A method for forming a metal line includes sequentially depositing a low-resistivity metal layer having aluminum on a base substrate and an upper layer having molybdenum on the low-resistivity metal layer, forming a photoresist pattern having a linear shape on the upper layer, etching the upper layer via a mixed gas using the photoresist pattern as a mask, the mixed gas including a chlorine based gas mixed with an additional gas having at least one of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas, and etching the low-resistivity metal layer using the photoresist pattern as the mask thereby removing any stringer that may be caused by a residue of the low-resistivity metal layer.
METHOD FOR FORMING A METAL LINE AND METHOD FOR MANUFACTURING DISPLAY SUBSTRATE HAVING THE METAL LINE

REFERENCE TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The present invention relates to a method of manufacturing a display substrate and, more particularly, to a method of manufacturing a display substrate having a metal line exhibiting reduced resistance.

[0004] 2. Description of the Related Art
[0005] Generally, a liquid crystal display (“LCD”) apparatus includes a display substrate, a counter substrate, and a liquid crystal layer disposed between the display substrate and the counter substrate. Gate lines and source lines whose longitudinal directions cross each other are formed on the display substrate. A switching element, electrically connected to the gate and source lines and a pixel electrode, electrically connected to the switching element, are formed on the display substrate.

[0006] As display apparatus have become larger the RC delay of the metal layer formed on the display substrate has increased. To minimize the RC delay, the metal layer is formed by using aluminum having a low resistance. However, many defects may be generated in manufacturing an aluminum metal layer which also tends to exhibit a high contact resistance with other layers.

[0007] Thus, a double layer structure or a triple layer structure having a low resistivity metal layer is employed that may include an aluminum (Al) layer and a molybdenum (Mo) layer while the triple layer structure may include a first molybdenum (Mo) layer, an aluminum (Al) layer and a second molybdenum (Mo) layer.

[0008] In order to form the low resistivity metal layer structure, the molybdenum layer is etched by using a chlorine based gas mixed with oxygen gas. Because the chlorine based gas mixed with oxygen has high reactivity, contamination may be a problem. In addition, the mixed gas reacts with aluminum forming an undesired aluminum oxide layer allowing a stringer of the aluminum layer to remain at the edge of a pattern.

SUMMARY OF THE INVENTION

[0009] According to an aspect of the present invention a display substrate having an accurately formed metal layer of low resistance is made by depositing, on a base substrate, a low resistivity aluminum layer and then sequentially depositing an upper layer having molybdenum on the low resistivity metal layer. A photoresist pattern having a linear shape is formed on the upper layer. The upper layer is etched using a mixed gas with the photoresist pattern as a mask. The low resistivity metal layer is etched using the photoresist pattern as the mask. The mixed gas includes a chlorine based gas mixed with an additional gas having at least one of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas.

[0010] In an exemplary method for manufacturing the display substrate according to the present invention, a gate insulating layer is formed on a base substrate, and a gate pattern having a gate line and a gate electrode is formed on the base substrate. A source metal layer is formed by sequentially forming a lower layer, a low-resistivity layer, and an upper layer on the gate insulating layer. A source pattern having a source line, a source electrode and a drain electrode, is formed by etching the upper layer using a mixed gas including a chlorine based gas mixed with an additional gas having at least one of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas. A protective insulating layer having a contact hole is formed in the protective insulating layer. A pixel electrode electrically connected to the drain electrode through the contact hole is formed. The lower layer has molybdenum formed on the gate insulating layer. The low-resistivity metal layer has aluminum formed on the lower layer. The upper layer has molybdenum formed on the low-resistivity metal layer. The contact hole partially exposes the drain electrode.

According to the present invention, etching of the molybdenum layer formed on the aluminum layer is performed so that a stringer that the aluminum layer includes may be removed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The above and other features and advantages of the present invention will become more apparent by describing in detailed example embodiments thereof with reference to the accompanying drawings, in which:

[0013] FIGS. 1A to 1D are sectional views illustrating a method for forming a metal layer according to a first example embodiment of the present invention;

[0014] FIG. 2 is a schematic view illustrating a reactive ion etcher in accordance with one embodiment of the present invention;

[0015] FIG. 3 is a scanning electron microscope images illustrating etching stringers according to a power density in etching conditions for upper molybdenum;

[0016] FIG. 4 is a plan view illustrating a display substrate according to an example embodiment of the present invention;

[0017] FIGS. 5A to 8 are cross-sectional views illustrating a method for manufacturing a display substrate according to a second example embodiment of the present invention; and

[0018] FIGS. 9 to 12 are cross-sectional views illustrating a method for manufacturing a display substrate according to a third example embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0019] The invention is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

[0020] It will be understood that when an element or layer is referred to as being “on,” “connected to” or “coupled to” another element or layer, it can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly connected to” or “directly coupled to” another element or layer, there are no intervening elements or layers present.
Spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures.

Embodiments of the invention are described herein with reference to cross-section illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected.

Example Embodiment 1

Method for Forming a Metal Line

FIGS. 1A to 1D are sectional views illustrating a method for forming a metal layer according to a first example embodiment of the present invention. FIG. 2 is a schematic view illustrating a reactive ion etcher (“RIE”) in accordance with one embodiment of the present invention.

Referring to FIG. 1A, an insulating layer 110 is formed on a base substrate 101. A metal line layer 120 is formed on the insulating layer 110.

The metal line layer 120 includes a triple layer having a lower layer 121, a low resistivity metal layer 122, and an upper layer. The lower layer 121 includes molybdenum or molybdenum alloy. The low resistivity metal layer 122 includes aluminum or aluminum alloy. The upper layer 123 includes molybdenum or molybdenum alloy.

A photoresist pattern 140 is formed to correspond to a metal line, via coating and patterning a photoresist layer on the metal line layer 120. The metal line layer 120 is dry-etched by using the photoresist pattern 140.

A dry-etching process, a post-treatment process and an ashing process which will be explained, are performed by using the RIE illustrated in FIG. 2.

Referring to FIG. 2, the RIE 200 includes a vacuum chamber 210, an RF generator 212 and a power supply part 214, so that etches a substrate 100 by using an etching gas. The vacuum chamber 210 includes a lower electrode 220, a ground cover part 230, an upper electrode 240, a gas supply part 250, and a vacuum pump part 260.

The lower electrode 220 is disposed over the ground cover part 230, and is connected to the RF generator 212 to receive an RF power. The substrate 100 is disposed on the upper electrode 240. The upper electrode 240 is disposed over the lower electrode 220, and is electrically connected to the vacuum chamber 210 directly. In this case, the upper electrode 240 may be replaced with the vacuum chamber 210. In this case, the lower electrode 220 is used as a cathode, and the upper electrode 230 is used as an anode.

The gas supply part 250 supplies gas that will be used for the dry-etching, ashing and post-treatment processes into the vacuum chamber 210. The gas provided by the gas supply part 250 is discharged by the RF power, so that plasma is formed.

The vacuum pump part 260 emits the gas inside of the vacuum chamber 210 into an exterior, so that maintains the vacuum chamber 210 in a vacuum state.

Then, referring to FIGS. 1A and 2, the dry-etching, ashing and post-treatment processes on the substrate 100 having the metal line layer 120 formed on the substrate 100 will be explained.

Referring to FIGS. 1A and 2, the substrate 100 that has the photoresist pattern 140 formed on the substrate 100, is disposed on the lower electrode 220 in the vacuum chamber 210.

The vacuum chamber 210 is set to a first dry-etching condition, and then, an oxygen layer (not shown) formed on the upper layer 121 is removed. The first dry-etching condition is that a pressure is about 15 mT, a source power is about 2000 W, and the etching gas of 100BCl3 is used. The source power and the bias power that will be explained below are powers applied to the lower electrode 220.

Referring to FIGS. 1B and 2, after removing the oxygen layer formed on the upper layer 123, the vacuum chamber 210 is set to a second dry-etching condition, and then the upper layer 123 is etched.

The second dry-etching condition is that the pressure is about 15 mT, the source power density which is defined as the source power divided by an area of the electrode is between about 1 W/cm2 and about 2 W/cm2, and the bias power density which is defined as the bias power divided by the area of the electrode is between about 0.3 W/cm2 and about 0.6 W/cm2. The area of the electrode is defined as the area of the lower electrode 220. The etching gas is a mixed gas including a chlorine based gas (for example, C12 or HCl) mixed with an additional gas having one of nitrogen gas (N2), argon gas (Ar), helium gas (He) and sulfur hexafluoride gas (SF6). A ratio of the additional gas with respect to the chlorine based gas is about 50% and about 200%. The upper layer 123 is etched with the second dry-etching condition, to form the upper pattern 123a.

Referring to FIGS. 1C and 2, after etching the upper layer 123, the vacuum chamber 210 is set to a third dry-etching condition, and then the oxygen layer formed on the low-resistivity metal layer 122 is removed.

The third dry-etching condition is that the pressure is about 15 mT, the source power is about 2000 W, and the etching gas of 20C12/100BCl3 that is the chlorine based gas mixed with BCl3, is used. The oxygen layer formed on the low-resistivity metal layer 122 is removed with the third dry-etching condition.

After the oxygen layer formed on the low-resistivity metal layer 122 is removed, the vacuum chamber 210 is set to a fourth dry-etching condition, and then the low-resistivity metal layer 122 is etched.

The fourth dry-etching condition is that the pressure is between about 10 mT and about 30 mT, the source power density is between about 0.7 and about 1.8, and the bias power density is between about 0.7 and about 1.8. The mixed gas that is the chlorine based gas mixed with one of BCl3, nitrogen gas (N2) and argon gas (Ar) is used as the etching gas. Preferably, the mixed gas that is the chlorine based gas (for example, C12 or HCI) mixed with one of nitrogen gas (N2) and argon gas (Ar) (Ar) is used. A ratio of nitrogen gas (N2) or argon gas (Ar) with respect to the chlorine based gas is between about 50% and about 150%.

The low-resistivity metal layer 122 is etched with the fourth dry-etching condition, to form a low-resistivity pattern 122a.

Referring to FIGS. 1D and 2, after etching the low-resistivity metal layer 122, the vacuum chamber 210 is set to a fifth dry-etching condition, and then, the lower layer 121 is etched. The fifth dry-etching condition is that the...
power is between about 15 mT and about 100 mT, the source power is about 1000 W. The mixed gas that is the chlorine based gas mixed with the additional gas having one of nitrogen gas (N₂), argon gas (Ar), helium gas (He) and sulfur hexafluoride gas (SF₆) is used as the etching gas. The ratio of the additional gas with respect to the chlorine based gas is about 200%. The lower layer 121 is etched to form a lower pattern 121a.

[0043] According to the dry-etching process, a metal line 120a having the low resistance is formed on the base substrate 101.

[0044] When forming the metal line, a chlorine ion remains on the base substrate 101 due to chlorine gas Cl₂ that the etching gas includes. When the chlorine ion remaining on the base substrate 101 is exposed to the atmosphere, the chlorine ion is reacted with moisture in the atmosphere to form hydrochloric acid (HCl). HCl corrodes the low-resistivity pattern 122a including aluminum (Al), so that line stringers occur.

[0045] Thus, after forming the metal line, the post-treatment process is performed to remove the chlorine ion remaining on the base substrate 101. To perform the post-treatment process, at least one of H₂ gas and H₂O gas is provided into the vacuum chamber 210.

[0046] H₂ gas or H₂O gas provided into the vacuum chamber 210 is dissociated by a plasma discharge to generate a hydrogen ion (H+). The hydrogen ion (H+) is reacted with the chlorine ion remaining on the base substrate 101, to generate hydrochloric acid (HCl). HCl generated from the vacuum chamber 210 is generated and evaporated at the same time due to an equilibrium vapor pressure. The evaporated HCl is emitted outside of the vacuum chamber 210 through the vacuum pump part 260. Accordingly, the chlorine ion remaining on the base substrate 101 is removed, so that the corrosion of the low-resistivity pattern 122a may be prevented.

[0047] Alternatively, the post-treatment process may be performed by using a fluorine (F) based gas in spite of H₂ gas or H₂O gas.

[0048] For example, the fluorine based gas provided into the vacuum chamber 210 is discharged by the RF power, so that the plasma is formed. Thus, fluorine radical is generated. The fluorine radical has a better reactivity than the chlorine ion. Thus, the fluorine radical is reacted with the low-resistivity pattern 122a on an exposed surface of the low-resistivity pattern 122a, to substitute the remaining chlorine ion. Accordingly, a corrosion preventing layer including aluminum fluoride (AlF) is formed on the exposed surface of the low-resistivity pattern 122a. Thus, the corrosion of the low-resistivity pattern 122a may be prevented.

[0049] Before the post-treatment process or after the post-treatment process, oxygen gas is provided into the vacuum chamber 210 to perform the ashing process that removes the photoresist.

[0050] Referring to Tables 1, 2, and FIG. 3, effects of etching the molybdenum layer with the etching conditions of the present example embodiment will be explained.

[0051] Tables 1, 2, and 3 show etching uniformity of the molybdenum layer with the etching conditions of the present example embodiment. The etching uniformity means uniformity in etching quantity of the molybdenum layer. For example, the etching uniformity is a value of measuring surface topography after the etching process, to find out how uniformly the molybdenum layer is etched in the base substrate. Thus, the surface topography having a lower value may be better in the uniformity.

[0052] Tables 1, 2 and 3 show results after etching the single molybdenum layer using a test substrate having the single molybdenum formed on the test substrate, when a nitrided silicon layer (n-SiNx), an amorphous silicon layer (a-Si) and an n⁺ ion doped layer are sequentially formed.

[0053] Tables 1 and 2 show results after etching an upper molybdenum layer in the single molybdenum layer including Mo/Al/Mo layer. Table 3 shows results after etching a lower molybdenum layer in the single molybdenum layer including Mo/Al/Mo layer.

[0054] Referring to Tables 1, 2 and 3, the oxygen layer was removed before etching the single molybdenum layer. The etching condition for removing the oxygen layer was that the pressure was about 15 mT, the source power was about 2000 W, and the etching gas of 100BCl₃ was used.

Table 1 shows results after etching the upper molybdenum layer (Mo-t) with a main etching condition that the pressure was about 15 mT; the source power was about 1500 W, and the ratio of the additional gas with respect to the chlorine based gas was about 2:1.

In Comparative Example 1 (No.1), the conventional etching gas, for example the chlorine based gas mixed with oxygen gas (O₂), was used. In that case, an etching rate (E/R) was about 3285 Å/min and the etching uniformity was about 3.7%.

In Example 1 (T#1), the etching gas including the chlorine based gas mixed with oxygen gas (O₂), was used. In that case, the etching rate (E/R) was about 1450 Å/min and the etching uniformity was about 5.2%. In Example 2 (T#2), the etching gas including the chlorine based gas mixed with argon gas (Ar), was used. In that case, the etching rate (E/R) was about 1356 Å/min and the etching uniformity was about 3.7%.

In Example 3 (T#3), the etching gas including the chlorine based gas mixed with helium gas (He), was used. In that case, the etching rate (E/R) was about 1537 Å/min and the etching uniformity was about 7.9%.

When Comparative Example 1 is compared with Examples 1, 2 and 3, the etching rate (E/R) in Examples 1, 2 and 3 is smaller than that of in Comparative Example 1, but Examples 1 and 2 may be enough to be applied to the etching process. The etching uniformity in Example 2 is substantially the same as that in Comparative Example 1.
and the etching uniformity in Examples 1 and 3 is substantially same as that in Comparative Example 1.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Stacked layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass/a-SiN/a-Si/a-Si/a-Si/Mo</td>
<td></td>
</tr>
<tr>
<td>Mo+b oxygen layer etching condition</td>
<td></td>
</tr>
<tr>
<td>Pressure(15 mT), Source power(2000 W), Gas(100BCl2), Size(20&quot;)</td>
<td></td>
</tr>
<tr>
<td>Mo+b main etching condition</td>
<td></td>
</tr>
<tr>
<td>Example 4 (T#4)</td>
<td>Example 5 (T#5)</td>
</tr>
<tr>
<td>15 mT, 2000 W, 60Cl2/80O2</td>
<td>15 mT, 2000 W, 60Cl2/80Ar</td>
</tr>
<tr>
<td>Etching rate [Å/min]</td>
<td>2338</td>
</tr>
<tr>
<td>Etching uniformity [%]</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Table 2 shows results after etching the upper molybdenum layer (Mo-t) with the main etching condition that the pressure was about 15 mT, the source power was about 2000 W, and the ratio of the additional gas with respect to the chlorine based gas was about 1:1. In Table 2, the ratio of the chlorine based gas in the etching gas was controlled to be higher than in Table 1.

In Example 4 (T#4), the etching rate (E/R) was about 2338 Å/min and the etching uniformity was about 8.9%. In Example 5 (T#5), the etching rate (E/R) was about 2406 Å/min and the etching uniformity was about 7.5%. In Example 6 (T#6), the etching rate (E/R) was about 2431 Å/min and the etching uniformity was about 8.2%.

When Examples 1, 2 and 3 in Table 1 is compared with Examples 4, 5 and 6 in Table 2, the value of the etching uniformity in Examples 4, 5 and 6 is increased so that the etching uniformity is a little worse than in Examples 1, 2 and 3. However, the etching rate (E/R) is somewhat increased in Examples 4, 5 and 6.

Accordingly, when Examples 1, 2 and 3 in Table 1 are compared with Examples 4, 5 and 6 in Table 2, the etching rate (E/R) is substantially same, and the etching uniformity is enough.

Table 3 shows results after etching the lower molybdenum layer (Mo-b) with the main etching condition that the pressure was about 100 mT, the source power was about 1000 W, and the ratio of the additional gas with respect to the chlorine based gas was about 4:1.

In the main etching condition of the lower molybdenum layer (Mo-b), a selective ratio should be higher than in the main etching condition of the upper molybdenum layer (Mo-t) illustrated in Tables 1 and 2, to prevent the n' ion doped layer (n' a-Si) that is formed under the lower molybdenum layer (Mo-b) from being etched. Accordingly, the ratios of the pressure and the additional gas are increased.

In Comparative Example 2 (T#2), the conventional etching gas, for example the chlorine based gas mixed with oxygen gas (O2), was used. In that case, an etching rate (E/R) was about 3509 Å/min and the etching uniformity was about 6.8%.

In Example 7 (T#7), the etching gas including the chlorine based gas mixed with nitrogen gas (N2), was used. In that case, the etching rate (E/R) was about 1437 Å/min and the etching uniformity was about 6.7%.

In Example 8 (T#8), the etching gas including the chlorine based gas mixed with argon gas (Ar), was used. In that case, the etching rate (E/R) was about 1684 Å/min and the etching uniformity was about 6.9%.

In Example 9 (T#9), the etching gas including the chlorine based gas mixed with helium gas (He), was used. In that case, the etching rate (E/R) was about 1637 Å/min and the etching uniformity was about 7.1%.

When Comparative Example 2 is compared with Examples 7, 8 and 9, the etching rate (E/R) in Examples 7, 8 and 9 is smaller than that in Comparative Example 2, but Examples 7, 8 and 9 may be enough to be applied to the etching process. The etching uniformity in Examples 7, 8 and 9 is substantially same as in Comparative Example 2.

Therefore, as illustrated in Tables 1, 2 and 3, the etching uniformity in etching the upper and lower molybdenum layers (Mo-t, Mo-b) using the mixed gas including the chlorine based gas mixed with the additional gas having one of nitrogen gas (N2), argon gas (Ar) and helium gas...
(He), is substantially the same as that in etching the upper and lower molybdenum layers using conventional oxygen gas (O2).

**[0069]** FIG. 3 is a scanning electron microscope (“SEM”) images illustrating etching strings according to a power density in etching conditions for upper molybdenum.

**[0070]** The SEM pictures illustrated in FIG. 3, show a channel portion and a line portion, after etching the upper molybdenum layer having the Mo/AI/Mo layer with the corresponding source power density and bias power density conditions, and then sequentially etching the aluminum layer and the lower molybdenum layer.

**[0071]** Comparative Example 3 (#3) shows the channel and line portions, after etching the upper molybdenum layer with the condition that the source power density was about 0.365 W/cm² and the bias power density was about 0.122 W/cm². Comparative Example 4 (#4) shows the channel and line portions, after etching the upper molybdenum layer with the condition that the source power density was about 0.73 W/cm² and the bias power density was about 0.244 W/cm².

**[0072]** Referring to the SEM pictures of Comparative Example 3 and Comparative Example 4, a surface of the etched metal pattern includes metal remnants, and the metal remnants having a stringer remain at an edge portion of the etched metal pattern.

**[0073]** Example 10 (T=10) shows the line portion, after etching the upper molybdenum layer with the condition that the source power density was about 1.095 W/cm² and the bias power density was about 0.366 W/cm². Example 11 (T=11) shows the channel and line portions, after etching the upper molybdenum layer with the condition that the source power density was about 1.825 W/cm² and the bias power density was about 0.61 W/cm².

**[0074]** Referring to the SEM pictures of Example 10 and Example 11, the surface and the edge portion of the etched metal pattern include little metal remnants. The stringer due to the metal remnants does not occur in the power densities used in Example 10 and Example 11.

**Example Embodiment 2**

**Method for Manufacturing a Display Substrate**

**[0075]** FIG. 4 is a plan view illustrating a display substrate according to an example embodiment of the present invention. FIGS. 5A to 8 are cross-sectional views illustrating a method for manufacturing a display substrate according to a second example embodiment of the present invention.

**[0076]** FIGS. 5A and 5B are cross-sectional views illustrating the method for manufacturing the display substrate using a first mask.

**[0077]** Referring to FIGS. 4, 5A and 5B, a gate metal layer 310 is deposited on a base substrate 101 via a sputtering process. The gate metal layer 310 includes a double layer having a low-resistivity metal layer 311 and an upper layer 312. For example, the low-resistivity metal layer 311 includes aluminum or aluminum alloy, and the upper layer 312 includes molybdenum or molybdenum alloy.

**[0078]** A first photore sist layer is formed on the gate metal layer 310, and then the first photore sist layer is patterned using the first mask, to form a first photore sist pattern PR1. The gate metal layer 310 is etched using the first photore sist pattern PR1, to form a gate pattern including a gate line GLn, a gate electrode GE and a storage common line STL.

**[0079]** The gate metal layer 310 may be wet-etched or dry-etched. Preferably, as explained above in FIGS. 1A to 1C, in etching the gate metal layer 310, an oxygen layer of the upper layer 312, the upper layer 312, the oxygen layer of the low-resistivity metal layer 311 and the low-resistivity metal layer 311 are sequentially etched with the first to fourth dry-etching conditions.

**[0080]** FIGS. 6A to 6D are cross-sectional views illustrating the method for manufacturing the display substrate using a second mask.

**[0081]** Referring to FIGS. 4 and 6A, a gate insulating layer 320 and a semiconductor layer 330 including a silicon nitride (SiN) layer are formed on the base substrate 301 on which the gate pattern is formed, via a plasma enhanced chemical vapor deposition (“PECVD”) process. The semiconductor layer 330 includes an active layer 331 having amorphous silicon (a-Si:H), and an ohmic contact layer 332 doped with n⁺ ion at a high concentration.

**[0082]** Then, a source metal layer 340 is deposited on the ohmic contact layer 332. The source metal layer 340 has a triple layer including a lower layer 341, a low-resistivity metal layer 342 and an upper layer 343 sequentially formed. The lower layer 341 includes molybdenum or molybdenum alloy, the low-resistivity metal layer includes aluminum or aluminum alloy, and the upper layer includes molybdenum or molybdenum alloy.

**[0083]** A second photore sist layer is formed on the base substrate 301 on which the source metal layer 340 is formed, and then, a second photore sist pattern (PR2) is formed by using the second mask having a slit.

**[0084]** The second photore sist pattern PR2 includes a first picture pattern PR21 and a second picture pattern PR22. The first picture pattern PR21 corresponds to an area in which a source electrode SE, a drain electrode DE, and a source line DLm of a switching element TFT are formed. The second picture pattern PR22 corresponds to an area in which a channel portion CH of the switching element TFT is formed, and the second picture pattern PR22 has a thinner thickness than that of the first picture pattern PR21.

**[0085]** Referring to FIGS. 4 and 6B, the source metal layer 340 is patterned by using the second photore sist pattern PR2, so that the source pattern having an electrode pattern 340α and the source line DLm is formed. The electrode pattern 340α corresponds to the source and drain electrodes of the switching element TFT.

**[0086]** The source metal layer 340 is wet-etched. In addition, as explained above in FIGS. 1A to 1D, the source metal layer 340 that is wet-etched may include a better accurate pattern than the source metal layer 340 that is etched with the first to fifth dry-etching conditions.

**[0087]** Referring to FIGS. 4, 6C and 6D, after forming the source pattern, the semiconductor layer 330 is etched using the second photore sist pattern and the source pattern as a mask. Accordingly, semiconductor patterns 330a and 330b that are patterned along the source pattern, are formed under the source pattern.

**[0088]** The second photore sist pattern PR2 is removed to have a predetermined thickness using an oxygen (O2) plasma discharge via the ashing process (or etch-back process). The electrode pattern 340α corresponding to the channel portion CH of the switching element TFT is partially exposed via the ashing process. A remaining pattern PR23 of the second photore sist pattern PR2 is formed on the
area in which the source electrode SE, the drain electrode DE, and the source line DLm are formed, via the ashing process.

[0089] The exposed electrode pattern 340a is dry-etched by using the remaining pattern PR23 as the mask.

[0090] The upper layer 343 of the electrode pattern 340a is etched with the first and second dry-etching conditions, as explained above in FIGS. 1A and 1B. For example, the oxygen layer formed on the upper layer 343 is etched with the first condition that the pressure is about 15 mT, the source power is about 2000 W, and the etching gas of 100%BCl3 is used. After removing the oxygen layer formed on the upper layer 343, the upper layer 343 is etched with the second dry-etching condition.

[0091] The second dry-etching condition is that the pressure is about 15 mT, the source power density is between about 1 W/cm² and about 2 W/cm², and the bias power density is between about 0.3 W/cm² and about 0.6 W/cm². The mixed gas including the chlorine based gas is mixed with the additional gas having one of argon gas (Ar), nitrogen gas (N₂), helium gas (He) and sulfur hexafluoride gas (SF₆). The ratio of the additional gas with respect to the chlorine based gas is between about 50% and about 200%.

[0092] After etching the upper layer 343, the low-resistivity metal layer 342 of the electrode pattern 340a, as illustrated in FIG. 1, is etched with the third and fourth dry-etching conditions. The oxygen layer formed on the low-resistivity metal layer 342 is etched with the third dry-etching condition that the pressure is about 15 mT, the source power is about 2000 W and the etching gas of 20%C/100%BCl3 is used.

[0093] After removing the oxygen layer formed on the low-resistivity metal layer 342, the low-resistivity metal layer 342 is etched with the fourth dry-etching condition. The fourth dry-etching condition is that the pressure is between about 10 mT and 30 mT, the source power density is between about 0.7 W/cm² and about 1.8 W/cm², and the bias power density is between about 0.7 W/cm² and about 1.8 W/cm². The mixed gas including the chlorine based gas mixed with argon gas (Ar) or nitrogen gas (N₂) is used as the etching gas. The ratio of argon gas (Ar) or nitrogen gas (N₂) with respect to the chlorine based gas is between about 50% and about 150%.

[0094] After etching the low-resistivity metal layer 342, as explained above in FIG. 1D, the lower layer 341 of the electrode pattern 340a is etched with the fifth dry-etching condition.

[0095] The electrode pattern 340a is patterned to be the source electrode SE and the drain electrode DE, via the dry-etching process mentioned above. The ohmic contact layer 332 exposed between the source and drain electrodes SE and DE is dry-etched by using the source and drain electrodes SE and DE as the mask. Thus, the channel portion CH through which the active layer 331 is exposed, is formed between the source and drain electrodes SE and DE, so that the switching element TFT is formed.

[0096] After the fifth dry-etching process, the chlorine ion provided from the chlorine based etching gas is reacted with the low-resistivity metal layer 342 including aluminum or aluminum alloy, to remain on an exposed surface of the low-resistivity metal layer 342. The post-treatment process is performed to remove the remaining chlorine ion. The surface of the low-resistivity metal layer 342 is prevented from being corroded, via the post-treatment process. The post-treatment process is performed with the same condition as the first example embodiment.

[0097] FIG. 7 is a cross-sectional view illustrating the method for manufacturing the display substrate using a third mask. FIG. 8 is a cross-sectional view illustrating the method for manufacturing the display substrate using a fourth mask.

[0098] Referring to FIGS. 4, 7 and 8, a protective insulating layer 350 is formed on the base substrate 301 on which the switching element TFT is formed. The protective insulating layer 350 includes the silicon nitride layer. A contact hole 353 that partially exposes the drain electrode DE, is formed via a photolithography process using the third mask.

[0099] The protective insulating layer 350 including the silicon nitride layer is explained in the present example embodiment, but the protective insulating layer 350 may include an organic layer such as an acrylic material. In addition, the protective insulating layer 350 may include the double layer having the silicon nitride layer and the organic layer sequentially formed.

[0100] A transparent conductive material (not shown) is deposited on the protective insulating layer 350 in which the contact hole 353 is formed. Examples of materials that can be used for the transparent conductive material may include indium tin oxide or indium zinc oxide. Accordingly, the transparent conductive material is connected to the drain electrode DE through the contact hole 353. The transparent conductive material is patterned by using the fourth mask, to form a pixel electrode PE. The pixel electrode PE is electrically connected to the switching element TFT through a contact portion CNT.

Example Embodiment 3
Method for Manufacturing a Display Substrate

[0101] FIGS. 9 to 12 are cross-sectional views illustrating a method for manufacturing a display substrate according to a third example embodiment of the present invention. The same reference numerals will be used to refer to the same or like parts as those described in the second example embodiment and any further repetitive explanation concerning the above elements will be omitted.

[0102] FIG. 9 is a cross-sectional view illustrating the method for manufacturing the display substrate using a first mask and a second mask.

[0103] Referring to FIGS. 4 and 9, a gate pattern including a gate line GLn, a gate electrode GE and a storage common line STLi, is formed on a base substrate 301 by using the first mask. The gate pattern includes a double layer having a low-resistivity metal layer 311 and an upper layer 312. The low-resistivity metal layer 311 includes aluminum or aluminum alloy, and the upper layer 312 includes molybdenum or molybdenum alloy. The gate metal layer 310 may be wet-etched or dry-etched. Preferably, as explained above in FIGS. 1A to 1C, the gate metal layer is sequentially etched with the first to fourth dry-etching conditions.

[0104] A gate insulating layer 320, an active layer 331 and an ohmic contact layer 332 are sequentially formed on the base substrate 301 on which the gate pattern is formed. A semiconductor layer 330 of the switching element TFT is formed by using a second photoresist pattern PR2 which is patterned by the second mask.
What is claimed is:

1. A method for forming a metal line, the method comprising:

   sequentially depositing a low-resistivity metal layer having aluminum on a base substrate, and an upper layer having molybdenum on the low-resistivity metal layer; forming a photoresist pattern having a linear shape on the upper layer; etching the upper layer via a mixed gas using the photoresist pattern as a mask, the mixed gas including a chlorine based gas mixed with an additional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas; and etching the low-resistivity metal layer using the photoresist pattern as the mask.

2. The method of claim 1, wherein a ratio of the additional gas with respect to the chlorine based gas is between about 50% and about 200%.

3. The method of claim 2, wherein the upper layer is etched with conditions that a source power density [W/cm²] is between about 1 and about 2, and a bias power density [W/cm²] is between about 0.3 and about 0.6.

4. The method of claim 1, wherein the low-resistivity metal layer is etched by the mixed gas including the chlorine based gas mixed with the argon gas or the nitrogen gas.

5. The method of claim 4, wherein a ratio of the argon or nitrogen gas with respect to the chlorine based gas is between about 50% and about 150%.

6. The method of claim 5, wherein the low-resistivity metal layer is etched with conditions that a source power density [W/cm²] is between about 0.7 and about 1.8, and a bias power density [W/cm²] is between about 0.7 and about 1.8.

7. The method of claim 1, further comprising removing a corrosive element remaining on the base substrate after etching the low-resistivity metal layer.

8. The method of claim 7, further comprising forming a lower layer including the molybdenum under the low-resistivity metal layer.

9. The method of claim 8, further comprising etching the lower layer using the mixed gas including the chlorine based gas mixed with the additional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas, before removing the corrosive element.

10. The method of claim 7, wherein the corrosive element is removed by using at least one selected from the group consisting of H₂O gas and H₂ gas.

11. The method of claim 7, wherein the corrosive element is removed by using a fluorine (F₂) based gas.

12. The method for manufacturing a display substrate, the method comprising:

   forming a gate insulating layer on a base substrate, a gate pattern having a gate line and a gate electrode formed on the base substrate; sequentially forming a source metal layer including a lower layer, a low-resistivity layer and an upper layer, the lower layer having molybdenum formed on the gate insulating layer, the low-resistivity metal layer having aluminum formed on the lower layer, the upper layer having molybdenum formed on the low-resistivity metal layer; forming a source pattern having a source line, a source electrode and a drain electrode by etching the upper layer using a chlorine based gas mixed with an addi-
tional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas;

forming a protective insulating layer having a contact hole formed in the protective insulating layer, the contact hole partially exposing the drain electrode; and

forming a pixel electrode electrically connected to the drain electrode through the contact hole.

13. The method of claim 12, wherein a ratio of the additional gas with respect to the chlorine based gas is between about 50% and about 200%.

14. The method of claim 13, wherein the upper layer is etched with conditions that a source power density [W/cm²] is between about 1 and about 2, and a bias power density [W/cm²] is between about 0.3 and about 0.6.

15. The method of claim 14, wherein forming the source pattern comprises:

forming an electrode pattern and the source line, via etching the source metal layer;

etching an upper layer of the electrode pattern using the chlorine based gas mixed with the additional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas;

etching a low-resistivity metal layer of the electrode pattern using the mixed gas including the chlorine based gas mixed with argon gas or nitrogen gas; and

etching a lower layer of the electrode pattern using the chlorine based gas mixed with the additional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas, and sulfur hexafluoride gas.

16. The method of claim 15, wherein the low-resistivity metal layer is etched with conditions that a chamber pressure is between about 10 and about 30, the source power density [W/cm²] is between about 0.7 and about 1.8, and the bias power density [W/cm²] is between about 0.7 and about 1.8.

17. The method of claim 14, wherein forming the source pattern comprises:

etching an upper layer of the source metal layer using chlorine based gas mixed with the additional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas;

etching a low-resistivity metal layer of the source metal layer using the chlorine based gas mixed with argon gas or nitrogen gas; and

forming the source line, the source electrode and the drain electrode by etching a lower layer of the source metal layer using the chlorine based gas mixed with the additional gas having at least one selected from the group consisting of nitrogen gas, argon gas, helium gas and sulfur hexafluoride gas.

18. The method of claim 12, further comprising removing a corrosive element corroding the low-resistivity metal layer, after forming the source pattern.

19. The method of claim 18, wherein the corrosive element is removed by using at least one selected from the group consisting of H₂O gas and H₂ gas.

20. The method of claim 18, wherein the corrosive element is removed by using a fluorine (F⁻) based gas.

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