saving. These devices use a TFT substrate, etc., as a switching device for driving. In the TFT substrate, it is a mainstream practice to use an aluminum alloy as low-resistance electrode-wiring materials. As a material for a transparent electrode, an indium-tin oxide (ITO), an indium-zinc oxide (IZO), etc., are mainly used.

However, the following is known. When a transparent electrode is formed directly on an electrode made of an aluminum alloy via a through hole formed through an insulating interlayer, aluminum undergoes oxidation to cause a contact resistance between the electrode and the transparent electrode, and a liquid crystal display comprising a TFT substrate made of such materials no longer operates properly.

For overcoming the above problem, it is general

practice to employ a three-layer structure in which the electrode made of an aluminum alloy is sandwiched between layers made of Mo, Ti, Cr or the like to prevent a direct contact between the aluminum alloy and the transparent electrode, so that an increase in the contact resistance is suppressed.

However, for forming a three-layer structure of the aluminum alloy with metals such as Mo, Ti, Cr, etc., it is required to form three films of such metals, and it is accordingly required to carry out an etching procedure three times, so that there have been a problem that the process of manufacturing a TFT substrate is complicated.

It is an object of the present invention to provide a TFT substrate that operates stably, a liquid crystal display and a method for efficiently manufacturing the TFT substrate.

The present inventors have made diligent studies and as a result have found that the above object can be achieved by forming a metal thin-film buffer layer between source-drain electrodes and a transparent electrode, which layer prevents the direct contact.

Disclosure of the Invention

According to the present invention, there is provide a TFT substrate comprising: source-drain electrodes, a transparent electrode, an insulating film interposed therebetween, and a through hole formed in the insulating film for electrically connecting the source-drain electrodes to the transparent electrode, wherein the source-drain electrodes are made mainly of metal aluminum, and a metal thin-film buffer layer is formed between the source-drain

electrodes and the transparent electrode in the through hole.

The metal thin-film buffer layer is provided between the source-drain electrodes and the transparent electrode, whereby an increase in contact resistance between the electrodes can be prevented, so that the TFT substrate can operate stably.

In one embodiment of the specific structure of the TFT substrate of the present invention, on a substrate, there are formed a gate electrode (gate wiring), a gate insulating film, a first silicon layer, a channel protection layer, a second silicon layer, source-drain electrodes, an insulating interlayer, the metal thin-film buffer layer and the transparent electrode. In this case, the source-drain electrodes and the transparent electrode are electrically connected through a through hole formed through the insulating interlayer. A TFT substrate of a type free of the channel protection layer is also known.

In the TFT substrate of the present invention, further, the metal thin-film buffer layer is preferably formed of a material that can be etched with the same etchant as that used for etching to form the transparent electrode.

When the metal thin-film buffer layer is formed of a material that can be etched with the same etchant as that used for etching to form the transparent electrode, the etching step can be simplified.

Further, the above metal thin-film buffer layer is preferably formed mainly of a metal that is more easily oxidizable than aluminum.

When a metal that is more easily oxidizable than

aluminum is used, the oxidation of aluminum is more suppressed, and electrical conductivity between the aluminum and the transparent electrode is improved.

Further, aluminum oxide formed on an aluminum surface after the sputtering of aluminum is reduced, so that the contact resistance may sometimes decrease as compared with a case using a metal that is not easily oxidizable.

Further, the above metal is preferably a metal that exhibits electrical conductivity when oxidized, and is more preferably a metal that exhibits transparency.

When the metal oxide is electrically conductive, the contact resistance between the source-drain electrodes and the transparent electrode can be further decreased. Further, when it is transparent, the transparency of the entire metal thin-film buffer layer is improved, and a pixel portion is also improved in transparency.

In the TFT substrate of the present invention, further, the metal thin-film buffer layer is preferably formed of at least one metal or alloy selected from Ag, Au, Pt, Rh, Pd, Cr, In, Ga, Zn, Mo, Ti, Sn and alloys of such metals.

The above metals and alloys are excellent in film formability. Further, they are excellent in stability of a formed film.

In the TFT substrate of the present invention, further, the metal thin-film buffer layer is preferably formed of at least one metal or alloy selected from Cr, In, Ga, Zn, Mo, Ti, Sn and alloys of such metals.

That is because oxides formed from the above metals or alloys are excellent in electrical conductivity.

Further, in the TFT substrate of the present

invention, the metal thin-film buffer layer is preferably formed of at least one metal or alloy selected from In, Ga, Zn, Sn and alloys of such metals.

That is because the above metals are more easily oxidized than aluminum and because oxides thereof are excellent in transparency and electrical conductivity.

In the TFT substrate of the present invention, further, the metal thin-film buffer layer preferably has a thickness of 30 to 300 Å.

In view of the prevention of an increase in the contact resistance between the electrodes and the transparency of the metal thin-film buffer layer, it is preferred to bring the layer thickness into the above range.

According to another aspect of the present invention, there is provided a liquid crystal display comprising the above TFT substrate. Employing the above TFT substrate, this liquid crystal display can operate without degradation of its performances.

According to still another aspect of the present invention, there is provided a method for manufacturing a TFT substrate, which comprises the steps of forming an insulating layer on source-drain electrodes, forming a through hole through the insulating layer, forming a metal buffer film and a transparent electrically conductive film on the insulating layer and the above through hole, and simultaneously etching the metal buffer film and the transparent electrically conductive film to form a metal thin-film buffer layer and a transparent electrode.

Since the metal buffer film is formed, the source-drain electrodes are no longer required to have a multi-layered structure. Further, since the metal buffer film and

the transparent electrically conductive film can be etched with the same etchant, it is no longer necessary to repeat etching, so that the TFT substrate can be efficiently manufactured. Further, the amount of materials to be used is reduced, so that TFT substrates can be manufactured at a lower cost.

Brief Description of Drawings

Fig. 1 is a cross-sectional view of an α -Si TFT substrate that is one embodiment of the TFT substrate of the present invention.

Best Modes for Carrying out the Invention

The TFT substrate, the liquid crystal display using the TFT substrate and the method of manufacturing a TFT substrate, provided by the present invention, will be explained below.

1. TFT substrate and liquid crystal display

(1) Source-drain electrodes

The material for the source-drain electrodes is not specially limited so long as it contains metal aluminum as a main component. Components other than the metal aluminum and amounts thereof are not limited, either. Examples of the components other than the metal aluminum include metals such as Nd, Pt, Pd, Zn, Ni, and the like.

(2) Metal thin-film buffer layer

The metal thin-film buffer layer is formed between the source-drain electrodes and the transparent electrode and works to prevent an increase in contact resistance between these electrodes.

The metal thin-film buffer layer is electrically

conductive, and it may be easily oxidizable or may not be easily oxidizable. When it is easily oxidizable, an oxide is preferably electrically conductive, and it is more preferably transparent.

The material for the metal thin-film buffer layer is not specially limited so long as it can prevent an increase in contact resistance between the electrodes. Examples of the above material include Ag, Au, Pt, Rh, Pd, Cr and alloys of these, and at least one member selected from these metals and alloys is used.

Further, the above metals and alloys are preferably those which can be etched with the same etchant as that used for the etching to form the transparent electrode. Further, those which are more easily oxidizable than aluminum are preferred, and metal oxides thereof are more preferably transparent and electrically conductive.

Although not specially limited, the above etchant includes, for example, an oxalic acid aqueous solution, a nitric acid-acetic acid-phosphoric acid-containing aqueous solution, a hydrochloric acid aqueous solution, a hydrogen bromide aqueous solution, an iron chloride-hydrochloric acid aqueous solution and aqua regia.

Further, examples of the materials that can be simultaneously etched include metals such as Ag, Au, Pt, Rh, Pd, Cr, In, Ga, Zn, Mo, Ti and Sn and alloys of these, and at least one member from these metals and alloys is used.

Further, those materials which are more easily oxidizable than aluminum and whose oxides are transparent and electrically conductive include, for example, Cr, In, Ga, Zn, Mo, Ti and Sn and alloys of these, and at least one member of these metals and alloys is used.

The metal thin-film buffer layer preferably has a film thickness of 30 to 300 Å. When the film thickness is less than 30 Å, the thickness of the metal thin film is too small, and the effect of the metal thin-film buffer layer is sometimes not exhibited. When the film thickness exceeds 300 Å, it is sometimes poor in transparency.

When a metal that is easily oxidizable is used as a material for the metal thin-film buffer layer, the metal thin film may have a larger thickness since it is improved in transparency.

When a metal that is not easily oxidizable are used, the metal thin film is to have a thickness of 30 to 100 Å. When the film thickness is 30 Å or smaller, the thickness of the thin film is too small, so that aluminum in the source-drain electrodes is oxidized, and the contact resistance between the layer and the transparent electrode sometimes comes to be high. When the film thickness is 100 Å or larger, light transmittance sometimes decreases.

Further, when a metal whose oxide is transparent and electrically conductive is used as a material for the metal thin-film buffer layer, the thin film thickness is preferably 30 to 300 Å. When the film thickness is less 30 Å or less, the film thickness is too small, and the metal thin-film buffer layer sometimes does not produce the effect on the prevention of an increase in contact resistance. When the film thickness is 300 Å or larger, the degree of oxidation may be low, and the transparency sometimes decreases.

(3) Transparent electrode

The material for the transparent electrode includes, for example, oxides such as indium-tin oxide (ITO) and

indium-zinc oxide (IZO).

(4) Others

In the TFT substrate of the present invention, there is no special limitation to be imposed on constituting members such as a substrate, a gate electrode, and the like other than the above members, and generally used constitutions and materials can be employed.

Further, concerning the liquid crystal display, there is no special limitation to be imposed on constituting members other than the above TFT substrate, and generally used constitutions and materials can be employed.

2. Method for manufacture of TFT substrate

In the method for manufacturing a TFT substrate, provided by the present invention, the metal buffer film and the transparent electrically conductive film are simultaneously etched with one and the same etchant, to form the metal thin-film buffer layer and the transparent electrode.

Since the simultaneous etching is carried out as described above, the number of steps of etching can be decreased, and the amount of materials to be used can be suppressed.

Further, there is no critical limitation to be imposed on the steps of forming members of the TFT substrate including the metal thin-film buffer layer and the transparent electrode. As a method of forming layers for the members, for example, a vacuum vapor deposition method, a sputtering method, and the like can be employed. In this case, there is no critical limitation to be imposed on the method and the apparatus for carrying out the vacuum vapor

deposition and the sputtering. Examples of the vacuum vapor deposition method include an electron beam method, an ion plating method and a resistance heating method. Examples of the sputtering method include a high-frequency sputtering method, a DC sputtering method, an RF sputtering method, a DC magnetron sputtering method, an RF magnetron sputtering method, an ECR plasma sputtering method and an ion beam sputtering method.

Further, there is no critical limitation to be imposed on the means of patterning metal thin films formed by these methods in the form of intended electrodes and the means of forming the through hole. A general photolithography method or the like may be employed.

Examples

The present invention will be explained in detail with reference to Examples hereinafter, while the present invention shall not be limited thereto.

Example 1

One example of the present invention will be explained with reference to Fig. 1.

Fig. 1 is a cross-sectional view of an α -Si TFT substrate that is one embodiment of the TFT substrate of the present invention.

Metal Al (resistivity: $5 \mu\Omega\cdot\text{cm}$) containing 1 at% of Nd was deposited on a transparent glass substrate 2 by a high-frequency sputtering method, to form a 1,500 Å thick layer. The layer was etched by a photo-etching method using a nitric acid-acetic acid-phosphoric acid-containing aqueous solution as an etching solution, to form a gate electrode 4

and a gate wiring (not shown) having a predetermined form each.

Then, a gate insulating film 6 formed of a first silicon nitride (SiN_x) film was deposited from $\text{SiH}_4\text{-NH}_3\text{-N}_2$ -containing gas as a discharge gas, so that the film had a thickness of 3,000 Å.

Thereafter, an $\alpha\text{-Si:H(i)}$ film (first silicon layer) 8 was formed from $\text{SiH}_4\text{-N}_2$ -containing mixture gas as a discharge gas, so that the film had a thickness of 3,500 Å.

Further, a second silicon nitride (SiN_x) film was deposited thereon from $\text{SiH}_4\text{-NH}_3\text{-N}_2$ -containing gas as a discharge gas, so that the film had a thickness of 700 Å. A predetermined channel protection layer 10 was formed from the above second SiN_x film by dry etching using CF_4 gas.

Then, an $\alpha\text{-Si:H(n)}$ film (second silicon layer) 12 was deposited from $\text{SiH}_4\text{-H}_2\text{-PH}_3$ -containing mixture gas, so that the film had a thickness of 1,000 Å.

The gate insulating film 6, the $\alpha\text{-Si:H(i)}$ film 8, the channel protection layer 10 and the $\alpha\text{-Si:H(n)}$ film 12 were formed by a glow discharge CVD method.

Then, Al (resistivity: $5\ \mu\Omega\cdot\text{cm}$) containing 1 at% of Nd was deposited thereon by a vacuum vapor deposition method or a sputtering method, so that the film had a thickness of 0.3 μm . The Al layer was photo-etched with a nitric acid-acetic acid-phosphoric acid-containing etching solution, to form a pattern of source-drain electrodes 14, 15 and source-drain wirings (not shown).

Further, the $\alpha\text{-Si:H}$ films were etched by a combination of dry etching using CF_4 gas and wet etching using a hydrazine ($\text{NH}_2\text{NH}_2\cdot\text{H}_2\text{O}$) aqueous solution, to modify the

pattern of the α -Si:H(i) film 8 and the α -Si:H(n) film 12 into a predetermined pattern.

A source-drain insulating film (insulating interlayer) 16 that was a third silicon nitride (SiN_x) film was deposited thereon by a glow discharge CVD method, so that the film had a thickness of 3,000 Å. In this case, as a discharge gas, SiH_4 - NH_3 - N_2 -containing gas was used for the third SiN_x film.

Further, a lead 24 from the gate electrode, a lead (not shown) from the source electrode and a through hole 22 that was to be an electrically contact point between the source-drain electrodes 15 and a transparent electrode (pixel electrode) 20 were formed by a photo-etching method according to a dry etching method using CF_4 gas.

Then, as a metal buffer film, a film having a thickness of 100 Å was formed from metal In on the entire surface of the source-drain insulating film 16 by a vacuum vapor deposition method or a sputtering method. Then, an amorphous transparent electrically conductive film composed of indium oxide and zinc oxide as main components was deposited thereon by a sputtering method. An In_2O_3 -ZnO sintered body having its In/Zn atomic ratio $[\text{In}/(\text{In}+\text{Zn})]$ adjusted to 0.83 was set as a planar magnetron type cathode and used as a sputtering target, pure argon or argon gas containing oxygen gas in a trace amount of about 1 vol% was used as a discharge gas, and the transparent electrically conductive film having a thickness of 1,000 Å was deposited.

When analyzed by an X-ray diffraction method, the above In_2O_3 -ZnO film showed no peaks and was amorphous. The metal buffer film and the thin transparent electrically conductive film were patterned by a photo-etching method

using an aqueous solution containing 3.4 % by weight of oxalic acid, to form a metal thin-film buffer layer 18, a transparent electrode 20 and a lead electrode. Further, a glare protection pattern was formed, to complete an α -Si TFT substrate 1.

The above substrate was used to manufacture a TFT-LCD method flat display, and the flat display was evaluated for display performances by inputting video signals, to show excellent display performances.

Example 2

A TFT-LCD method flat display was manufactured in the same manner as in Example 1 except that the metal thin-film buffer layer 18 in Example 1 was changed from the 100 Å thick metal In film to a 50 Å thick metal Ag film and that the etchant for the metal thin-film buffer layer 18 and the transparent electrode 20 was changed from the aqueous solution containing 3.4 % by weight of oxalic acid to a nitric acid-acetic acid-phosphoric acid-containing aqueous solution. The thus-obtained liquid crystal display was evaluated for display performances by inputting video signals, to show excellent display performances.

Comparative Example 1

A TFT-LCD method flat display was manufactured in the same manner as in Example 1 except that the step of forming the metal thin-film buffer layer in Example 1 was omitted. When attempts were made to input video signals to the thus-obtained liquid crystal display for testing its display performance, no video signals were inputted, and the display performance was defective.

Industrial Utility

According to the present invention, there can be provided a TFT substrate and a liquid crystal display that can operate stably and a method for efficiently manufacturing the TFT substrate.

CLAIMS

1. A TFT substrate comprising:
 source-drain electrodes,
 a transparent electrode,
 an insulating film interposed therebetween, and
 a through hole formed in the insulating film for
electrically connecting the source-drain electrodes to the
transparent electrode,
 wherein the source-drain electrodes are made mainly
of metal aluminum, and a metal thin-film buffer layer is
formed between the source-drain electrodes and the
transparent electrode in the through hole.
2. The TFT substrate of claim 1, wherein said metal
thin-film buffer layer is formed of a material that can be
etched with the same etchant as that used for etching to
form said transparent electrode.
3. The TFT substrate of claim 1 or 2, wherein said
metal thin-film buffer layer is composed mainly of a metal
that is more liable to be oxidized than aluminum.
4. The TFT substrate of claim 3, wherein said metal is
a metal that exhibits transparency and electrical
conductivity when oxidized.
5. The TFT substrate of claim 1 or 2, wherein said
metal thin-film buffer layer is formed of at least one metal
or alloy selected from Ag, Au, Pt, Rh, Pd, Cr, In, Ga, Zn,
Mo, Ti, Sn and alloys of these.

6. The TFT substrate of claim 3, wherein said metal thin-film buffer layer is formed of at least one metal or alloy selected from In, Ga, Zn, Sn and alloys of these.

7. The TFT substrate of claim 1 or 2, wherein said metal thin-film buffer layer has a thickness of 30 to 300 Å.

8. A liquid crystal display comprising the TFT substrate recited in any one of claims 1 to 7.

9. A method for manufacturing the TFT substrate recited in any one of claims 1 to 7, which comprises the steps of

forming an insulating layer on source-drain electrodes,

forming a through hole through the insulating layer,
forming a metal buffer film and a transparent electrically conductive film on the insulating layer and the through hole, and

simultaneously etching the metal buffer film and the transparent electrically conductive film to form a metal thin-film buffer layer and a transparent electrode.