The present invention provides a touch switch having two ITO-free electrode layers that are bonded together, the touch switch having good visibility, and a planar body that forms such a touch switch. The planar body includes a mesh-like electrode formed in a mesh shape by multiple conductor lines L on one side of a substrate, in which the mesh-like electrode is separated into multiple conductive areas disposed at intervals, and non-conductive areas each disposed between each of the conductive areas; each non-conductive area has multiple cutting portions that cut the conductor lines L, and each non-conductive area insulates between the adjacent conductive areas by the cutting portions.
The present invention relates to a planar body and a touch switch.

These days, in the field of computers and electronic devices, operations performed using the contents displayed on a display device, rather than using buttons, have been increasingly developed. To perform such operations, a touch switch is arranged at the front side of the display device, and a touch position is detected. The types of touch switches include a resistive type, a surface acoustic wave type, an infrared type, and the like. There is also a capacitive type, in which a position is detected by a variation in capacitance caused by a touch of a finger and/or proximity of a finger. For example, Patent Literature 1 discloses a capacitive touch switch having a matrix electrode (a two-layer structure in X-direction and Y-direction), as shown in Figs. 19 and 20.

A detailed description is provided with reference to Fig. 21, which is a schematic plan diagram schematically showing the structure of a capacitive touch switch as described above; and Fig. 22, which is a cross-sectional view of the structure. A known capacitive touch switch 400 comprises a first planar body 403 having a substrate 401 and transparent first electrodes 402 comprising ITO, and arranged in a strip pattern on one side of the substrate 401; and a second planar body 406 having a substrate 404 and transparent second electrodes 405 comprising ITO, and arranged in a strip pattern on one side of the substrate 404. The first planar body 403 and the second planar body 406 are bonded via an adhesive layer 407 in such a manner that the first electrodes and second electrodes face each other.

When an arbitrary position on the planar body is touched with a finger or the like, the electrodes 402 and 405 detect a change in the voltage or the like based on the capacitance of a human body at the contact position, and a coordinate of the contact position is thereby calculated.

However, the resistivity of ITO is high, usually 200Ω/㎢ to 1000Ω/㎢. This results in an increase in the size of the touch switch, along with an increase in the resistance between terminals of the electrodes. This reduces the detection sensitivity of the capacitance, and disables the operation of the touch switch.

Further, Patent Literature 2 discloses a capacitive touch switch that does not use ITO. A copper or copper-alloy electrode is formed in a mesh pattern, thereby allowing the transmission of the electrode to be 70% or higher. A low-resistance electrode is formed while maintaining the visibility.

However, the electrodes in Patent Literature 2 are only provided on one side of the substrate. When two layers of electrodes are formed using the first electrodes and the second electrodes, as described in Patent Literature 1, the visibility will be reduced when the first planar body is overlapped with the second planar body.

An object of the present invention is to provide a touch switch having two ITO-free electrode layers bonded together, wherein the touch switch has good visibility; and to provide a planar body that forms such a touch switch.

In this planar body, the cutting portions are preferably formed at intersections of the conductor lines of the mesh-like electrode.
Further, the mesh pitch of the mesh-like electrode is preferably 100 μm to 1,000 μm.

Further, the conductive areas preferably have multiple cutting portions that cut the conductor lines without interfering with the conductivity between the ends of each conductive area.

The above-described object of the present invention is also achieved by a capacitive touch switch including the multiple planar bodies, in which the planar bodies are bonded together via an adhesive layer.

Further, in this touch switch, the conductive areas formed on one planar body are preferably disposed to perpendicularly intersect the conductive areas formed on a different planar body.

The above-described object of the present invention is also achieved by a touch switch including the multiple planar bodies, in which the planar bodies are bonded together via an adhesive layer.

Further, the conductive areas formed on one side of the substrate and arranged at certain intervals; and multiple second electrodes formed on the other side of the substrate and arranged at certain intervals to form a grid pattern with the multiple first electrodes, in which each of the first and second electrodes forms a mesh structure with multiple conductor lines, and the direction of the conductor lines is inclined with respect to a black matrix in a display device.

The above-described touch switch includes first auxiliary lines formed between the first electrodes on the one side of the substrate; and second auxiliary lines formed between the second electrodes on the other side thereof; in which a grid pattern with equal intervals is preferably formed by the conductor lines of the first electrodes, the first auxiliary lines, the conductor lines of the second electrodes, and the second auxiliary lines.

Further, the conductor lines of the first electrodes, the first auxiliary lines, or both of them formed on the one side of the substrate form continuous lines with the conductor lines of the second electrodes, the second auxiliary lines, or both of them formed on the other side of the substrate.

The above-described object of the present invention is also achieved by a touch switch including a substrate; multiple first electrodes formed on one side of the substrate and arranged at certain intervals; and multiple second electrodes formed on the other side of the substrate and arranged at certain intervals to form a grid pattern with the multiple first electrodes, in which each of the first and second electrodes forms a mesh structure with multiple conductor lines, and the direction of the conductor lines is inclined with respect to a black matrix in a display device.

The above-described touch switch includes first auxiliary lines formed between the first electrodes on the one side of the substrate, specifically on the side facing the first substrate; and second auxiliary lines formed between the second electrodes on the other side thereof; in which a grid pattern with equal intervals is preferably formed by the conductor lines of the first electrodes, the first auxiliary lines, the conductor lines of the second electrodes, and the second auxiliary lines.

Further, the conductor lines of the first electrodes, the first auxiliary lines, or both of them formed on the first substrate form continuous lines with the conductor lines of the second electrodes, the second auxiliary lines, or both of them formed on the second substrate.

Advantageous Effects of Invention

The present invention provides a touch switch having two ITO-free electrode layers bonded to each other, wherein the touch switch has good visibility; and also provides a planar body that forms such a touch switch.

Brief Description of Drawings

[Fig. 1] Fig. 1 shows a partial cross section of a touch switch according to a first embodiment of the present invention.
[Fig. 2] Fig. 2 shows electrodes and auxiliary lines of the touch switch. Fig. 2(a) shows first electrodes and first auxiliary lines, and Fig. 2(b) shows second electrodes and second auxiliary lines.
[Fig. 3] Fig. 3 shows a positional relationship of the first electrodes, the first auxiliary lines, the second electrodes, and the second auxiliary lines.
[Fig. 4] Fig. 4 is a partially enlarged view of Fig. 3.
[Fig. 5] Fig. 5 shows a partial cross section of the touch switch.
[Fig. 6] Fig. 6 shows a partial cross section of the touch switch.
[Fig. 7] Fig. 7 shows electrodes and auxiliary lines of the touch switch. Fig. 7(a) shows first electrodes and first auxiliary lines, and Fig. 7(b) shows second electrodes and second auxiliary lines.
[Fig. 8] Fig. 8 shows a positional relationship of the first electrodes, the first auxiliary lines, the second electrodes, and the second auxiliary lines of Fig. 7.
[Fig. 9] Fig. 9 shows electrodes used for comparison between mesh-like electrodes and ITO electrodes.
[Fig. 10] Fig. 10 is a schematic cross-sectional diagram of the main components of a touch switch according to a second embodiment of the present invention.
First Embodiment

[0024] A touch switch according to a first embodiment of the present invention is described with reference to the drawings. The touch switch is a capacitive touch switch mounted to a front side of a display device. A black matrix forming a grid pattern of horizontal and vertical lines is formed in the display device.

[0025] A touch switch 10 shown in Fig. 1 includes a substrate 12, first electrodes 14 formed on one side of the substrate 12, and second electrodes 16 formed on the other side of the substrate 12. In the description, the "one side" of the substrate 12 is an upper side, and the "other side" of the substrate 12 is a lower side, which is mounted to a display device 18.

[0026] The substrate 12 is a dielectric substrate. Examples of materials of the substrate 12 include transparent materials such as glass, polyester, polyethylene terephthalate, polycarbonate, polymethylmethacrylate, polyethylene naphthalate, etc. In the case of glass, the thickness is about 0.1 to 2 mm. In the case of plastic film, the thickness is about 10 to 2,000 μm.

[0027] As shown in Fig. 2, the first electrodes 14 and the second electrodes 16 are all arranged at certain intervals. The first electrodes 14 and the second electrodes 16 are oriented in mutually perpendicularly intersecting directions. As shown in Fig. 3, the first electrodes 14 and the second electrodes 16 form a grid pattern.

[0028] Each of the first electrodes 14 and second electrodes 16 has multiple conductor lines, and forms a mesh structure with the conductor lines. The conductor lines include long lines 20a and 20b, and multiple short lines 22a and 22b that intersect the long lines 20a and 20b. The long lines 20a and 20b and the short lines 22a and 22b are all disposed inclined with respect to the black matrix in the display device 18. This is because a moiré pattern would easily occur if the conductor lines and the black matrix were oriented in the same direction.

[0029] The long lines 20a and 20b curve at certain positions. The angle of the curve is the same at each position. The angle of the curve is an angle (bias angle) at which a moiré pattern does not occur along the vertical or horizontal axis of the display device 18. The long lines 20a of the first electrodes 14 and the short lines 22b of the second electrodes 16 are oriented in the same direction, and the short lines 22a of the first electrodes 14 and the long lines 20b of the second electrodes 16 are oriented in the same direction. The line width of the long lines 20a and 20b and the short lines 22a and 22b is, for example, about 10 to 30 μm. The pitch of the long lines 20a and 20b is about 200 to 400 μm. Because the line width is very thin and the pitch is sufficiently large relative to the line width, the electrodes 14 and 16 are inconspicuous and unlikely to degrade the display quality level of the display device 18.

[0030] Note that rhombuses as shown in Fig. 4 are formed by the first electrodes 14 and the second electrodes 16. In the present description, the grid pattern forms rhombuses rather than squares. The angle of the curves of the long lines 20a and 20b is suitably selected according to the size of the display device 18 and the like. Because of the curves, the conductor lines are not formed in the same direction as the black matrix. Consequently, first auxiliary lines 24 and second auxiliary lines 26, which are described below, are also disposed inclined with respect to the black matrix.

[0031] Further, because of the mesh pattern, even if one of the long lines 20a and 20b or one of the short lines 22a and 22b is cut during manufacturing, electrical signals can be applied by another one of the long lines 20a and 20b or another one of the short lines 22a and 22b, thus preventing a reduction in the manufacturing yield. The volume resistivity of the electrodes constituting the first electrodes 14 and the second electrodes 16 is 0.5×10-5 to 5×10-5Ω·cm, which is lower than that of ITO. Further, the volume resistivity, line width, and height are adjusted in such a manner that the resistance between terminals of electrodes 16x and 14y is 5 kΩ or less, preferably 1 kΩ or less.
The short lines 22a and 22b are arranged at greater intervals than the long lines 20a and 20b, and each second electrode 16 is arranged between the adjacent short lines 22a of the first electrodes 14. Further, each first electrode 14 is arranged between the adjacent short lines 22b of the second electrodes 16. The conductor lines such as the short lines 22a of the first electrodes 14 and the long lines 20b of the second electrodes 16 are arranged at equal intervals. The conductor lines such as the short lines 20a of the first electrodes 14 and the long lines 22b of the second electrodes 16 are arranged at equal intervals. The short lines 22a of the first electrodes 14 do not overlap with the second electrodes 16, thereby preventing the occurrence of a moiré pattern. Also, the short lines 22b of the second electrodes 16 do not overlap with the first electrodes 14, thereby preventing the occurrence of a moiré pattern.

The present invention includes the multiple first auxiliary lines 24 and the multiple second auxiliary lines 26. The first auxiliary lines 24 are formed on the one side of the substrate 12, and the second auxiliary lines 26 are formed on the other side of the substrate 12. Each first auxiliary line 24 is formed between the adjacent first electrodes 14, and each second auxiliary line 26 is formed between the adjacent second electrodes 16. Materials of the first auxiliary lines 24 and the second auxiliary lines 26 are the same as those of the first electrodes 14 and the like. The first auxiliary lines 24 and the second auxiliary lines 26 are not connected to either first electrodes 14 or second electrodes 16.

Fig. 4 shows an enlarged view of the electrodes 14 and 16, and the auxiliary lines 24 and 26. The white solid lines are the first electrodes 14 and the first auxiliary lines 24 formed on the one side of the substrate 12, and the black solid lines are the second electrodes 16 and the second auxiliary lines 26 formed on the other side of the substrate 12. The first auxiliary lines 24 are oriented in the same direction as the short lines 22b of the second electrodes 16, and the length of the first auxiliary line 24 is equal to an interval d2 between the adjacent second electrodes 16. Further, the second auxiliary lines 26 are oriented in the same direction as the short lines 20a of the second electrodes 16, and the length of the second auxiliary lines 26 is equal to an interval d1 between the adjacent first electrodes 14. Each first auxiliary line 24 and each second auxiliary line 26 mutually intersect at their centers.

When the touch switch 10 is viewed from above or below, the first auxiliary lines 24 form continuous lines with the short lines 22b of the second electrodes 16. The first auxiliary lines 24 are formed on the one side of the substrate 12, and the short line 22b of the second electrodes 16 are formed on the other side thereof. Therefore, these lines are not actually in contact with each other; they are, however, arranged to form seemingly continuous lines. Likewise, the second auxiliary lines 26 and the short line 22a of the first electrodes 14 are also arranged to form continuous lines. Further, the long lines 20a of the first electrodes 14, the first auxiliary lines 24, and the short lines 22b of the second electrodes 16 are arranged at equal intervals. The long lines 20b of the second electrodes 16, the second auxiliary lines 26, and the short lines 22a of the first electrodes 14 are arranged at equal intervals. The equally spaced arrangement of these lines results in the formation of a grid with the first electrodes 14 and the like. As described above, these lines are seemingly continuous lines with curves at certain positions, and can form a grid pattern with the electrodes 14 and 16. One grid pattern is formed with the first electrodes 14 and the second electrodes 16 formed on two separate sides; it is not the case that two grid patterns are overlapped with each other to seemingly form one grid pattern. When two grid patterns are overlapped with each other, even a slight displacement causes a moiré pattern to appear; however, the present invention can prevent the occurrence of such a moiré pattern.

As described above, the seemingly connected lines are formed, and these lines are arranged at equal intervals. As a result, the conductor lines in a grid pattern are formed in the touch switch 10 as shown in Fig. 3. A grid pattern is formed when the first electrodes 14 and the second electrodes 16 are overlapped with each other. In this point, the present invention is different from prior Patent Literature 2. Even if the positions of the first electrodes 14 and the like are somewhat dislocated, the grid pattern is only slightly deformed, and a moiré pattern does not easily occur. It is possible to improve the manufacturing yield, compared to the case where the electrodes disclosed in Patent Literature 2 are arranged on both sides of the substrate.

An acrylic transparent adhesive 28 is used to bond a cover film 30 to the one side of the substrate 12. The first electrodes 14 and the first auxiliary lines 24 are protected by the cover film 30. The one side of the substrate 12 may be treated for nanoparticles. Material of the electrodes 14 and 16 do not include ITO containing indium, which is a rare element. Accordingly, it is possible to lower the cost of the electrode materials.
be coated with a transparent resin, rather than using the cover film 30. An acrylic transparent adhesive 32 is used to bond the other side of the substrate 12 to a front surface of the display device 18. The electrodes 14 and 16 have the terminals 14y and 16x at their ends, and lead wires (not shown) extend from the terminals 14y and 16x for connection. The lead wires are connected to a control circuit for detecting the voltage applied to the electrodes 14 and 16 and a touch position. A touch position is detected by applying a predetermined voltage to the electrodes 14 and 16, and detecting an electrical change that occurs when a finger is moved closer to the touch switch 10.

[0039] A method for manufacturing the touch switch 10 is described: (1) The above-described substrate 12 and ink are provided. The substrate 12 is cut as needed into a desired shape, and washed. (2) The first electrodes 14 and the first auxiliary lines 24 are formed by printing the ink on the one side of the substrate 12. (3) The second electrodes 16 and the second auxiliary lines 26 are formed by printing the ink on the other side of the substrate 12. (4) The acrylic transparent adhesive 28 is applied to the one side of the substrate 12, and the cover film 30 is then bonded to the one side of the substrate 12.

[0040] The printing in (2) and (3) is carried out by screen printing or ink-jet printing. The ink still has a high specific resistance and no conductivity after simply carrying out screen printing or ink-jet printing. Conductivity is imparted to the ink by firing the ink in a kiln after printing. The electrodes 14 and 16 can be very easily produced without the need for vacuum film formation and etching, which are required for the manufacturing of ITO.

[0041] Further, the lead wires are formed using silver ink and the like so as to extend from the end of each of the electrodes 14 and 16, and the electrodes 14 and 16 are connected to the control circuit of the touch switch via the lead wires. By forming the lead wires by screen printing and the like using the same ink used for the electrodes, it is possible to simultaneously form the lead wires and the electrodes 14 and 16.

[0042] The completed touch switch 10 is mounted to the front side of the display device 18 using the acrylic transparent adhesive 32 or the like. Alignment marks are provided, if necessary, to the corners of the substrate 12 and the display device 18 for positioning.

[0043] Next, a different type of touch switch is described. Descriptions of the same components as in the above-described touch switch may be omitted.

[0044] A touch switch 10b shown in Fig. 5 includes a first substrate 12a, a second substrate 12b disposed facing the first substrate 12a, the multiple first electrodes 14 formed on a first side of the first substrate 12a, and the multiple second electrodes 16 formed on a first side of the second substrate 12b. The first side of the first substrate 12a faces a second side of the second substrate 12b. The first side of the second substrate 12a is a side mounted to the display device 18. The first electrodes 14 and the second electrodes 16 are the same as those shown in Figs. 2 to 4. They are mesh-like electrodes formed by the long lines 20a and 20b, and the short lines 22a and 22b. Materials for the substrates 12a and 12b and the electrodes 14 and 16 are the same as those for the touch switch 10.

[0045] The first auxiliary lines 24 are formed on the first side of the first substrate 12a, and the second auxiliary lines 26 are formed on the first side of the second substrate 12b. Each first auxiliary line 24 is formed between the adjacent first electrodes 14, and each second auxiliary line 26 is formed between the adjacent second electrodes 16. The first auxiliary lines 24 are oriented in the same direction as the short lines 22b of the second electrodes 16, and the length of each first auxiliary line 24 is equal to an interval d1 between the adjacent second electrodes 16. Further, the second auxiliary lines 26 are oriented in the same direction as the short lines 22a of the second electrodes 14, and the length of each second auxiliary line 26 is equal to an interval d2 between the adjacent first electrodes 14. Materials for the first auxiliary lines 24 and the second auxiliary lines 26 are the same as those for the first electrodes 14 and the like.

[0046] As with the above-described touch switch 10, the first auxiliary lines 24 form continuous lines with the short lines 22b of the second electrodes 16. These lines are not in contact with each other; they are, however, arranged to form seemingly continuous lines. Likewise, the second auxiliary lines 26 and the short lines 20a of the first electrodes 14 are also arranged to form continuous lines.

[0047] As shown in Fig. 5, the first substrate 12a and the second substrate 12b are bonded to each other using a transparent acrylic transparent adhesive 34 or the like. The second substrate 12b and the second electrodes 16 are bonded to the display device 18 using a transparent acrylic transparent adhesive 36 or the like.

[0048] Additionally, lead wires (not shown) are connected to the terminals 14y and 16x of the electrodes 14 and 16. The lead wires are connected to a control circuit that detects the voltage applied to the electrodes 14 and 16, and a touch position. A touch position is detected by applying a predetermined voltage to the electrodes 14 and 16, and detecting an electrical change that occurs when a finger is moved closer to the touch switch 10b.

[0049] A method for manufacturing the touch switch 10b is described: (1) The above-described substrate 12 and ink are provided. The substrates 12a and 12b are cut as needed into a desired shape, and washed. (2) The first electrodes 14 and the first auxiliary lines 24 are formed by printing the ink on the first side of the substrate 12a. (3) The second electrodes 16 and the second auxiliary lines 26 are formed by printing the ink on the first side of the second substrate 12b. (4) The first substrate 12a and the second substrate 12b are bonded to each other using the acrylic transparent adhesive 34, in such a manner that the second side of the second substrate 12b is disposed facing the first side of the first substrate 12a.
The present invention can be practiced in embodiments to which various improvements, modifications, and changes are added based on the knowledge of a person skilled in the art, without departing from the scope of the invention.

Second Embodiment

Hereinbelow, a second embodiment of the present invention is described with reference to the attached drawings. Note that none of the drawings reflects the actual size. They are partially enlarged or reduced in order to facilitate the understanding of the structures.

Fig. 10 is an enlarged schematic cross-sectional diagram of the main components of a touch switch according
to a second embodiment of the present invention. This touch switch 105 is a capacitive touch switch, and includes, as shown in Figs. 11 and 12, a first planar body 101 in which a mesh-like electrode 112 is formed on one side of a substrate 111, and a second planar body 102 in which a mesh-like electrode 122 is formed on one side of a substrate 121. Note that Fig. 11 is a plan view of the first planar body 101, and Fig. 12 is a plan view of the second planar body 102. The first planar body 101 and the second planar body 102 are integrally bonded via an adhesive layer 103 in such a manner that the mesh-like electrodes 112 and 122 on their respective planar bodies face each other. Note that the first planar body 101 and the second planar body 102 are bonded in such a manner that conductive areas 112a of the first planar body 101 and conductive areas 122a of the second planar body 102, which are described below, perpendicularly intersect each other.

[0060] The substrates 111 and 121 are dielectric substrates. Examples of materials of the substrates 111 and 121 include transparent materials such as glass, polyester, polyethylene terephthalate, polycarbonate, polymethylmethacrylate, polyethylene naphthalate, etc. In the case of glass, the thickness is preferably about 0.1 to 3 mm; in the case of plastic film, the thickness is preferably about 10 to 2,000 μm. These materials may also be laminated in multiple layers.

[0061] As shown in Figs. 11 and 12, and their enlarged views Figs. 13(a) and 13(b) (showing the main parts), the mesh-like electrodes 112 and 122 respectively formed on one side of the first planar body 101 and on one side of the second planar body 102 are electrodes formed in a mesh pattern with multiple conductor lines L.

[0062] Further, the mesh-like electrode 112 (122) is separated into the multiple conductive areas 112a (122a) disposed substantially parallel to each other at predetermined intervals, and non-conductive areas 112b (122b) each disposed between the adjacent conductive areas. Fig. 14 is a diagram showing boundaries between the conductive areas 112a and the non-conductive areas 112b of Fig. 11. Fig. 15 is a diagram showing boundaries between the conductive areas 122a and the non-conductive areas 122b of Fig. 12. In both drawings, the gray colored portion represents the conductive areas 112a and 122a. The conductive areas 112a and 122a are connected to an outside drive circuit (not shown) via a routed circuit (not shown) formed of conductive ink, etc.

[0063] Further, each non-conductive area 112b (122b) includes multiple cutting portions 104 that cut the conductor lines L into island-like forms. Each non-conductive area 112b (122b) insulates between the adjacent conductive areas by the cutting portions 104. In the present embodiment, the cutting portions 104 are formed at intersections of the multiple conductor lines L that form the mesh-like electrodes 112 and 122. The cutting width of the cutting portions 104 is, for example, about the same as the line width of the conductor lines L, or about a few times greater than the line width of the conductor lines L.

[0064] As described above, the non-conductive areas 112b and 122b have the cutting portions 104 that cut the conductor lines L. This structure can ensure insulation in the non-conductive areas 112b and 122b of the mesh-like electrodes 112 and 122. Accordingly, when the touch switch 105 is formed by overlapping the first planar body 101 and the second planar body 102, the non-conductive areas 112b (122b) of the mesh-like electrode 112 (122) of the first planar body 101 (the second planar body 102) is prevented from adversely affecting the sensing of the mesh-like electrode 112 (122) of the other planar body, and thus the detection of capacitance can be stably performed.

[0065] The line width of the conductor lines L is, for example, 10 to 30 μm. The thickness of the conductor lines L is 100 to 1,000 μm. The thickness of the conductor lines L is usually about 1 to 30 μm. In view of the improvement of the visibility by allowing the shape of the pattern of the mesh-like electrodes 112 and 122 to be inconspicuous, the conductor lines L are preferably as thin as possible. However, when the conductor lines L are too thin, it is difficult to ensure the durability and weather resistance necessary for the mesh-like electrodes 112 and 122. Accordingly, the thickness is preferably about 10 to 30 μm. The mesh-like electrodes 112 and 122 having the above-described dimensions are inconspicuous because the line width of the conductor lines L is very thin, and the pitch is sufficiently large relative to the line width.

[0066] Examples of methods for forming the conductor lines L that form the mesh-like electrodes 112 and 122 include:
(i) a method in which a conductive paste containing ultrafine conductive particles is screen-printed on a transparent substrate (see Japanese Unexamined Patent Publication No. 2007-142334, and the like); and
(ii) a method in which metal foil such as copper or the like is laminated on a transparent substrate, a resist pattern is formed on the metal foil, and the metal foil is etched (see Japanese Unexamined Patent Publication No. 2008-32884, and the like).

[0067] The methods for forming the conductor lines L are not limited to the above described formation methods (i) and (ii). Printing methods other than the method (i), such as gravure printing, or photolithography other than the method (ii) may be used.

[0068] As shown in Figs. 11 to 15, the shape of the conductive areas 112a and 122a in the mesh-like electrodes 112 and 122 is formed from linearly connected multiple rhombuses. The rhombic conductive areas of each conductive area 112a and the rhombic conductive areas of each conductive area 122a are connected in the directions in which they intersect each other; and, as shown in Fig. 16, they are arranged in such a manner that the rhombuses of the conductive areas 112a and the rhombuses of the conductive areas 122a, which are arranged at the upper and lower sides, do not overlap each other when the first planar body 101 and the second planar body 102 are overlapped with each other. Note that the shape of the conductive areas 112a and 122a can be any shape, such as a linear shape, etc., insofar as the
The contact point of the finger or the like can be detected.

The first planar body 101 and the second planar body 102 are preferably bonded to each other with the adhesive layer 103 entirely interposed therebetween so as to avoid formation of an air layer. Epoxy-based, acryl-based and like generally used transparent adhesives may be used as the adhesive layer 103, and they may include a core material formed from a transparent film of norbornene-based resin. The thickness of the adhesive layer 103 is, for example, preferably 500 µm or less. The adhesive layer 103 may also be formed by overlapping multiple sheet-like adhesives, or by overlapping several different types of sheet-like adhesives.

Further, particularly preferably, a mesh pattern with an entirely uniform appearance is obtained as shown in Fig. 17 when the first planar body 101 and the second planar body 102 are bonded to each other in such a manner, for example, that the vertex of each mesh of the mesh-like electrode 122 on the second planar body 102 is positioned at the center of each mesh of the mesh-like electrode 112 on the first planar body 101, and the conductor lines L forming the meshes of the mesh-like electrode 112 intersect the conductor lines L forming the meshes of the mesh-like electrode 122. Note that Fig. 17 is a view showing the electrodes of Figs. 13(a) and 13(b) bonded to each other.

The touch switch 105 formed by bonding the first planar body 101 and the second planar body 102 to each other is used by being mounted, for example, to a display device in which a black matrix is formed. Preferably, the touch switch 105 is mounted to the display device in such a manner that the mesh patterns of the conductive areas 112a and 122a and the non-conductive areas 112b and 122b are inclined with respect to the black matrix, so as to avoid a moiré pattern that occurs when the black matrix and the mesh pattern are arranged in the same direction. The angle of inclination is suitably adjusted to an angle at which a moiré pattern does not easily occur, according to the display device that is actually used.

The method for detecting a touch position in the touch switch 105 having the above-described structure is the same as that in known capacitive touch switches. A change in the voltage based on the capacitance of a human body is detected at the contact position on the electrodes 112 and 122, and a coordinate of the contact position is thereby calculated.

The touch switch 105 according to the present embodiment includes the mesh-like electrodes 112 and 122 respectively formed on the first planar body 101 and the second planar body 102, in which the mesh-like electrode 112 (122) is separated into the strip-like conductive areas 112a (122a), and the strip-like non-conductive areas 112b (122b) having the multiple cutting portions 104 that intermittently cut the conductor lines L. Consequently, the touch switch 105 can effectively suppress the occurrence of variation in mesh density when the first planar body 101 and the second planar body 102 are overlapped with each other, while ensuring electrical insulation in the non-conductive areas 112b and 122b. Because the variation in mesh density can be suppressed, the shape of the pattern of the mesh-like electrodes 112 and 122 can be made inconspicuous, thus improving the visibility.

Further, the mesh-like electrodes 112 and 122 according to the present embodiment can be printed with ink containing conductive nanoparticles, using a mask having a predetermined mask pattern. Consequently, the first planar body 101 and the second planar body 102 can be efficiently manufactured.

An embodiment of the present invention is described above; however, the specific embodiment of the present invention is not limited to the above-described embodiment. For example, in the above-described embodiment, the cutting portions 104 formed in the non-conductive areas 112b and 122b have the cutting portions 104 that intermittently cut the conductor lines L; however, the cutting portions 104 may be disposed at any positions insofar as they do not interfere with the conductivity between the ends 221 and 222 (321 and 322) of each conductive area 112a (122a). The visibility can be further improved by the above-described structure.

Reference Signs List

10, 10b, 10c Touch switches
12, 12a, 12b, 12c Substrates
14, 14b, 16, 16b Electrodes
18 Display device
Claims

1. A planar body comprising a mesh-like electrode formed in a mesh shape with multiple conductor lines on one side of a substrate, wherein the mesh-like electrode is separated into multiple conductive areas disposed at intervals and non-conductive areas each disposed between the conductive areas, each non-conductive area has multiple cutting portions that cut the conductor lines, and each non-conductive area insulates between the adjacent conductive areas by the cutting portions.

2. The planar body according to claim 1, wherein the cutting portions are formed at intersections of the conductor lines of the mesh-like electrode.

3. The planar body according to claim 1, wherein the mesh pitch of the mesh-like electrode is 100 \( \mu \)m to 1,000 \( \mu \)m.

4. The planar body according to claim 1, wherein the conductive areas have at least one cutting portion that cuts the conductor lines without interfering with the conductivity between the ends of each conductive area.

5. A capacitive touch switch comprising a plurality of the planar bodies recited in claim 1, wherein the planar bodies are bonded together via an adhesive layer.
6. The capacitive touch switch according to claim 5, wherein the conductive areas formed on one planar body are disposed to perpendicularly intersect the conductive areas formed on a different planar body.

7. A touch switch mounted to a front side of a display device, the touch switch comprising:
   
   a substrate;
   multiple first electrodes formed on one side of the substrate and arranged at certain intervals; and
   multiple second electrodes formed on the other side of the substrate and arranged at certain intervals to form a grid pattern with the multiple first electrodes,
   wherein each of the first and second electrodes forms a mesh structure with multiple conductor lines, and the direction of the conductor lines is inclined with respect to a black matrix in the display device.

8. The touch switch according to claim 7, comprising:
   
   first auxiliary lines formed between the first electrodes on the one side; and
   second auxiliary lines formed between the second electrodes on the other side,
   wherein a grid pattern with equal intervals is formed by the conductor lines of the first electrodes, the first auxiliary lines, the conductor lines of the second electrodes, and the second auxiliary lines.

9. The touch switch according to claim 8, wherein the conductor lines of the first electrodes, the first auxiliary lines, or both of them formed on the one side of the substrate form continuous lines with the conductor lines of the second electrodes, the second auxiliary lines, or both of them formed on the other side of the substrate.

10. A touch switch comprising:

    a first substrate;
    a second substrate disposed facing the first substrate;
    multiple first electrodes formed on the first substrate, specifically on a side facing the second substrate, and arranged at certain intervals;
    and multiple second electrodes formed on the second substrate, specifically on a side away from the first substrate, and arranged at certain intervals to form a grid pattern with the multiple first electrodes,
    wherein each of the first and second electrodes form a mesh structure with multiple conductor lines, and the direction of the conductor lines is inclined with respect to a black matrix in a display device.

11. The touch switch according to claim 10, comprising:

    first auxiliary lines formed between the first electrodes on the first substrate, specifically on the side facing the second substrate; and
    second auxiliary lines formed between the second electrodes on the second substrate, specifically on the side away from the first substrate,
    wherein a grid pattern with equal intervals is formed by the conductor lines of the first electrodes, the first auxiliary lines, the conductor lines of the second electrodes, and the second auxiliary lines.

12. The touch switch according to claim 11, wherein the conductor lines of the first electrodes, the first auxiliary lines, or both of them formed on the first substrate form continuous lines with the conductor lines of the second electrodes, the second auxiliary lines, or both of them formed on the second substrate.
Fig. 1
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

G06F3/041(2006.01)i, G06F3/044(2006.01)i, H01H36/00(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)

G06F3/041, G06F3/044, H01H36/00

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


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

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>JP 2006-344163 A (NISSHA Printing Co., Ltd.), 21 December, 2006 (21.12.06), (Family: none)</td>
<td>1-5, 6, 8, 9, 11, 12</td>
</tr>
<tr>
<td>Y</td>
<td>JP 2007-157107 A (Wacom Co., Ltd.), 21 June, 2007 (21.06.07), Par. No. [0023]; Fig. 4 (Family: none)</td>
<td>6, 8, 9, 11, 12</td>
</tr>
</tbody>
</table>

**Further documents are listed in the continuation of Box C.**

**See patent family annex.**

* special category of cited documents:
*"A" document defining the general state of the art which is not considered to be of particular relevance
*"E" earlier application or patent but published on or after the international filing date
*"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
*"O" document referring to an oral disclosure, use, exhibition or other means of publication prior to the international filing date but later than the priority date claimed
*"P" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

**Date of the actual completion of the international search**

02 October, 2009 (02.10.09)

**Date of mailing of the international search report**

13 October, 2009 (13.10.09)

Name and mailing address of the ISA/Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X A</td>
<td>JP 11-110115 A (Fujitsu General Ltd.), 23 April, 1999 (23.04.99), Full text; all drawings (Family: none)</td>
<td>7,10, 8,9,11,12</td>
</tr>
</tbody>
</table>
INTERNATIONAL SEARCH REPORT

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The matter common to the inventions of claims 1 – 12 is to comprise a planar element, which is provided on a substrate with mesh-like electrodes formed of plural conductors into a mesh shape.

However, the search has revealed that the aforementioned common matter is not novel, since it was disclosed in Document: JP 2006-344163 A (NISSHA Printing Co., Ltd.), 21 December 2006 (21.12.2006), paragraphs [0048] to [0052]; fig. 9 (no family).

(continued to extra sheet)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest the

☐ The additional search fees were accompanied by the applicant’s protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)
As a result, the aforementioned common matter is not the special technical feature within the meaning of PCT Rule 13.2, second sentence, since the common matter makes no contribution over the prior art.

There exists no other common matter which can be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence. Therefore, no technical relationship within the meaning of PCT Rule 13 can be seen between those different inventions.

Hence, it is apparent that the inventions of claims 1 - 12 do not comply with the requirement of unity of invention.
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader’s convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2006511879 A [0008]
- JP 2006344163 A [0008]
- JP 2007142334 A [0066]
- JP 2008032884 A [0066]