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(71) Applicant (for all designated States except US): **LG INNOTEK CO., LTD.** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **YOU, Young Sun** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **LEE, Yong Jin** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **CHAI, Kyung Hoon** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **LEE, Dong Youl** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR).

(74) Agent: **SEO, Kyo Jun**; 9th Fl. Hyun Juk Bldg., 832-41, Yeoksam-dong, Gangnam-gu, Seoul 135-080 (KR).

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(54) Title: TOUCH PANEL AND METHOD FOR MANUFACTURING THE SAME

(57) Abstract: A touch panel according to the embodiment includes a substrate; a first electrode formed on the substrate in a first direction and including a plurality of sensor parts and connection parts connecting the sensor parts with each other; and a second electrode formed in a second direction crossing the first direction while being insulated from the first electrode and including a plurality of sensor parts and connection parts connecting the sensor parts with each other. The sensor parts and the connection parts include transparent conductive materials, and the connection parts have resistance lower than resistance of the sensor parts in at least one of the first and second electrodes.



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Description

Title of Invention: TOUCH PANEL AND METHOD FOR MANUFACTURING THE SAME

Technical Field

- [1] The disclosure relates to a touch panel and a method for manufacturing the same.

Background Art

- [2] Recently, touch panels are employed in various electronic appliances to allow a user to input data by touching an image displayed on a display device using an input device, such as a finger or a stylus.
- [3] Such touch panels are mainly classified into resistive touch panels and capacitive touch panels. According to the resistive touch panel, an electrode is shorted as pressure is applied thereto from an input device so that a position is detected. According to the capacitive touch panel, capacitance between electrodes is varied as a finger touches the touch panel and a position is detected based on the capacitance variation.
- [4] The performance of the resistive touch panel may be degraded if the resistive touch panel is repeatedly used for a long time, and scratch may be generated. For this reason, the capacitive touch panel has been spotlighted due to the superior durability and long life span.

Disclosure of Invention

Technical Problem

- [5] The embodiment provides a touch panel capable of improving electric stability and touch sensitivity and a method for manufacturing the same.

Solution to Problem

- [6] A touch panel according to the embodiment includes a substrate; a first electrode formed on the substrate in a first direction and including a plurality of sensor parts and connection parts connecting the sensor parts with each other; and a second electrode formed in a second direction crossing the first direction while being insulated from the first electrode and including a plurality of sensor parts and connection parts connecting the sensor parts with each other, wherein the sensor parts and the connection parts include transparent conductive materials, and the connection parts have resistance lower than resistance of the sensor parts in at least one of the first and second electrodes.
- [7] A touch panel according to another embodiment includes a substrate; a first electrode formed on the substrate in a first direction and including a plurality of sensor parts and connection parts connecting the sensor parts with each other; and a second electrode formed in a second direction crossing the first direction while being insulated from the

first electrode and including a plurality of sensor parts and connection parts connecting the sensor parts with each other, wherein the connection parts of at least one of the first and second electrodes include at least one selected from the group consisting of a carbon nano tube, a nano wire and a conductive polymer.

[8] A method for manufacturing a touch panel according to the embodiment includes the steps of forming a plurality of first sensor parts and second sensor parts including transparent conductive materials on a substrate; forming first connection parts connecting the first sensor parts with each other by printing a transparent conductive composition on the substrate; forming an insulating layer including an insulating material on the first connection parts; and forming second connection parts connecting the second sensor parts with each other on the insulating layer by using the transparent conductive composition.

[9] A method for manufacturing a touch panel according to another embodiment includes the steps of forming a plurality of first sensor parts, a plurality of second sensor parts and first connection parts connecting the first sensor parts with each other on a substrate by using a transparent conductive material; forming an insulating layer by printing an insulating material on the first connection parts; and forming second connection parts connecting the second sensor parts with each other on the insulating layer by using a transparent conductive composition.

Advantageous Effects of Invention

[10] According to the touch panel of the embodiment, resistance of the connection part is lower than resistance of the sensor part, so that resistance of the first electrode and/or the second electrode is lowered, thereby improving the electric stability and touch sensitivity.

[11] According to the touch panel of another embodiment, the connection part includes a nano wire or carbon nano tube, so superior optical and electric characteristics can be obtained. In detail, the transmittance and transparent degree of the touch panel can be improved while lowering resistance.

[12] According to the method for manufacturing the touch panel of the embodiment, the connection part is formed through the printing process, so that the manufacturing process can be simplified. Since the connection part of the first electrode, the insulating layer and the connection part of the second electrode are sequentially formed through the printing process, the manufacturing process can be more simplified.

Brief Description of Drawings

[13] FIG. 1 is a plan view of a touch panel according to embodiment;

[14] FIG. 2 is a sectional view taken along line II-II of FIG. 1;

[15] FIG. 3 is a sectional view of a touch panel according to the second embodiment;

- [16] FIG. 4 is a sectional view of a touch panel according to the third embodiment;
[17] FIGS. 5 to 8 are plan and sectional views for explaining a method for manufacturing a touch panel according to the first embodiment; and
[18] FIGS. 9 to 11 are plan and sectional views for explaining a method for manufacturing a touch panel according to the second embodiment.

Mode for the Invention

- [19] In the description of the embodiments, it will be understood that, when a layer (or film), a region, a pattern, or a structure is referred to as being "on" or "under" another substrate, another layer (or film), another region, another pad, or another pattern, it can be "directly" or "indirectly" on the other substrate, layer (or film), region, pad, or pattern, or one or more intervening layers may also be present. Such a position of the layer has been described with reference to the drawings.
- [20] The thickness and size of each layer shown in the drawings may be exaggerated, omitted or schematically drawn for the purpose of convenience or clarity. In addition, the size of elements does not utterly reflect an actual size.
- [21] Hereinafter, the embodiments will be described in detail with reference to the accompanying drawings.
- [22] First, a touch panel according to the embodiment will be described in detail with reference to FIGS. 1 and 2.
- [23] FIG. 1 is a plan view of the touch panel according to embodiment and FIG. 2 is a sectional view taken along line II-II of FIG. 1.
- [24] Referring to FIG. 1, the touch panel 100 according to the embodiment includes a substrate 110, first and second electrodes 10 and 20 formed on the substrate 110, an insulating layer 30 formed at an intersection between the first and second electrodes 10 and 20 to insulate the first electrodes 10 from the second electrodes 20, and a protective member 120 for protecting the first and second electrodes 10 and 20 and the insulating layer 30.
- [25] The first electrodes 10 are drawn to the lower end of the substrate 110 by first wires 40 and the second electrodes 20 are drawn to the lower end of the substrate 110 by second wires 50. Terminal parts (not shown) can be formed on the first wires 40 or the second wires 50 and a flexible printed circuit board (FPCB) can be connected to the terminal parts such that the FPCB can be connected to an external circuit (not shown).
- [26] Although it has been described and illustrated that the first and second electrodes 10 and 20 are drawn to the lower end of the substrate 110, the embodiment is not limited thereto. The first electrodes 10 may be drawn in opposition to the second electrodes 20. Otherwise, the first electrodes 10 may be drawn to the lower end of the substrate 110 and the second electrodes 10 may be drawn to the left and right sides of the substrate

110. In addition, the first and second electrodes 10 and 20 may be drawn in various configurations such that the first and second electrodes 10 and 20 can be connected to the external circuit.

[27] Hereinafter, the substrate 110, the first electrodes 10, the second electrodes 20, the insulating layer 30 and the first and second wires 40 and 50 will be described in detail.

[28] The substrate 110 may include various materials capable of supporting the first electrodes 10, the second electrodes 10, the insulating layer 30 and the first and second wires 40 and 50 formed on the substrate 110. For instance, the substrate 110 may include a glass substrate.

[29] The first electrodes 10 include a plurality of first sensor parts 12 for detecting whether an input device, such as a finger, makes contact with the first electrode 10 and first connection parts 14 for connecting the first sensor parts 12 with each other. The first connection parts 14 connect the first sensor parts 12 in the first direction (X-axis direction in the drawing), so that the first electrodes 10 extend in the first direction.

[30] Similarly to the first electrodes 10, the second electrodes 20 include a plurality of second sensor parts 22 for detecting whether an input device, such as a finger, makes contact with the second electrode 20 and second connection parts 24 for connecting the second sensor parts 22 with each other. The second connection parts 24 connect the second sensor parts 22 in the second direction (Y-axis direction in the drawing) crossing the first direction so that the second electrodes 20 extend in the second direction.

[31] The first and second sensor parts 12 and 22 and the first and second connection parts 14 and 24 may include transparent conductive materials such that electricity can be applied thereto without interfering with the transmission of the light. The transparent conductive materials may include various materials, such as indium tin oxide, indium zinc oxide, a carbon nano tube, a Ag nano wire and a conductive polymer.

[32] According to the present embodiment, the first and second connection parts 14 and 24 have resistance lower than that of the first and second sensor parts 12 and 22. This is because the manufacturing process and manufacturing method for the first and second connection parts 14 and 24 are different from the manufacturing process and manufacturing method for the first and second sensor parts 14 and 24.

[33] For instance, the first and second connection parts 14 and 24 may include materials having resistance lower than that of the first and second sensor parts 12 and 22 or the first and second connection parts 14 and 24 may have the thickness thicker than that of the first and second sensor parts 12 and 22 to lower the resistance of the first and second connection parts 14 and 24.

[34] In the case that the first and second connection parts 14 and 24 include materials different from materials of the first and second sensor parts 12 and 22, the first and

second sensor parts 12 and 22 exclusively include transparent conductive materials and inevitable impurities. In addition, the first and second connection parts 14 and 24 include at least one of a carbon nano tube (CNT), a nano wire and a conductive polymer as well as the transparent conductive materials. In addition, the first and second connection parts 14 and 24 may include conductive materials including at least one of the CNT, the nano wire and the conductive polymer. The resistance of the first and second connection parts 14 and 24 may be lowered due to the CNT, the nano wire and the conductive polymer.

[35] Referring to FIG. 2, in the case that the thickness of the first and second connection parts 14 and 24 is different from the thickness of the first and second sensor parts 12 and 22, the thickness of the first and second connection parts 14 and 24 is thicker than the thickness of the first and second sensor parts 12 and 22, so that the resistance of the first and second connection parts 14 and 24 is lowered.

[36] For instance, the thickness of the first and second connection parts 14 and 24 is thicker than the thickness of the first and second sensor parts 12 and 22 by 1.5 to 10 times. Although the thickness T2 of the second connection part 24 and the thickness T1 of the second sensor part 22 are shown in the drawing, the first connection part 14 and the first sensor part 12 may have the above thickness.

[37] If the first and second connection parts 14 and 24 are thicker than the first and second sensor parts 12 and 22 less than 1.5 times, the resistance of the first and second connection parts 14 and 24 may not be sufficiently lowered. In addition, if the first and second connection parts 14 and 24 are thicker than the first and second sensor parts 12 and 22 more than 10 times, the thickness of the touch panel 100 may be increased and the amount of materials for manufacturing the first and second connection parts 14 and 24 may be increased, so that the manufacturing cost may rise. Thus, the thickness is set within the range of 1.5 to 10 times by taking the manufacturing cost into consideration.

[38] Although it has been described and illustrated that the first and second connection parts 14 and 24 have the resistance different from the resistance of the first and second sensor parts 12 and 22, the embodiment is not limited thereto. It is also possible to allow only the first connection part 14 to have the resistance lower than that of the first sensor part 12 or to allow only the second connection part 24 to have the resistance lower than that of the second sensor part 22.

[39] The insulation layer 30 is positioned at the intersection between the first and second connection parts 14 and 24 in order to prevent the electric short between the first and second connection parts 14 and 24. The insulating layer 30 may include a transparent insulating material capable of insulating the first connection part 14 from the second connection part 24. For instance, the insulating layer 30 may include metal oxide, such as silicon oxide or resin, such as acryl.

- [40] The first and second wires 40 and 50 may include various materials capable of transferring electricity to the first and second electrodes 10 and 20, respectively. The first and second wires 40 and 50 may include materials having superior electric conductivity, such as a metal.
- [41] The protective member 120 is aligned to cover the first and second electrodes 10 and 20, the insulating layer 30 and the first and second wires 40 and 50. The protective member 120 may include various materials capable of protecting the first and second electrodes 10 and 20, and the insulating layer 30, and the embodiment is not limited thereto.
- [42] If the input device, such as the finger, makes contact with the touch panel 100, capacitance difference may occur at a region that comes into contact with the input device, so this region is detected as the contact position.
- [43] In the case of the touch panel 100 having the above structure, the first and second connection parts 14 and 24 have the relatively low resistance, so the resistance of the first and second electrodes 10 and 20 can be lowered. Thus, the electric stability and the touch sensitivity of the touch panel 100 can be improved.
- [44] Hereinafter, the touch panel according to the second embodiment will be described with reference to FIG. 3. Description about the elements and structures that have been described in the first embodiment will be omitted in order to clarify and simplify the explanation.
- [45] FIG. 3 is a sectional view of the touch panel according to the second embodiment.
- [46] Referring to FIG. 3, the touch panel 200 according to the second embodiment includes a second connection part 24 having nano wires 24a. The nano wires 24a are connected to each other by a binder (not shown). Since the second connection part 24 includes the nano wires 24a, the second connection part 24 may have the superior optical and electric characteristics. In detail, the transparent degree and the transmission degree of the touch panel can be improved while lowering the resistance.
- [47] However, the embodiment is not limited to the above. For instance, the second connection part 24 may include carbon nano tubes connected to each other by the binder.
- [48] Hereinafter, the touch panel according to the third embodiment will be described with reference to FIG. 4.
- [49] FIG. 4 is a sectional view of the touch panel according to the second embodiment.
- [50] Referring to FIG. 4, the touch panel 300 according to the third embodiment includes a second connection part 24. The second connection part 24 may include at least one selected from the group consisting of a carbon nano tube, a nano wire, and a conductive polymer.
- [51] In detail, in the second connection part 24, the nano wires 24b are distributed in the

conductive polymer 24c. However, the embodiment is not limited to the above. For instance, carbon nano tubes may be distributed in the conductive polymer instead of the nano wires.

- [52] Hereinafter, the method for manufacturing the touch panel according to the first embodiment will be described with reference to FIGS. 5 to 8.
- [53] FIGS. 5 to 8 are plan and sectional views for explaining the method for manufacturing the touch panel according to the first embodiment. In detail, FIGS. 5(a), 6(a), 7(a), and 8(a) are plan views showing the first electrode 10, the second electrode 20 and the insulating layer 30 formed in a region A of FIG. 1, and FIGS. 5(b), 6(b), 7(b), and 8(b) are sectional views taken along line B-B shown in FIGS. 5(a), 6(a), 7(a), and 8(a).
- [54] First, as shown in FIG. 5, a plurality of first sensor parts 12 and a plurality of second sensor parts 22 are formed on the substrate 110 by using the transparent conductive material. The transparent conductive material may include various materials, such as indium tin oxide or indium zinc oxide. The first and second sensor parts 12 and 22 can be formed by depositing the transparent conductive material, for example, through a vacuum deposition process.
- [55] Then, as shown in FIG. 6, the first connection part 14 connecting the first sensor parts 12 with each other is formed by performing the printing process using a transparent conductive composition.
- [56] The transparent conductive composition may include ink that contains the transparent conductive material. The transparent conductive composition may include a transparent conductive material, a binder, a dispersing agent, and an additive. Various materials generally known in the art may be used as the binder, the dispersing agent and the additive.
- [57] Since the first connection part 14 is formed separately from the first sensor part 12, the first connection part 14 can be configured to have the resistance lower than that of the first sensor part 12. To this end, the first connection part 14 may have a thickness thicker than that of the first sensor part 12 or a carbon nano tube, a nano wire or a conductive polymer may be added to a material (that is, the transparent conductive composition) for the first connection part 14.
- [58] According to the related art, after depositing the transparent conductive material, the first connection part 14 is formed by patterning the transparent conductive material through the exposure/developing/etching processes, so the manufacturing process is complicated. However, according to the embodiment, the first connection part 14 is formed through the printing process, so the process for manufacturing the first connection part 14 can be simplified. In particular, the printing process is advantageous to form a thick layer, so the printing process is suitable for forming the first connection

part 14 having the thickness thicker than the first sensor part 12.

- [59] After that, as shown in FIG. 7, the insulating layer 30 including the insulating material is formed on the first connection part 14. The insulating layer 30 can be formed through the printing process by using resin. Since the insulating layer 30 is formed through the printing process by using the resin, the insulating resistance of the insulating layer 30 can be improved, so that the reliability of the touch panel 100 can be enhanced. For instance, the insulating layer 30 may have the resistance of about $60\text{G}\Omega$.
- [60] The insulating layer 30 may have the thickness T3 of about $0.1\mu\text{m}$ to about $100\mu\text{m}$. The thickness T3 of the insulating layer 30 may be changed by taking the printing characteristic of the second connection part 24 (see, FIG. 8) into consideration. If the thickness T3 of the insulating layer 30 is less than $0.1\mu\text{m}$, the insulating layer 30 may not sufficiently insulate the first connection part 14 from the second connection part 24. In addition, if the thickness T3 of the insulating layer 30 exceeds $100\mu\text{m}$, the thickness of the touch panel may be increased.
- [61] Then, as shown in FIG. 8, the second connection part 24 connecting the second sensor parts 22 with each other is formed on the insulating layer 30 by performing the printing process using the transparent conductive composition.
- [62] The transparent conductive composition may include ink that contains the transparent conductive material. The transparent conductive composition may include a transparent conductive material, a binder, a dispersing agent, and an additive. Various materials generally known in the art may be used as the binder, the dispersing agent and the additive.
- [63] For instance, the transparent conductive composition may be ink including a nano wire, a solvent and a binder. Such ink can be printed through the ink-jet scheme. According to the ink-jet scheme, the ink is sprayed from a slim nozzle. After the ink has been sprayed, the solvent is evaporated and the curing process is performed. The printing can be achieved by repeating the above processes.
- [64] Thus, the final materials constituting the second connection part 24 may be the nano wire and the binder. The touch panel 200 shown in FIG. 3 can be manufactured through the above printing process. At this time, the carbon nano tube may be used instead of the nano wire.
- [65] In addition, the transparent conductive composition may be a paste including a nano wire and a conductive polymer. In detail, the transparent conductive composition may be the paste including the nano wires distributed in the conductive polymer. The paste can be printed through the off-set printing scheme or the screen printing scheme. According to the off-set printing scheme, a paste is filled in an intaglio plate having a pattern and the primary transfer process is performed by using silicon rubber called a

blanket. Then, the secondary transfer process is performed by closely attaching the blanket to the substrate formed with a conductive layer. According to the screen printing scheme, the paste is formed on the screen having the pattern and then the paste is pressed by a squeeze, so that the paste is directly printed onto the substrate having the conductive layer through the screen having space sections.

[66] Therefore, the second connection part may include the nano wires distributed in the conductive polymer. The touch panel 300 shown in FIG. 4 can be manufactured through the above printing process. At this time, the carbon nano tube may be used instead of the nano wire.

[67] However, the embodiment is not limited to the above, and the second connection part 24 can be formed through various printing schemes.

[68] Since the second connection part 24 is formed separately from the second sensor part 22, the second connection part 24 can be configured to have the resistance lower than that of the second sensor part 22. To this end, the second connection part 24 may have a thickness thicker than that of the second sensor part 22 or a carbon nano tube, a nano wire or a conductive polymer may be added to a material (that is, the transparent conductive composition) for the second connection part 24.

[69] According to the related art, after depositing the transparent conductive material, the second connection part 24 is formed by patterning the transparent conductive material, so the manufacturing process is complicated. However, according to the embodiment, the second connection part 24 is formed through the printing process, so the process for manufacturing the second connection part 24 can be simplified. In particular, the printing process is advantageous to form a thick layer, so the printing process is suitable for forming the second connection part 24 having the thickness thicker than the second sensor part 22.

[70] A width W1 of the second connection part 24 may be narrower than a width W2 of the insulating layer 30. In detail, the width W1 of the second connection part 24 may be 1% to 99% based on the width W2 of the insulating layer 30. Thus, the electric short can be prevented between the first and second connection parts 14 and 24.

[71] After that, the protective member 120 is formed, thereby manufacturing the touch panel shown in FIG. 2.

[72] According to the present embodiment, the first connection part 14, the insulating layer 30, and the second connection part 24 can be sequentially formed through the printing process, so that the touch panel can be easily manufactured.

[73] Hereinafter, the method for manufacturing the touch panel according to the second embodiment will be described with reference to FIGS. 9 to 11.

[74] FIGS. 9 to 11 are plan and sectional views for explaining the method for manufacturing the touch panel according to the second embodiment.

- [75] First, as shown in FIG. 9, a plurality of first sensor parts 12, a first connection part 14 connecting the first sensor parts 12 with each other, and a plurality of second sensor parts 22 are formed on the substrate 110. That is, the first connection part 14 is prepared as a pattern connected between the first sensor parts 12 without separately forming the first connection part 14, so that the manufacturing steps and the manufacturing time can be reduced.
- [76] Then, as shown in FIG. 10, the insulating layer 30 is formed on the first connection part 14.
- [77] After that, as shown in FIG. 11, a second connection part 24 connecting the second sensor parts 22 with each other is formed on the insulating layer.
- [78]

Claims

- [Claim 1] A touch panel comprising:
a substrate;
a first electrode formed on the substrate in a first direction and including a plurality of sensor parts and connection parts connecting the sensor parts with each other; and
a second electrode formed in a second direction crossing the first direction while being insulated from the first electrode and including a plurality of sensor parts and connection parts connecting the sensor parts with each other,
wherein the sensor parts and the connection parts include transparent conductive materials, and
the connection parts have resistance lower than resistance of the sensor parts in at least one of the first and second electrodes.
- [Claim 2] The touch panel of claim 1, wherein the connection parts of at least one of the first and second electrodes include at least one selected from the group consisting of a carbon nano tube, a nano wire and a conductive polymer.
- [Claim 3] The touch panel of claim 1, wherein the connection parts are thicker than the sensor parts in at least one of the first and second electrodes.
- [Claim 4] The touch panel of claim 3, wherein the connection parts are thicker than the sensor parts by 1.5 to 10 times in at least one of the first and second electrodes.
- [Claim 5] The touch panel of claim 1, wherein the sensor parts include at least one selected from the group consisting of an indium tin oxide, an indium zinc oxide, a carbon nano tube, a Ag nano wire and a conductive polymer.
- [Claim 6] A touch panel comprising:
a substrate;
a first electrode formed on the substrate in a first direction and including a plurality of sensor parts and connection parts connecting the sensor parts with each other; and
a second electrode formed in a second direction crossing the first direction while being insulated from the first electrode and including a plurality of sensor parts and connection parts connecting the sensor parts with each other,
wherein the connection parts of at least one of the first and second

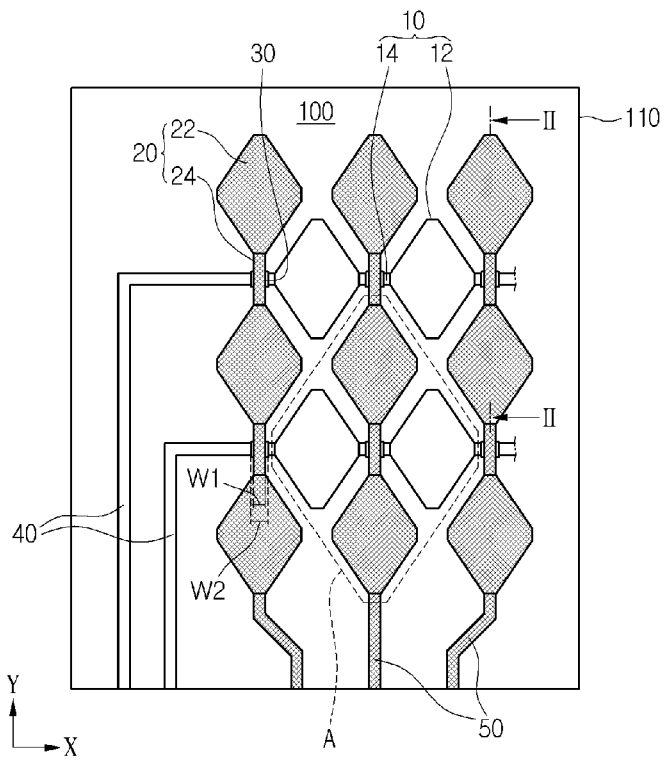
- electrodes include at least one selected from the group consisting of a carbon nano tube, a nano wire and a conductive polymer.
- [Claim 7] The touch panel of claim 6, wherein the connection parts of at least one of the first and second electrodes include the carbon nano tube or the nano wire distributed in the conductive polymer.
- [Claim 8] A method for manufacturing a touch panel, the method comprising:
forming a plurality of first sensor parts and second sensor parts including transparent conductive materials on a substrate;
forming first connection parts connecting the first sensor parts with each other by printing a transparent conductive composition on the substrate;
forming an insulating layer including an insulating material on the first connection parts; and
forming second connection parts connecting the second sensor parts with each other on the insulating layer by using the transparent conductive composition.
- [Claim 9] The method of claim 8, wherein the forming of the insulating layer comprises printing the insulating material.
- [Claim 10] The method of claim 8, wherein the insulating layer has a thickness in a range of $0.1\mu\text{m}$ to $100\mu\text{m}$ in the forming of the insulating layer.
- [Claim 11] The method of claim 8, wherein the forming of the second connection parts comprises printing the transparent conductive composition.
- [Claim 12] The method of claim 8, wherein a width of the second connection parts is 1% to 99% based on a width of the insulating layer.
- [Claim 13] The method of claim 8, wherein resistance of the connection parts is lower than resistance of the sensor parts in at least one of the first and second electrodes.
- [Claim 14] The method of claim 13, wherein the connection parts of at least one of the first and second electrodes include at least one selected from the group consisting of a carbon nano tube, a nano wire and a conductive polymer.
- [Claim 15] The method of claim 13, wherein the connection parts are thicker than the sensor parts in at least one of the first and second electrodes.
- [Claim 16] A method for manufacturing a touch panel, the method comprising:
forming a plurality of first sensor parts, a plurality of second sensor parts and first connection parts connecting the first sensor parts with each other on a substrate by using a transparent conductive material;
forming an insulating layer by printing an insulating material on the

first connection parts; and
forming second connection parts connecting the second sensor parts
with each other on the insulating layer by using a transparent
conductive composition.

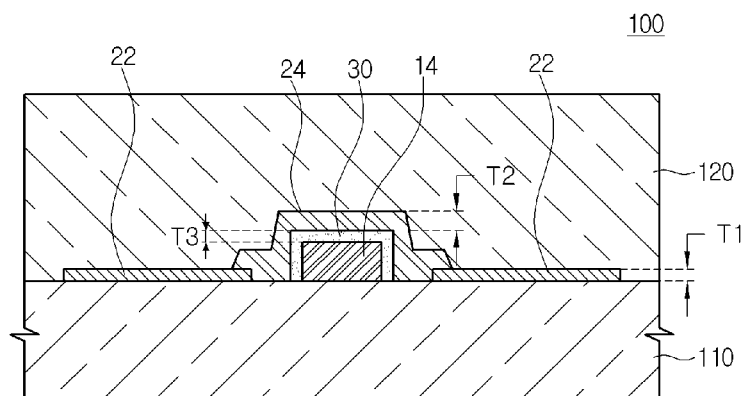
[Claim 17]

The method of claim 16, wherein the forming of the second connection
parts comprises printing the transparent conductive composition.

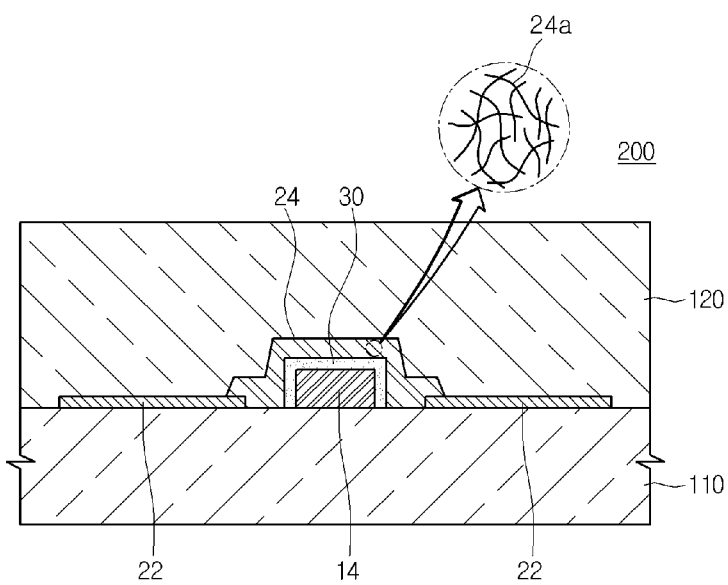
[Fig. 1]



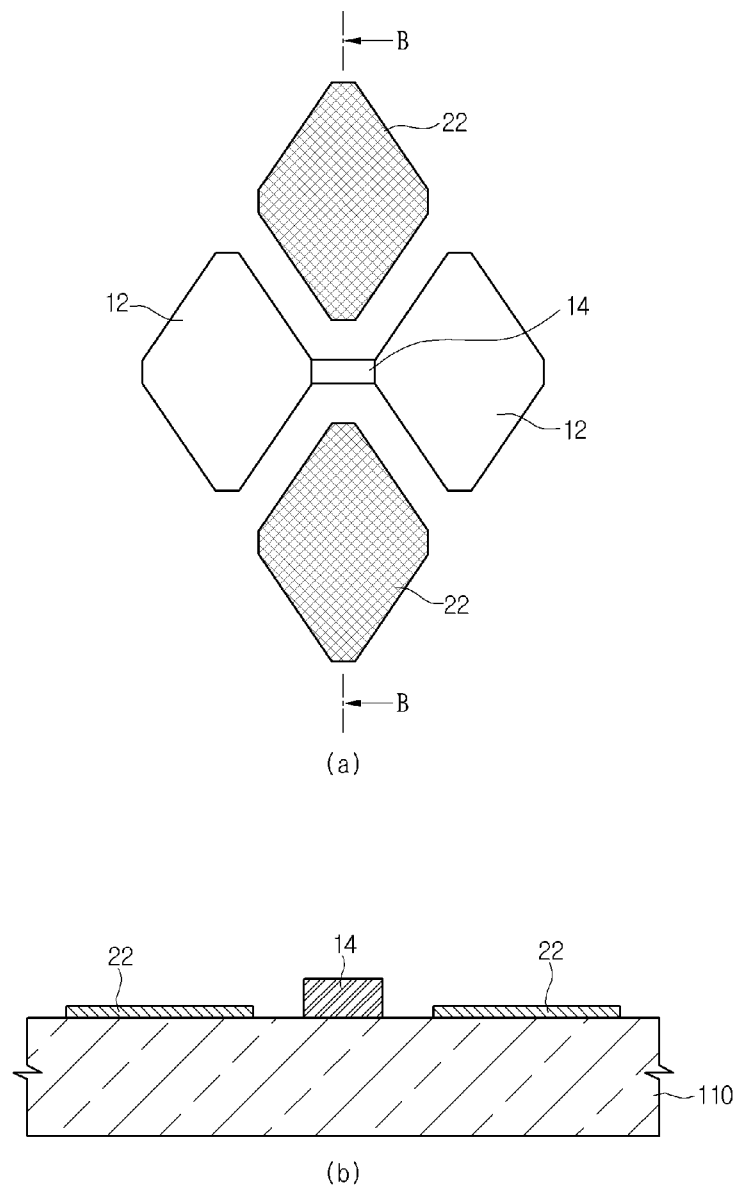
[Fig. 2]



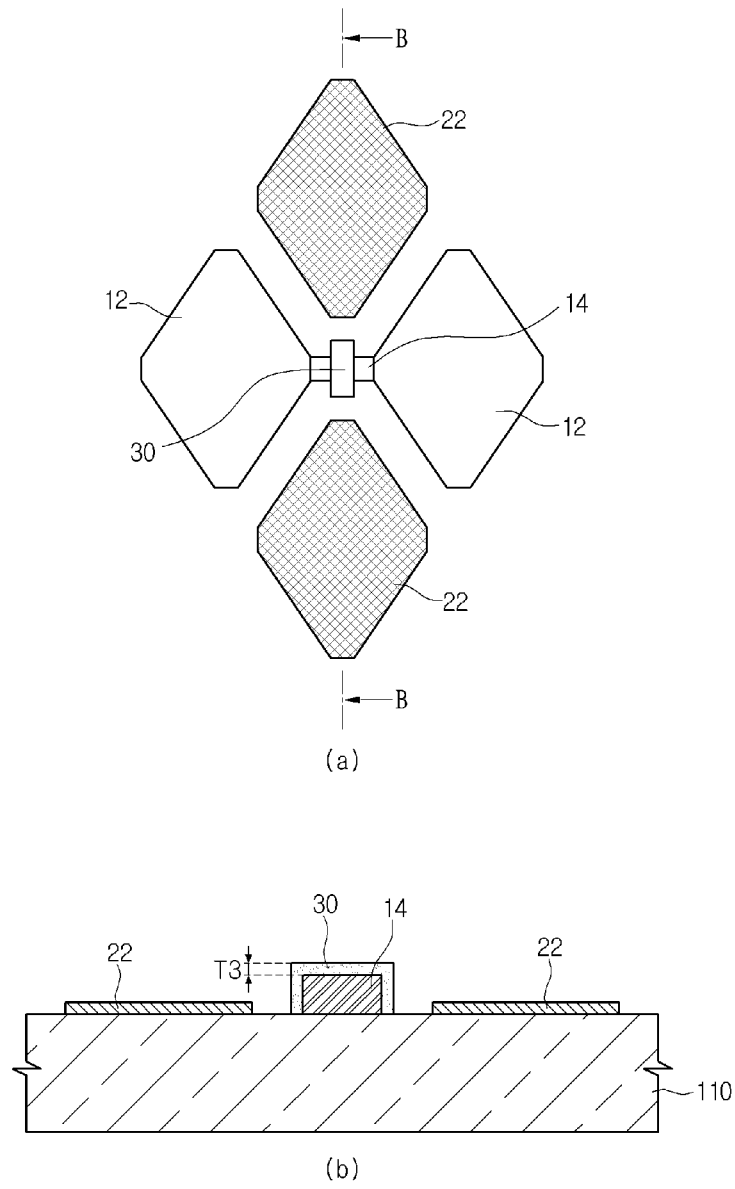
[Fig. 3]



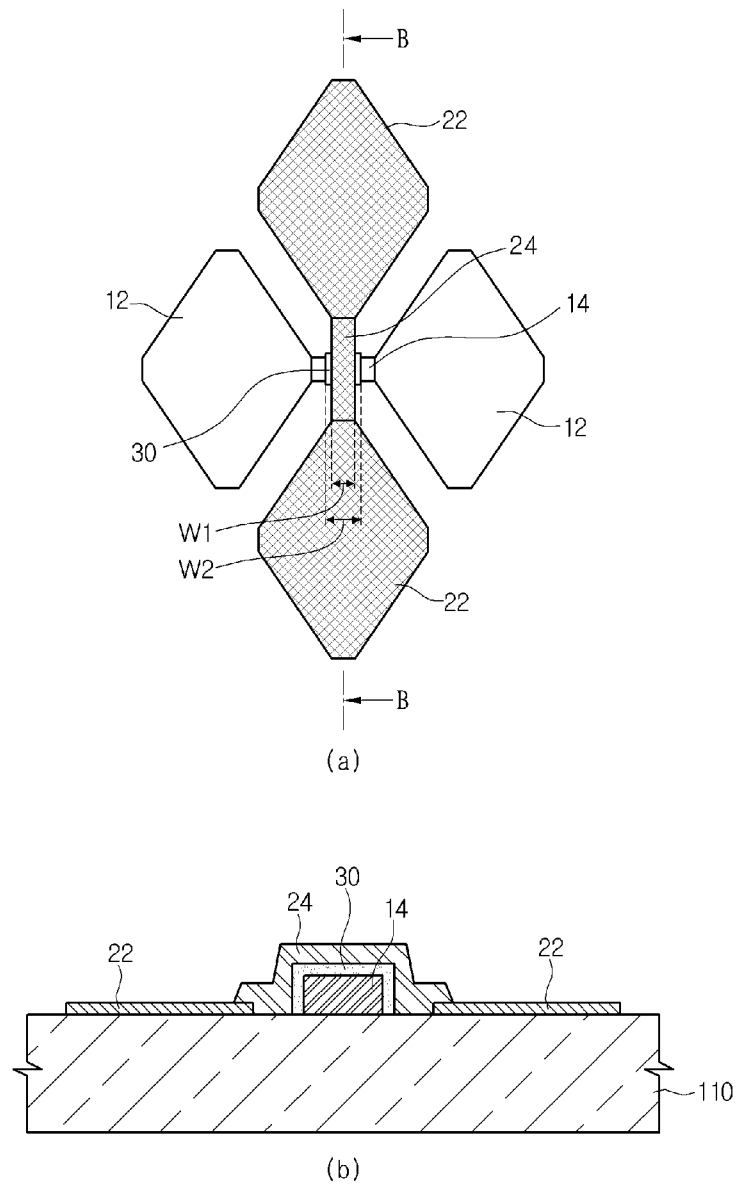
[Fig. 6]



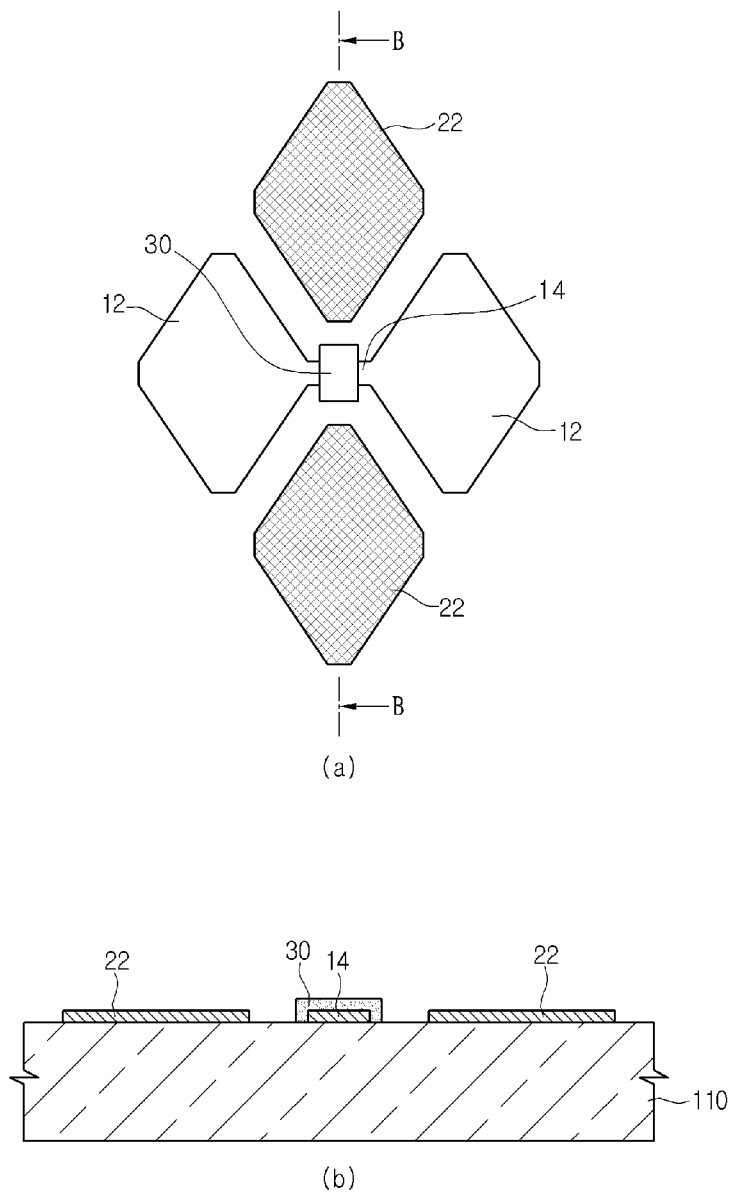
[Fig. 7]



[Fig. 8]



[Fig. 10]



[Fig. 11]

