TRANSPARENT CONDUCTIVE MEMBRANE OF HIGH RESISTANCE TOUCH PANEL OF CAPACITANCE AND MANUFACTURE METHOD THEREOF

Provide are a transparent conductive layer of a high-resistance capacitive touch panel and a method of manufacturing the same, in which a high-resistance substrate is manufactured using a sputtering process. The transparent conductive layer of the high-resistance capacitive touch panel is manufactured by sputtering an oxide compound target formed of antimony (Sb) and tin (Sn) at a temperature of about 200 to 300 °C. The transparent conductive layer of the high-resistance capacitive touch panel can be formed of low-cost antimony (Sb) and tin oxide (SnO) and have desired sheet resistance, optical transmittance, and surface flatness.
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[DESCRIPTION]

TRANSPARENT CONDUCTIVE MEMBRANE OF HIGH RESISTANCE TOUCH PANEL OF CAPACITANCE AND MANUFACTURE METHOD THEREOF

[Technical Field]

The present invention relates to a transparent conductive layer of a high-resistance capacitive touch panel and a method of manufacturing the same, and more particularly, to a transparent conductive layer of a high-resistance capacitive touch panel and a method of manufacturing the same, in which a high-resistance substrate is manufactured using a sputtering process.

[Background Art]

In general, a transparent conductive layer may be applied in various fields, for example, as an anti-static layer or an electromagnetic shielding layer of various household appliances and display devices, an electromagnetic shielding layer or a transparent electrode for power application in liquid crystal displays (LCDs), field emission displays (FEDs) and plasma display panels (PDPs), or an electrode of solar batteries.

In particular, when a transparent conductive layer is used as an electromagnetic shielding layer of PDPs or an electrode of dye-sensitized solar cells (DSSCs), the transparent conductive layer must have a sheet resistance of 120Ω/sq. or lower in order to achieve the scaling-up of the PDPs and the DSSCs.

A PDP, which displays an image using gas discharge, is excellent in terms of various display characteristics, such as display capability, luminance, contrast, a residual image, and a viewing angle, so that the PDP has attracted considerable attention as a display device that can replace a cathode-ray tube (CRT).

In the PDP, when a direct-current (DC) or alternating-current (AC) voltage is applied between electrodes, discharge occurs in a gas between the electrodes, thus creating ultraviolet (UV) rays that excite phosphor layers to form an image.

In the PDP, a current supplied to a driver circuit and an AC electrode and a high voltage applied for plasma discharging result in occurrence of electromagnetic waves. Thus, a transparent conductive layer or a conductive mesh, which has a high transmittance, is used as a filter for shielding the electromagnetic waves.

Typically, the transparent conductive layer may be a conductive layer obtained by sputtering silver (Ag), copper (Cu), or indium tin oxide (ITO), and the conductive mesh may be an optical transmissive conductive mesh or a fine metal mesh. The
formation of the optical transmissive conductive mesh involves electroless plating a fabric mesh, such as a polyester mesh, with a metal, such as Cu or a compound of Cu and nickel (Ni), and processing the plated mesh with special resin. The fine metal mesh is obtained using a photolithography process.

However, the sputtered conductive layer has a high transmittance but its manufacture requires additional expensive equipment and precludes mass production.

Also, low thermal stability of the sputtered conductive layer becomes an obstacle to the scaling - up of solar batteries.


As illustrated in FIG. 1, Korean Patent Laid-open Publication No. 2005-0080609 has proposed a technique of manufacturing a transparent conductive layer using a spray method. Specifically, a spray composite for forming a thin layer, which is formed of ITO and fluorine-doped tin oxide (FTO), is transferred with a predetermined pressure from a liquid tank 11 to spray nozzle 12 and sprayed using a spray system. Thus, an ITO-FTO composite layer 16 is repetitively deposited on a transparent glass substrate 15, which is heated by a heat source 14 to a temperature of 200°C or higher, until the ITO-FTO composite layer 16 has a desired thickness and conductivity.

However, since the above-described conventional technique employs expensive oxide layers, the productivity of substrates is low due to high-cost materials.

Also, since the above-described conventional technique uses the spray system, an undesired region other than a glass substrate may be sprayed, thereby increasing the cost of post-processing.

[Disclosure]
[Technical Problem]

The present invention is directed to a transparent conductive layer of a high-resistance capacitive touch panel and a method of manufacturing the same, in which a transparent conductive layer is manufactured using low-cost materials, namely, antimony (Sb) and tin oxide (SnO).

Specifically, the present invention provides a process technique for manufacturing an optimal substrate of a capacitive touch panel using an oxide compound formed of Sb and Sn by appropriately controlling a deposition thickness, a deposition time, and an O₂ flow rate and performing post-processing so that the
substrate can have a sheet resistance of 3,000Ω/sq. or lower and an optical transmittance of 80% or more.

[Technical Solution]

One aspect of the present invention provides a transparent conductive layer of a high-resistance capacitive touch panel, which is manufactured by sputtering an oxide compound target formed of antimony (Sb) and tin (Sn) at a temperature of about 200 to 300 °C.

The oxide compound target may be sputtered using a radio-frequency (RF) magnetron sputtering chamber.

The transparent conductive layer may have a sheet resistance of 3,000Ω/sq. or lower and an optical transmittance of 80% or more.

The transparent conductive layer may be manufactured in the RF magnetron sputtering chamber by controlling a process pressure, a deposition temperature, an O₂ flow rate, a deposition time, and a power such that the transparent conductive layer is the most suitable for a substrate of the high-resistance capacitive touch panel.

The transparent conductive layer may be manufactured under a pressure of 8 mTorr at a temperature of 300 °C and an O₂ flow rate of 1 seem for 10 minutes.

The transparent conductive layer may have a sheet resistance of 1432 Ω/sq, an optical transmittance of 81%, and a surface flatness of 0.83 nm.

The transparent conductive layer may be used as an electromagnetic shield layer of a sensor or an electrode of a solar battery.

Another aspect of the present invention provides a method of manufacturing a transparent conductive layer of a high-resistance capacitive touch panel. The method includes the steps of: preparing an oxide compound target formed of antimony (Sb) and tin (Sn); loading the oxide compound target into a radio-frequency (RF) magnetron sputtering chamber; controlling a process pressure, a deposition temperature, an O₂ flow rate, a deposition time, and power in the RF magnetron sputtering chamber; and forming the transparent conductive layer by sputtering the oxide compound target at a temperature of about 200 to 300 °C.

The deposition temperature, the O₂ flow rate, and the deposition time may be controlled to be 8 mTorr, 300 °C, 1 seem, and 10 minutes, respectively.
[Description of Drawings]

FIG. 1 is a construction diagram illustrating a conventional method of manufacturing a transparent conductive layer;

FIG. 2 is scanning electron microscope (SEM) images showing deposition of x-ray diffraction (XRD) patterns of an antimony tin oxide (ATO) layer over time at a temperature of about 300 °C, according to an experimental embodiment of the present invention;

FIG. 3 is diagrams showing surface flatness of an ATO layer relative to a deposition temperature according to an exemplary embodiment of the present invention;

FIG. 4 is diagrams showing surface flatness of an ATO layer over time according to an exemplary embodiment of the present invention;

FIG. 5 is SEM images showing deposition of XRD patterns of an ATO layer relative to an O₂ flow rate according to an exemplary embodiment of the present invention;

FIG. 6 is diagrams showing sheet resistance of an ATO layer relative to an O₂ flow rate according to an exemplary embodiment of the present invention;

FIG. 7 is diagrams showing surface flatness of an ATO layer relative to an O₂ flow rate according to an exemplary embodiment of the present invention;

FIG. 8 is a flowchart illustrating a method of manufacturing a transparent conductive layer of a high-resistance capacitive touch panel according to an exemplary embodiment of the present invention; and

FIG. 9 is a photograph of an ATO/SiO₂/glass substrate for a touch panel, which is manufactured according to the method shown in FIG. 8.

[Mode for Invention]

The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown.

Initially, the concept of the present invention will be described.

The present invention will be described with reference to results of initial experiments for manufacturing an antimony tin oxide (ATO) thin layer. Thereafter, variations in physical properties of an ATO layer relative to a deposition temperature under secured deposition conditions will be described. The deposition conditions were the same as initial conditions. As a result of experimentation, the thickness of an ATO layer decreased as the deposition temperature increased. This is because particles deposited on a substrate evaporated due to thermal energy.
Also, it can be seen that the deposited thickness of an ATO layer increases linearly over time under the same conditions. An appropriate thickness of the ATO layer is determined by the following analysis of electrical properties and surface flatness.

Variations in thickness of an ATO layer relative to a deposition temperature and a deposition time will now be described.

Initially, the crystallinity of an ATO layer relative to a deposition temperature will be explained. A large portion of the ATO layer remained in an amorphous phase at a deposition temperature of 200 °C or lower, while crystals having planes (101) and (211) were observed at a deposition temperature of 300 °C or higher. X-ray diffraction (XRD) patterns were not changed at the deposition temperature of 300 °C or higher.

However, at the deposition temperature of 300 °C, as the ATO layer became thicker, the entire ATO layer became gradually more crystalline over time, as can be seen from scanning electron microscope (SEM) images. Also, the crystallinity of the ATO layer is correlated with the following electrical properties.

The crystallinity of an ATO layer
Priority orientation of Plane (101): hole concentration ↑, mobility ↓.
Priority orientation ↑ of Plane (211): hole concentration ↓, mobility ↑.

FIG. 2 shows deposition of XRD patterns of an ATO layer over substrate temperature and time.

Next, the optical transmittance of an ATO layer relative to a deposition temperature will be described. As the result of an experiment, the thickness of the present sample increased in proportion to a deposition temperature. Thus, the optical transmittance of the ATO layer can be explained in relation to a thickness variation. It can be also reflected by a phenomenon where the optical transmittance (or thickness) moves towards a short wavelength in the range of 250 to 350 nm. Also, the variation of an optical transmittance over time comes to the same conclusion. The average optical transmittance decreased with an increase in the deposited thickness in the visible light (VL) range of 400 to 700 nm. However, the average optical transmittance obtained in the VL range is too low to be applied to a substrate of a touch panel.

Hereinafter, the optical transmittance of an ATO layer relative to a deposition temperature and the optical transmittance of the ATO layer over time will be described.

A variation in the sheet resistance of an ATO layer over time was analyzed. As a result, it can be seen that the sheet resistance of the ATO layer continuously decreased over time (i.e., as the deposited thickness of the ATO layer increases). The ATO layer obtained an appropriate sheet resistance for a substrate of a touch panel when a
deposition time was 10 minutes. Thus, according to the present invention, it is
concluded that the ATO layer can be deposited for 10 minutes in order to obtain an
appropriate sheet resistance.

In an analysis of the sheet resistance of the ATO layer over time, the sheet
resistance and resistivity of the ATO layer according to a deposition temperature were
measured. As a result, the ATO layer obtained an appropriate sheet resistance of
1007Ω/sq. at a deposition temperature of about 300 °C. The resistivity of the ATO
layer also showed the same tendency as the sheet resistance thereof.

The electrical properties of a transparent conductive layer depend on hole
concentration and mobility, which were calculated by measuring a hole effect of an
ATO thin layer. As a result, the ATO thin layer had the highest hole concentration and
the lowest mobility at a temperature of about 300 °C. Therefore, it can be seen that as
both the hole concentration and the mobility of the ATO thin layer increase, the
electrical properties of the ATO layer are improved, but when only the hole
concentration of the ATO thin layer increases, the mobility of the ATO thin layer
decreases due to scattered impurities, thereby degrading the electrical properties of the
ATO layer.

Also, the electrical properties of an ATO thin layer relative to a deposition
temperature will now be described.

A heat-resistance test was performed on the ATO thin layer in a heater under an
atmospheric pressure while varying a deposition temperature. In order to perform the
heat-resistance test on the ATO layer, the ATO layer should be annealed for a
predetermined amount of time (e.g., 3 hours) at a temperature of about 500 °C or higher
at which a protection coating layer is plasticized, and then the electrical properties of the
ATO thin layer should be maintained. The heat-resistance test, which is necessarily
required to manufacture a touch panel, included a first heating process, a first annealing
process (1.5 hours and 500 °C or higher), a first cooling process, a second heating
process, a second annealing process (1.5 hours and 500 °C), and a second cooling
process.

After the heat-resistance test was performed on the ATO thin layer, the changed
electrical properties of the ATO thin layer were calculated as shown in Equation 1:

\[
SR \text{ ratio} = \left( \frac{\text{SRf} - \text{SRi}}{\text{SRi}} \right) \times 100 \%
\]

wherein the SR ratio denotes a rate of change of sheet resistance, SRi denotes sheet
resistance measured before the heat-resistance test, and SRf denotes sheet resistance
measured after the heat-resistance test.
Furthermore, a variation in sheet resistance of an ATO thin layer relative to a deposition temperature after the heat-resistance test will now be described.

From calculation results, it can be seen that when the ATO thin layer is deposited at a temperature of 300 °C and 400 °C, the ATO thin layer can obtain an appropriate SR ratio of 1.5 or less for a touch panel. In the present invention, in order to enhance heat resistance, an ATO thin layer was deposited at a high temperature and naturally cooled in an O₂-H₂ atmosphere under a pressure of 100 mTorr.

Hereinafter, results of a chemical resistance test will be described. A transparent conductive layer should have an SR ratio of 1.1 or less after the chemical resistance test such that the transparent conductive layer can be applied to a touch panel. In order to perform the chemical resistance test, an ATO thin layer was exposed to a solution obtained by diluting acid/alkali in deionized water (DIW) at a dilution ratio of 10%, for 24 hr or more and the SR ratio of the ATO thin layer was measured.

<table>
<thead>
<tr>
<th>Substrate temperature (°C)</th>
<th>Sheet resistance before test [Ω/sq.]</th>
<th>Sheet resistance after test [Ω/sq.]</th>
<th>SR ratio [%]</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>~100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>2382</td>
<td>2685</td>
<td>12.7</td>
<td>Partially delaminated</td>
</tr>
<tr>
<td>300</td>
<td>1007</td>
<td>1063</td>
<td>5.5</td>
<td>Passed</td>
</tr>
<tr>
<td>400</td>
<td>834</td>
<td>878</td>
<td>5.3</td>
<td>Passed</td>
</tr>
<tr>
<td>500</td>
<td>877</td>
<td>932</td>
<td>6.8</td>
<td>Cloudy</td>
</tr>
</tbody>
</table>

Hereinafter, the surface flatness of an ATO thin layer relative to a deposition temperature will be described. The ATO thin layer had the lowest surface flatness (Rms) at a temperature of about 300 °C. Also, the surface flatness of the ATO thin layer over time was analyzed under the same conditions. As shown in FIGS. 3 and 4, the surface flatness of the ATO thin layer sharply increased over time.

FIG. 3 is diagrams showing surface flatness of an ATO layer relative to a deposition temperature according to an embodiment of the present invention.

The results shown in FIG. 3 are arranged in Table 2.
[Table 2]: The surface flatness of the ATO thin layer relative to the deposition temperature

<table>
<thead>
<tr>
<th>Substrate temperature [°C]</th>
<th>RT</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface flatness [nm]</td>
<td>Rms:1.31/ Ra:0.83</td>
<td>Rms:1.86/ Ra:1.11</td>
<td>Rms:1.35/ Ra:1.01</td>
<td>Rms:0.56/ Ra:0.44</td>
<td>Rms:1.05/ Ra:0.75</td>
<td>Rms:1.11/ Ra:0.75</td>
</tr>
</tbody>
</table>

FIG. 4 is diagrams showing surface flatness of an ATO layer over time according to an exemplary embodiment of the present invention.

Referring to FIG. 4, when the ATO thin layer was deposited at a temperature of about 300 °C for 10 minutes, the surface flatness of the ATO thin layer had the best value. However, the ATO thin layer did not reach an optical transmittance of 80% or higher appropriate for a touch panel. Accordingly, improved process conditions should be secured so as to enhance the optical transmittance of the ATO thin layer.

The present inventors made attempts to secure improved process conditions by injecting a reactive gas (i.e., O₂ gas) in order to enhance optical transmittance. Typically, when injecting the O₂ gas, the crystallinity and transmittance of a deposited thin layer are changed. Also, during the deposition of the thin layer, collision energy increases due to ionized oxygen and affects growth of nuclei on a substrate. Also, the deposition rate of the thin layer is markedly reduced. This phenomenon can be confirmed by measuring the thickness of the thin layer relative to an O₂ flow rate. The thickness of the thin layer hardly varied at an O₂ flow rate of 0.5 seem or lower, while the thickness of the thin layer was sharply reduced and saturated at an O₂ flow rate higher than 0.5 seem.

Also, the optical transmittance of the ATO thin layer can be improved by injecting O₂ gas. Hereinafter, a variation in the optical transmittance of an ATO thin layer relative to an O₂ flow rate will be explained. The average optical transmittance continuously increased with the flow rate of the O₂ gas in the visible light (VL) wavelength range of 400 to 700 nm. A transparent conductive ATO layer of a touch panel must have an optical transmittance of about 80% or higher, which can be obtained at an O₂ flow rate of 1 seem or higher. A variation in the optical transmittance of an ATO thin layer is closely associated with the optical bandgap of the ATO thin layer and affects the electrical properties of the ATO thin layer.

FIG. 5 is SEM images showing deposition of XRD patterns of an ATO layer relative to an O₂ flow rate according to an exemplary embodiment of the present
invention. Referring to FIG. 5, the crystallinity of the ATO thin layer gradually increased at an O\textsubscript{2} flow rate of 1 seem or lower. However, crystals were not clearly grown at an O\textsubscript{2} flow rate higher than 1 seem. That is, the crystallinity of the ATO thin layer cannot be precisely measured due to a small thickness of the ATO thin layer. In general, the growth of crystals with a (211) plane in the ATO thin layer depends on an increase in thickness relative to supplied power, a process pressure, and a deposition time. Also, it is known that the growth of crystals with a (211) plane on a thin layer due to the injection of O\textsubscript{2} gas leads to degradation of electrical properties (e.g., sheet resistance) of the thin layer and affects even the crystal size and sheet resistance of the thin layer. An increase in the crystal size of the ATO thin layer can be confirmed by analyzing SEM images.

During the deposition of a thin layer, the injection of O\textsubscript{2} gas is related to a process pressure. When a small amount of reactive gas is injected into a reactor, it is difficult to precisely control the amount of gas remaining in the reactor due to the flow rate of the reactive gas. Therefore, a method for supplying a small amount of gas is required to obtain the effect of the reactive gas. In the present invention, the supply of a small amount of gas includes supplying a mixture gas, supplying a predeposition gas for a predetermined amount of time, and obstructing the supply of the predeposition gas.

Next, the sheet resistance of an ATO layer relative to an O\textsubscript{2} flow rate will be described. The sheet resistance was about 1000\textgamma\textpercm\textpercm at an O\textsubscript{2} flow rate of 0.5 seem or lower, while the sheet resistance linearly increased at an O\textsubscript{2} flow rate higher than 0.5 seem. It can be deduced that when O\textsubscript{2} gas is supplied at a flow rate of 0.5 to 1 seem, a transparent conductive substrate of a touch panel can have an optimal sheet resistance. In particular, when the O\textsubscript{2} flow rate ranged from 0.5 to 1 seem, the sheet resistance had the lowest dispersion of ±3% or less. Also, the sheet resistance had a low dispersion of ±10 or less at an O\textsubscript{2} flow rate of 3 to 5 seem.

Noticeably, when O\textsubscript{2} gas was supplied at a flow rate of 1 seem, the ATO thin layer had an optimal sheet resistance. Also, in this case, the ATO thin layer had a surface flatness of 0.83 nm, which was higher than when the O\textsubscript{2} flow rate was 0 seem but better than a target R\textgamma \ R\textsubscript{m} value of 5 nm or less. In addition, contact angles of the ATO layer were measured at an O\textsubscript{2} flow rate of 0 and 1 seem, respectively. The ATO thin layer had a good contact angle of about 58° under optimal sheet resistance conditions.

FIG. 6 is diagrams showing sheet resistance of an ATO layer relative to a flow rate of O\textsubscript{2} according to an exemplary embodiment of the present invention, and FIG. 7
is diagrams showing surface flatness of an ATO layer relative to a flow rate of O₂ according to an exemplary embodiment of the present invention.

Hereinafter, results of a heat-resistance test performed on an ATO thin layer relative to an O₂ flow rate will be described. In the heat-resistance test, all samples had SR ratios less than a target value of 1.5 and exhibited excellent sheet resistance in an optimal range of O₂ flow rate. However, after the heat-resistance test, samples were cloudy at an O₂ flow rate of 7 seem or higher.

The sheet resistance of the ATO thin layer relative to an O₂ flow rate after a heat-resistance test will now be explained.

That is, the SR ratio of the ATO thin layer manufactured under the same conditions as a sample that underwent a heat-resistance test was measured. As a result, the SR ratio of the ATO thin layer was 1.1 or less at an O₂ flow rate of 5 seem or lower, while the SR ratio of the ATO thin layer was unsuitable at an O₂ flow rate higher than 5 seem. A sample that departed from an optimal range of SR ratio was partially delaminated and became cloudy. After the heat-resistance test was performed, the sample was dried and exposed to air for 48 hours and the sheet resistance of the sample was measured again, with the result that the sample had a similar SR ratio. The above-described measurements are arranged in the following Table 3.

<table>
<thead>
<tr>
<th>O₂ flow rate</th>
<th>Surface resistance before test [Ω/sq.]</th>
<th>Surface resistance after test [Ω/sq.]</th>
<th>SR ratio [%]</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1007</td>
<td>1063</td>
<td>5.6</td>
<td>Passed</td>
</tr>
<tr>
<td>0.5</td>
<td>1000</td>
<td>1079</td>
<td>7.9</td>
<td>Passed</td>
</tr>
<tr>
<td>1</td>
<td>1434</td>
<td>1511</td>
<td>5.4</td>
<td>Passed</td>
</tr>
<tr>
<td>3</td>
<td>4678</td>
<td>5028</td>
<td>7.5</td>
<td>Passed</td>
</tr>
<tr>
<td>5</td>
<td>6105</td>
<td>7043</td>
<td>5.2</td>
<td>Passed</td>
</tr>
<tr>
<td>7</td>
<td>9588</td>
<td>10684</td>
<td>11.7</td>
<td>Partially delaminated</td>
</tr>
<tr>
<td>10</td>
<td>10687</td>
<td>13156</td>
<td>4.9</td>
<td>Cloudy</td>
</tr>
</tbody>
</table>

Hereinafter, a method of manufacturing a transparent conductive layer of a high-resistance capacitive touch panel according to an exemplary embodiment of the present invention will be described with reference to FIG. 8.
In the present embodiment, a technique of manufacturing a transparent conductive ATO thin layer of a capacitive touch panel was developed and the properties of the transparent conductive ATO thin layer were estimated.

In recent years, a vast amount of research has been conducted on applying an ATO thin layer to electrodes for solar batteries and various sensors. In the present invention, the process conditions and properties of an ATO thin layer suitable for a substrate of a touch panel were analyzed.

Referring to FIG. 8, at the outset, an oxide target was prepared by adding 5wt% Sb$_2$O$_3$ and impurities to SnO$_2$ in step S1.

The oxide target prepared in step S1 was loaded in a radio-frequency (RF) magnetron sputtering chamber and deposited by sputtering in step S2.

Thereafter, an ATO thin layer was deposited by controlling process parameters for satisfying conditions, such as a process pressure, a deposition temperature, an O$_2$ flow rate, a deposition time, a power and the like, and then annealed in step S3.

In step S4, considering a desired specification and sputtering result obtained in step S3, steps S1 through S3 were repeated (CD) or step S3 was repeated ((2)), so as to obtain optimal process conditions.

As a result, as shown in Tables 1 through 3, the ATO thin layer could have the best properties when the ATO thin layer was deposited under a pressure of 8 mTorr at a temperature of 300 °C and an O$_2$ flow rate of 1 seem for 10 minutes.

Under the optimal conditions according to the present invention, the ATO thin layer had a sheet resistance of 1432 Ω/sq, an optical transmittance of 81%, and a surface flatness of 0.83 nm that were appropriate for a substrate of a touch panel.

Also, an ATO thin layer according to the present invention satisfied required heat resistance and chemical resistance. Therefore, the present research achieved a transparent conductive ATO thin layer applicable to a substrate of a capacitive touch panel.

FIG. 9 is a photograph of an ATO/SiO$_2$/glass substrate for a touch panel, which is manufactured according to the method shown in FIG. 8.

While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

[Industrial Applicability]
According to the present invention as described above, a transparent conductive layer of a high-resistance capacitive touch panel can be formed of low-cost materials, namely, antimony (Sb) and tin oxide (SnO), and satisfy desired sheet resistance, optical transmittance, and sheet resistance.
[CLAIMS]

[Claim 1]
A transparent conductive layer of a high-resistance capacitive touch panel, which is manufactured by sputtering an oxide compound target formed of antimony (Sb) and tin (Sn) at a temperature of about 200 to 300 °C.

[Claim 2]
The transparent conductive layer according to claim 1, wherein the oxide compound target is sputtered using a radio-frequency (RF) magnetron sputtering chamber.

[Claim 3]
The transparent conductive layer according to claim 2, wherein the transparent conductive layer has a sheet resistance of 3,000Ω/sq. or lower and an optical transmittance of 80% or more.

[Claim 4]
The transparent conductive layer according to claim 3, wherein the transparent conductive layer is manufactured in the RF magnetron sputtering chamber by controlling a process pressure, a deposition temperature, an O₂ flow rate, a deposition time, and a power such that the transparent conductive layer is the most suitable for a substrate of the high-resistance capacitive touch panel.

[Claim 5]
The transparent conductive layer according to claim 4, wherein the transparent conductive layer is manufactured under a pressure of 8 mTorr at a temperature of 300 °C and an O₂ flow rate of 1 seem for 10 minutes.

[Claim 6]
The transparent conductive layer according to claim 5, wherein the transparent conductive layer has a sheet resistance of 1432 Ω/sq, an optical transmittance of 81%, and a surface flatness of 0.83 nm.

[Claim 7]
The transparent conductive layer according to claim 1, wherein the transparent conductive layer is used as an electromagnetic shield layer of a sensor or an electrode of a solar battery.

[Claim 8]
A method of manufacturing a transparent conductive layer of a high-resistance capacitive touch panel, comprising the steps of:

preparing an oxide compound target formed of antimony (Sb) and tin (Sn);
loading the oxide compound target into a radio-frequency (RF) magnetron sputtering chamber;
controlling a process pressure, a deposition temperature, an O₂ flow rate, a deposition time, and a power in the RF magnetron sputtering chamber; and
forming the transparent conductive layer by sputtering the oxide compound target at a temperature of about 200 to 300 °C.

[Claim 9]
The method according to claim 8, wherein the process pressure, the deposition temperature, the O₂ flow rate, and the deposition time are controlled to be 8 mTorr, 300 °C, 1 seem, and 10 minutes, respectively.

[Claim 10]
The method according to claim 9, wherein the transparent conductive layer has a sheet resistance of 3,000Ω/sq. or lower and an optical transmittance of 80% or more.

[Claim 11]
The method according to claim 8, wherein the transparent conductive layer has a sheet resistance of 1432 Ω/sq, an optical transmittance of 81%, and a surface flatness of 0.83 nm.
Digital Instruments Nanoscope
Scan size: 5.000 μm
Scan rate: 2.001 Hz
Number of samples: 256
Image Data: Height
Data scale: 10.000 nm

(a) RT

(b) 100 °C

Digital Instruments Nanoscope
Scan size: 5.000 μm
Scan rate: 2.001 Hz
Number of samples: 256
Image Data: Height
Data scale: 10.000 nm

(c) 200 °C

(d) 300 °C

Digital Instruments Nanoscope
Scan size: 5.000 μm
Scan rate: 2.001 Hz
Number of samples: 256
Image Data: Height
Data scale: 10.000 nm

(e) 400 °C

(f) 500 °C

FIG 3
4/9

Digital Instruments Nanoscope
Scan size 5,000 μm
Scan rate 2.001 Hz
Number of samples 256
Image Data Height
Data scale 10,000 nm

10 min. (Rms: 0.56 nm)

Digital Instruments Nanoscope
Scan size 5,000 μm
Scan rate 2.001 Hz
Number of samples 256
Image Data Height
Data scale 105.0 nm

20 min. (Rms: 2.86 nm)

Digital Instruments Nanoscope
Scan size 5,000 μm
Scan rate 2.001 Hz
Number of samples 256
Image Data Height
Data scale 100.0 nm

30 min. (Rms: 27.99 nm)

Digital Instruments Nanoscope
Scan size 5,000 μm
Scan rate 2.001 Hz
Number of samples 256
Image Data Height
Data scale 100.0 nm

50 min. (Rms: 30.95 nm)

FIG 4
FIG 5
Digital Instruments
Scan size
Scan rate
Number of samples
Image Data
Data scale

Surface roughness (Rms) : 0.56 nm
(a) 0 sccm

Digital Instruments Nanoscope
Scan size 5.000 nm
Scan rate 2.001 Hz
Number of samples 256
Image Data Height
Data scale 10.00 nm

Surface roughness (Rms) : 0.83 nm
(b) 1 sccm

FIG 6
FIG 7

(a) 0 sccm

(b) 1 sccm
START

2

S1

PREPARE SPUTTERING TARGET
FORMED OF Sb AND Sn
(Antimony + Tin)

S2

LOAD SPUTTERING TARGET
INTO RF MAGNETRON
SPUTTERING CHAMBER

S3

CONTROL PROCESS PARAMETERS
AND ANNEAL SPUTTERING TARGET
1. O2 FLOW RATE
2. PROCESS PRESSURE
3. POWER
4. DEPOSITION TIME
5. DEPOSITION TEMPERATURE

S4

DOES RESULT MEET DESIRED
SPECIFICATION?

NO

YES

END

FIG 8
INTERNATIONAL SEARCH REPORT

PCT/KR2007/006479

A. CLASSIFICATION OF SUBJECT MATTER

HO1B l/08 (2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 HOIB

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

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

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

eKIPASS (KIPO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
</tr>
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<tbody>
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<td>US 05772924 A, (Mitsui Mining &amp; Smelting Co., Ltd.), 30 June 1998 (30 06 1998) see the abstract, column 3 lines 28 ~ 49, column 6 lines 32 ~ 55, claims 1 ~ 3, claim 5</td>
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☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents
  - "A": document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search
20 MARCH 2008 (20 03 2008)

Date of mailing of the international search report
20 MARCH 2008 (20.03.2008)

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
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JOUNG, Meyeong Ju

Facsimile No 82-42-472-7140

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### INTERNATIONAL SEARCH REPORT

**Information on patent family members**

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