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Inventor(s) LIM; SANGHYUN

ELECTRONIC DEVICE

Abstract

An electronic device includes a display layer including a display area and a non-display area adjacent to the display area and a sensor layer on the display layer. The sensor layer includes a plurality of first electrodes arranged in a first direction, a plurality of second electrodes arranged in a second direction intersecting the first direction and intersecting the first electrodes, a plurality of first auxiliary electrodes arranged in the first direction and overlapping the first electrodes, a plurality of second auxiliary electrodes arranged in the second direction and overlapping the second electrodes, and an auxiliary trace line electrically connected to at least one second auxiliary electrode among the second auxiliary electrodes. At least a portion of the auxiliary trace line overlaps the display area.

Inventors: **LIM; SANGHYUN (Yongin-si, KR)**

Applicant: **Samsung Display Co., Ltd.** (Yongin-si, KR)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to and the benefit of Korean Patent Application No. 10-2024-0023921, filed on Feb. 20, 2024, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field

[0002] Aspects of some embodiments of the present disclosure relate to an electronic device capable of sensing an input generated by a pen.

2. Description of Related Art

[0003] Multimedia electronic devices, such as televisions, mobile phones, tablet computers, notebook computers, navigation units, and game units, include a display device to display images. The electronic device may include a sensor layer (or an input sensor) that provides a touch-based input method allowing users to relatively easily and intuitively input information or commands in addition to the usual input methods, such as a button, a keyboard, a mouse, etc. The sensor layer senses a touch or pressure generated by a user's body. Meanwhile, consumer demand for the use of a pen is increasing for users who are familiar with inputting information using a writing instrument or for specific application programs (e.g., for sketching or drawing application programs) that require detailed and precise touch input.

[0004] The above information disclosed in this Background section is only for enhancement of understanding of the background and therefore the information discussed in this Background section does not necessarily constitute prior art.

SUMMARY

[0005] Aspects of some embodiments of the present disclosure include an electronic device capable of sensing an input generated by a pen.

[0006] Aspects of some embodiments of the present disclosure include an electronic device including a display layer including a display area defined therein and a non-display area defined therein and adjacent to the display area, and a sensor layer located on the display layer. According to some embodiments, the sensor layer includes a plurality of first electrodes arranged in a first direction, a plurality of second electrodes arranged in a second direction intersecting the first direction and intersecting the plurality of first electrodes, a plurality of third electrodes arranged in the first direction and overlapping the plurality of first electrodes, a plurality of fourth electrodes arranged in the second direction and overlapping the plurality of second electrodes, and an auxiliary trace line electrically connected to at least one fourth electrode among the plurality of fourth electrodes. According to some embodiments, at least a portion of the auxiliary trace line overlaps the display area.

[0007] According to some embodiments, the auxiliary trace line includes a first portion extending from the at least one fourth electrode and overlapping the non-display area, a second portion extending from the first portion and overlapping the display area, and a third portion extending from the second portion and overlapping the non-display area.

[0008] According to some embodiments, at least one third electrode among the plurality of third electrodes includes a first electrode portion, a second electrode portion, and an auxiliary bridge electrically connected to the first electrode portion and the second electrode portion. According to some embodiments, the first electrode portion and the second electrode portion are spaced apart from each other with the auxiliary trace line interposed therebetween in the second direction, and

the auxiliary trace line is insulated from the auxiliary bridge while intersecting the auxiliary bridge.
[0009] According to some embodiments, the auxiliary trace line includes a first layer line and a second layer line located on the first layer line and electrically connected to the first layer line, at least one third electrode among the plurality of third electrodes includes a first electrode portion, a second electrode portion, and an auxiliary bridge electrically connected to the first electrode portion and the second electrode portion, the first electrode portion and the second electrode portion are spaced apart from each other with the first layer line interposed between, the first layer line is insulated from the auxiliary bridge while intersecting the auxiliary bridge, at least one first electrode among the first electrodes includes a first electrode pattern portion, a second electrode pattern portion, and an auxiliary bridge pattern electrically connected to the first electrode pattern portion and the second electrode pattern portion, the first electrode pattern portion is spaced apart from the second electrode pattern portion with the second layer line interposed therebetween, and the second layer line is insulated from the auxiliary bridge pattern while intersecting the auxiliary bridge pattern.
[0010] According to some embodiments, a length in the second direction of at least one third electrode among the plurality of third electrodes is shorter than a length in the second direction of another third electrode among the plurality of third electrodes.
[0011] According to some embodiments, the at least one third electrode is spaced apart from the non-display area with the auxiliary trace line interposed therebetween when viewed in a plane.
[0012] According to some embodiments, the sensor layer further includes an auxiliary electrode bridge electrically connected to the at least one third electrode and insulated from the auxiliary trace line while intersecting the auxiliary trace line.
[0013] According to some embodiments, the auxiliary trace line includes a first layer line and a second layer line located on the first layer line and electrically connected to the first layer line, the auxiliary electrode bridge is insulated from the first layer line while intersecting the first layer line, and the second layer line includes a first line portion and a second line portion spaced apart from the first line portion with the auxiliary electrode bridge interposed therebetween.
[0014] According to some embodiments, the auxiliary trace line is connected to the at least one fourth electrode in an area overlapping the display area.
[0015] According to some embodiments, the sensor layer further includes an additional auxiliary trace line that electrically connects the at least one fourth electrode to at least another fourth electrode among the plurality of fourth electrodes, and the additional auxiliary trace line overlaps the non-display area.
[0016] According to some embodiments, the auxiliary trace line is electrically connected to at least another fourth electrode among the plurality of fourth electrodes in the area overlapping the display area.
[0017] According to some embodiments, the sensor layer further includes a plurality of first auxiliary trace lines electrically connected to the plurality of third electrodes, and a portion of at least one first auxiliary trace line of the plurality of first auxiliary trace lines overlaps the display area.
[0018] According to some embodiments, a length in the second direction of at least one third electrode electrically connected to the at least one first auxiliary trace line among the plurality of third electrodes is equal to or smaller than a length in the second direction of another third electrode among the plurality of third electrodes.
[0019] According to some embodiments, the auxiliary trace line is located between the at least one first auxiliary trace line and the non-display area when viewed in the plane.
[0020] According to some embodiments, the at least one first auxiliary trace line is located between the auxiliary trace line and the non-display area when viewed in the plane.
[0021] According to some embodiments, another fourth electrode among the plurality of fourth electrodes includes a first electrode portion, a second electrode portion, and an auxiliary bridge

electrically connected to the first electrode portion and the second electrode portion, the first electrode portion and the second electrode portion are spaced apart from each other with the auxiliary trace line interposed therebetween in the first direction, and the auxiliary trace line is insulated from the auxiliary bridge while intersecting the auxiliary bridge.

[0022] According to some embodiments, the sensor layer further includes a plurality of first trace lines electrically connected to the plurality of first electrodes and a plurality of second trace lines electrically connected to the plurality of second electrodes, and the auxiliary trace line is insulated from at least one second trace line among the plurality of second trace lines while intersecting the at least one second trace line.

[0023] According to some embodiments, the auxiliary trace line includes a first portion extending from the at least one of the plurality of fourth electrodes and overlapping the non-display area and a second portion extending from the first portion to the display area, and the at least one second trace line is insulated from the second portion while intersecting the second portion.

[0024] According to some embodiments, the auxiliary trace line overlaps at least one first electrode among the plurality of first electrodes, the at least one first electrode includes a first mesh line extending in a first intersecting direction and a second mesh line extending in a second intersecting direction intersecting the first intersecting direction, and the auxiliary trace line includes a third mesh line extending in the first intersecting direction and a fourth mesh line extending in the second intersecting direction.

[0025] According to some embodiments, the first mesh line intersects and overlaps the fourth mesh line when viewed in the plane, and the second mesh line intersects and overlaps the third mesh line when viewed in the plane.

[0026] According to some embodiments, the third mesh line includes an end portion connected to the fourth mesh line and an extension portion extending from the end portion to the first intersecting direction, and the extension portion does not overlap the first mesh line.

[0027] According to some embodiments, each of the first electrodes includes a plurality of sensing patterns spaced apart from each other in the second direction and a plurality of bridge patterns electrically connected to the plurality of sensing patterns, and the auxiliary trace line is located closer to the display layer than the plurality of sensing patterns.

[0028] Aspects of some embodiments of the present disclosure include an electronic device including a display layer including a display area defined therein and a non-display area defined therein and adjacent to the display area and a sensor layer on the display layer. According to some embodiments, the sensor layer includes a plurality of first electrodes arranged in a first direction, a plurality of second electrodes arranged in a second direction intersecting the first direction and intersecting the plurality of first electrodes, a sensing auxiliary electrode including a plurality of auxiliary electrodes extending in the first direction and arranged in the second direction, and an auxiliary trace line electrically connected to the sensing auxiliary electrode. According to some embodiments, at least a portion of the auxiliary trace line overlaps the display area.

[0029] According to some embodiments, the sensor layer further includes an additional auxiliary trace line that electrically connects the plurality of auxiliary electrodes and overlaps the non-display area.

[0030] According to some embodiments, the auxiliary trace line includes a first portion extending from the sensing auxiliary electrode and overlapping the non-display area, a second portion extending from the first portion and overlapping the display area, and a third portion extending from the second portion and overlapping the non-display area.

[0031] According to some embodiments, the sensor layer further includes a plurality of charging electrodes extending in the second direction and arranged in the first direction, a plurality of first trace lines electrically connected to the plurality of first electrodes, a plurality of second trace lines electrically connected to the plurality of second electrodes, and a plurality of first auxiliary trace lines electrically connected to the plurality of charging electrodes.

[0032] According to some embodiments, a portion of at least one first auxiliary trace line among the plurality of first auxiliary trace lines overlaps the display area, and the portion of the at least one first auxiliary trace line is between the auxiliary trace line and the non-display area.
[0033] According to some embodiments, the sensor layer further includes a second auxiliary trace line electrically connected to the plurality of charging electrodes, the second auxiliary trace line is provided to surround an area in which the plurality of first trace lines, the plurality of second trace lines, the auxiliary trace line, and the plurality of first auxiliary trace lines are arranged.
[0034] According to some embodiments, the auxiliary trace line overlaps at least one first electrode among the plurality of first electrodes, the at least one first electrode includes a first mesh line extending in a first intersecting direction and a second mesh line extending in a second intersecting direction intersecting the first intersecting direction, the auxiliary trace line includes a third mesh line extending in the first intersecting direction and a fourth mesh line extending in the second intersecting direction, the first mesh line overlaps and intersects the fourth mesh line when viewed in a plane, and the second mesh line overlaps and intersects the third mesh line when viewed in the plane.
[0035] Aspects of some embodiments of the present disclosure include an electronic device including a sensor layer including a sensing area and a peripheral area adjacent to the sensing area and a sensor driver driving the sensor layer and being selectively driven in a first mode in which a touch input is sensed or a second mode in which a pen input is sensed. According to some embodiments, the sensor layer includes a plurality of first electrodes on the sensor layer, a plurality of second electrodes on the sensor layer, a sensing auxiliary electrode on the sensor layer, and an auxiliary trace line electrically connected to the sensing auxiliary electrode and partially in the sensing area. According to some embodiments, the sensing auxiliary electrode is floated or grounded in the first mode.
[0036] According to some embodiments, the auxiliary trace line includes a first portion extending from the sensing auxiliary electrode and overlapping the peripheral area, a second portion extending from the first portion and overlapping the sensing area, and a third portion extending from the second portion and overlapping the peripheral area.
[0037] According to some embodiments, the auxiliary trace line is connected to the sensing auxiliary electrode in the sensing area.
[0038] According to some embodiments, the auxiliary trace line overlaps at least one first electrode among the plurality of first electrodes, the at least one first electrode includes a first mesh line extending in a first intersecting direction and a second mesh line extending in a second intersecting direction intersecting the first intersecting direction, the auxiliary trace line includes a third mesh line extending in the first intersecting direction and a fourth mesh line extending in the second intersecting direction, the first mesh line overlaps and intersects the fourth mesh line when viewed in a plane, and the second mesh line overlaps and intersects the third mesh line when viewed in the plane.
[0039] According to some embodiments, the second mode includes a charging driving mode and a pen sensing driving mode, and the sensing auxiliary electrode is floated in the pen sensing driving mode.
[0040] According to some embodiments of the present disclosure, not only a touch input but also a pen input may be sensed using the sensor layer. Because an additional component, e.g., a digitizer, to sense the pen input may not be required, the increase in thickness and weight and the decrease in flexibility of the electronic device due to the addition of the digitizer may be avoided. In addition, among the trace lines located in an area where the trace lines are intensively (or densely) arranged in the peripheral area, e.g., an area between the sensing area and an area where the pads are located, at least a portion of some trace lines is located in the sensing area. Accordingly, the area occupied by the trace lines in the peripheral area may be relatively reduced, and the area where the trace lines are not located, i.e., an unused area, in the peripheral area may increase. When the unused

area is removed, for example, by cutting, the area occupied by the peripheral area in a total area of the display panel is reduced, and thus, a narrow bezel is implemented. In addition, a line width of each of the first trace lines or the second trace lines is able to be adjusted to relatively improve a resistance thereof by utilizing the unused area. In this case, a sensing sensitivity of the sensor layer may be enhanced.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] The above and other aspects and characteristics of embodiments according to the present disclosure will become readily apparent by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

[0042] FIG. **1**A is a perspective view of an electronic device according to some embodiments of the present disclosure;

[0043] FIG. **1**B is a rear perspective view of an electronic device according to some embodiments of the present disclosure;

[0044] FIG. **2** is a perspective view of an electronic device according to some embodiments of the present disclosure;

[0045] FIG. **3** is a perspective view of an electronic device according to some embodiments of the present disclosure;

[0046] FIG. **4** is a cross-sectional view of a display panel according to some embodiments of the present disclosure;

[0047] FIG. **5** is a block diagram illustrating an operation of an electronic device according to some embodiments of the present disclosure;

[0048] FIG. **6**A is a cross-sectional view of a display panel according to some embodiments of the present disclosure;

[0049] FIG. **6**B is a cross-sectional view of a sensor layer according to some embodiments of the present disclosure;

[0050] FIG. **7**A is a plan view of a display panel according to some embodiments of the present disclosure;

[0051] FIG. **7**B is a plan view of a display panel according to some embodiments of the present disclosure;

[0052] FIG. **8**A is a plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0053] FIG. **8**B is a plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0054] FIG. **9** is a cross-sectional view of a sensor layer taken along a line I-I′ of FIGS. **8**A and **8**B according to some embodiments of the present disclosure;

[0055] FIG. **10**A is an enlarged plan view of an area AA′ of FIG. **8**A;

[0056] FIG. **10**B is an enlarged plan view of an area BB′ of FIG. **8**B;

[0057] FIG. **11**A is a plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0058] FIG. **11**B is a plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0059] FIG. **12**A is an enlarged plan view of a portion of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0060] FIG. **12**B is an enlarged plan view of a portion of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0061] FIG. **12**C is a plan view of the portion of the first conductive layer shown in FIG. **12**A and the portion of the second conductive layer shown in FIG. **12**B;

[0062] FIG. **13**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0063] FIG. **13**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0064] FIG. **14**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0065] FIG. **14**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0066] FIG. **15**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0067] FIG. **15**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0068] FIG. **16**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0069] FIG. **16**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0070] FIG. **17**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0071] FIG. **17**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0072] FIG. **18** is a plan view of a display panel according to some embodiments of the present disclosure;

[0073] FIG. **19**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0074] FIG. **19**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0075] FIG. **20** is a plan view of a display panel according to some embodiments of the present disclosure;

[0076] FIG. **21** is a plan view of a display panel according to some embodiments of the present disclosure;

[0077] FIG. **22**A is an enlarged plan view of a first conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0078] FIG. **22**B is an enlarged plan view of a second conductive layer of a sensing unit according to some embodiments of the present disclosure;

[0079] FIG. **23** is a view illustrating an operation of a sensor driver according to some embodiments of the present disclosure;

[0080] FIG. **24** is a view illustrating an operation of a sensor driver according to some embodiments of the present disclosure;

[0081] FIG. **25** is a view illustrating a first mode according to some embodiments of the present disclosure;

[0082] FIG. **26** is a view illustrating a second mode according to some embodiments of the present disclosure;

[0083] FIG. **27**A is a view illustrating a waveform of a first signal according to some embodiments of the present disclosure;

[0084] FIG. **27**B is a view illustrating a waveform of a second signal according to some embodiments of the present disclosure;

[0085] FIG. **28** is a view illustrating a second mode according to some embodiments of the present disclosure; and

[0086] FIG. **29** is a view illustrating a second mode with respect to a sensing unit according to some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0087] In the present disclosure, it will be understood that when an element (or area, layer, or portion) is referred to as being “on”, “connected to” or “coupled to” another element or layer, it can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present.

[0088] Like numerals refer to like elements throughout. In the drawings, the thickness, ratio, and dimension of components are exaggerated for effective description of the technical content. As used herein, the term “and/or” may include any and all combinations of one or more of the associated listed items.

[0089] It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. Thus, a first element discussed below could be termed a second element without departing from the teachings of the present disclosure. As used herein, the singular forms, “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0090] Spatially relative terms, such as “beneath”, “below”, “lower”, “above”, “upper” and the like, may be used herein for ease of description to describe one element or feature's relationship to another elements or features as shown in the figures.

[0091] It will be further understood that the terms “include” and/or “including”, when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0092] Unless otherwise defined, all terms including technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0093] The term “part” or “unit” as used herein is intended to mean a software component or a hardware component that performs a specific function. The hardware component may include, for example, a field-programmable gate array (FPGA) or an application-specific integrated circuit (ASIC). The software component may refer to an executable code and/or data used by the executable code in an addressable storage medium. Thus, the software components may be, for example, object-oriented software components, class components, and task components, and may include processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, micro codes, circuits, data, a database, data structures, tables, arrays, or variables.

[0094] Hereinafter, embodiments of the present disclosure will be described with reference to accompanying drawings.

[0095] FIG. **1**A is a perspective view of an electronic device **1000** according to some embodiments of the present disclosure, and FIG. **1**B is a rear perspective view of the electronic device **1000** according to some embodiments of the present disclosure.

[0096] Referring to FIGS. **1**A and **1**B, the electronic device **1000** may be activated in response to electrical signals. As an example, the electronic device **1000** may display images and may sense external inputs applied thereto from the outside. The external input may be a user input. The user input may include a variety of forms of external inputs, such as a part of user's body, pen PN, light, heat, or pressure.

[0097] The electronic device **1000** may include a first display panel DP**1** and a second display panel DP**2**. The first display panel DP**1** and the second display panel DP**2** may be panels separated from each other. The first display panel DP**1** may be referred to as a main display panel, and the second display panel DP**2** may be referred to as an auxiliary display panel or an external display panel.

[0098] The first display panel DP**1** may include a first display part DA**1**-F, and the second display panel DP**2** may include a second display part DA**2**-F. The second display panel DP**2** may have a size smaller than a size of the first display panel DP**1**. Similar to the size of the first display panel DP**1** and the size of the second display panel DP**2**, the first display part DA**1**-F may have a size greater than a size of the second display part DA**2**-F.

[0099] When the electronic device **1000** is in an unfolded state, the first display part DA**1**-F may include a plane parallel to each of a first direction DR**1** and a second direction DR**2**. A thickness direction of the electronic device **1000** may be substantially parallel to a third direction DR**3** intersecting the first direction DR**1** and the second direction DR**2**. Hereinafter, front (or upper) and rear (or lower) surfaces of each member of the electronic device **1000** may be distinguished from each other based on the third direction DR**3**.

[0100] The first display panel DP**1** or the first display part DA**1**-F may include a folding area FA folded or unfolded and a plurality of non-folding areas NFA**1** and NFA**2** spaced apart from each other with the folding area FA interposed therebetween. The second display panel DP**2** may overlap one of the non-folding areas NFA**1** and NFA**2**. As an example, the second display panel DP**2** may overlap a first non-folding area NFA**1**.

[0101] A display direction of a first image IM**1***a* displayed through a portion of the first display panel DP**1**, for example, the first non-folding area NFA**1**, may be opposite to a display direction of a second image IM**2***a* displayed through the second display panel DP**2**. As an example, the first image IM**1***a* may be displayed to the third direction DR**3**, and the second image IM**2***a* may be displayed to a fourth direction DR**4** opposite to the third direction DR**3**.

[0102] The folding area FA may be folded with respect to a folding axis extending in a direction parallel to long sides of the electronic device **1000**, e.g., a direction parallel to the second direction DR**2**. When the electronic device **1000** is in a folded state, the folding area FA may be folded to have a curvature (e.g., a set or predetermined curvature) and a radius of curvature. The electronic device **1000** may be inwardly folded (inner-folding) such that the first non-folding area NFA**1** may face a second non-folding area NFA**2** and the first display part DA**1**-F is not exposed to the outside.

[0103] According to some embodiments, the electronic device **1000** may be outwardly folded (outer-folding) such that the first display part DA**1**-F may be exposed to the outside. According to some embodiments, the electronic device **1000** may be inwardly folded or outwardly folded from an unfolded state, however, it should not be limited thereto or thereby.

[0104] FIG. **1**A shows the structure in which the electronic device **1000** includes one folding area FA defined therein as a representative example, however, the present disclosure should not be limited thereto or thereby. As an example, the electronic device **1000** may include a plurality of folding axes defined therein and a plurality of folding areas corresponding thereto, and the electronic device **1000** may be inwardly or outwardly folded from an unfolded state in each of the folding areas.

[0105] According to some embodiments, at least one of the first display panel DP**1** or the second display panel DP**2** may sense an input given thereto by the pen PN even though the at least one of the first display panel DP**1** or the second display panel DP**2** does not include a digitizer. Because the digitizer required to sense the input by the pen PN is omitted, an increase in thickness and weight and a decrease in flexibility of the electronic device **1000** due to the addition of the digitizer may be prevented or reduced. Thus, not only the first display panel DP**1** but also the second display panel DP**2** may also be designed to sense the pen PN, because there is no concern of increased thickness and increased weight.

[0106] FIG. **2** is a perspective view of an electronic device **1000-1** according to some embodiments of the present disclosure, and FIG. **3** is a perspective view of an electronic device **1000-2** according to some embodiments of the present disclosure.

[0107] FIG. **2** shows a mobile phone as a representative example of the electronic device **1000-1**, and the electronic device **1000-1** may include a display panel DP. FIG. **3** shows a notebook computer as a representative example of the electronic device **1000-2**, and the electronic device **1000-2** may include a display panel DP. Although FIG. **3** is the perspective view of an electronic device **1000-2**, the coordinate axes included in FIG. **3** are displayed based on the display panel DP within the electronic device **1000-2**.

[0108] The display panel DP may sense external inputs applied thereto from the outside. The external input may be a user input. The user input may include a variety of forms of external inputs, such as a part of user's body, pen (refer to PN of FIG. **1**A), light, heat, or pressure.

[0109] According to some embodiments, even though the display panel DP does not include a digitizer, the display panel DP may sense an input given thereto by the pen PN. Because the digitizer required to sense the input by the pen PN is omitted, an increase in thickness and weight of the electronic device **1000-1** or **1000-2** due to the addition of the digitizer may be prevented or reduced.

[0110] FIG. **1**A shows a foldable-type electronic device **1000**, FIG. **2** shows a bar-type electronic device **1000-1**, however, embodiments according to the present disclosure are not limited thereto or thereby. As an example, the following descriptions may be applied to various electronic devices, such as a rollable type electronic device, a slidable type electronic device, a stretchable type electronic device, etc.

[0111] FIG. **4** is a cross-sectional view of a display panel DP according to some embodiments of the present disclosure.

[0112] Referring to FIG. **4**, the display panel DP may include a display layer **100** and a sensor layer **200**.

[0113] The display layer **100** may have a configuration that substantially generates the image. The display layer **100** may include a display area **100**A and a non-display area **100**NA adjacent to (e.g., in a periphery or outside a footprint of) the display area **100**A, which are defined therein. The image may be displayed through the display area **100**A.

[0114] The display layer **100** may be a light emitting type display layer. For example, the display layer **100** may be an organic light emitting display layer, an inorganic light emitting display layer, an organic-inorganic light emitting display layer, a quantum dot display layer, a micro-LED display layer, or a nano-LED display layer. The display layer **100** may include a base layer **110**, a circuit layer **120**, a light emitting element layer **130**, and an encapsulation layer **140**.

[0115] The base layer **110** may provide a base surface on which the circuit layer **120** is located. The base layer **110** may have a single-layer or multi-layer structure. The base layer **110** may be a glass substrate, a metal substrate, a silicon substrate, or a polymer substrate, however, embodiments according to the present disclosure are not limited thereto.

[0116] The circuit layer **120** may be located on the base layer **110**. The circuit layer **120** may include an insulating layer, a semiconductor pattern, a conductive pattern, and a signal line. An insulating layer, a semiconductor layer, and a conductive layer may be formed on the base layer **110** by a coating or depositing process. Then, the insulating layer, the semiconductor layer, and the conductive layer may be selectively patterned through several photolithography processes.

[0117] The light emitting element layer **130** may be located on the circuit layer **120**. The light emitting element layer **130** may include a light emitting element. For example, the light emitting element layer **130** may include an organic light emitting material, an inorganic light emitting material, an organic-inorganic light emitting material, a quantum dot, a quantum rod, a micro-LED, or a nano-LED.

[0118] The encapsulation layer **140** may be located on the light emitting element layer **130**. The encapsulation layer **140** may protect the light emitting element layer **130** from moisture, oxygen, and foreign substances, such as dust particles.

[0119] The sensor layer **200** may be located on the display layer **100**. The sensor layer **200** may include a sensing area **200**A and a peripheral area **200**NA adjacent to the sensing area **200**A, which are defined therein. The sensing area **200**A may overlap the display area **100**A, and the peripheral area **200**NA may overlap the non-display area **100**NA.

[0120] As shown in FIG. **4**, a boundary BD between the display area **100**A and the non-display area **100**NA may overlap a boundary BD between the sensing area **200**A and the peripheral area **200**NA, however, this is merely an example. As an example, a size of the sensing area **200**A may be greater than a size of the display area **100**A, or the size of the display area **100**A may be greater than the size of the sensing area **200**A.

[0121] The sensor layer **200** may sense an external input applied thereto from the outside. The sensor layer **200** may be an integrated sensor formed continuously in a manufacturing process of the display layer **100**, or the sensor layer **200** may be an external type sensor attached to the display layer **100**. The sensor layer **200** may be referred to as a sensor, an input sensing layer, an input sensing panel, or an input-coordinate sensing electronic device.

[0122] According to some embodiments, the sensor layer **200** may sense inputs from a passive type input such as a part of a user's body and an input device that generates a magnetic field of a resonant frequency (e.g., a set or predetermined resonant frequency). The input device may be referred to as a pen, an input pen, a magnetic pen, a stylus pen, or an electromagnetic resonance pen.

[0123] FIG. **5** is a block diagram illustrating an operation of the electronic device **1000** according to some embodiments of the present disclosure.

[0124] Referring to FIG. **5**, the electronic device **1000** may include a display layer **100**, a sensor layer **200**, a display driver **100**C, a sensor driver **2000**, a main driver **1000**C, and a power circuit **1000**P.

[0125] The sensor layer **200** may sense a first input **2000** or a second input **3000** applied thereto from the outside. Each of the first input **2000** and the second input **3000** may be an input by an input member that causes a variation in capacitance of the sensor layer **200** or an input by an input member that causes an induced current in the sensor layer **200**. As an example, the first input **2000** may be a passive-type input such as a part of a user's body. The second input **3000** may be an input generated by the pen PN or an input by an RFIC tag. As an example, the pen PN may be a passive-type pen or an active-type pen.

[0126] The pen PN may be a device that generates a magnetic field of a resonant frequency (e.g., a set or predetermined resonant frequency). The pen PN may be configured to transmit an output signal based on an electromagnetic resonance method. The pen PN may be referred to as an input device, an input pen, a magnetic pen, a stylus pen, or an electromagnetic resonance pen.

[0127] The pen PN may include an RLC resonant circuit, and the RLC resonant circuit may include an inductor L and a capacitor C. The RLC resonant circuit may be a variable resonant circuit that varies a resonant frequency. In this case, the inductor L may be a variable inductor and/or the capacitor C may be a variable capacitor, however, embodiments according to the present disclosure are not limited thereto or thereby.

[0128] The electronic device **1000** may form a magnetic field. For example, the magnetic field may be formed by the electronic device **1000**, e.g., a coil or current loop included in the sensor layer **200**. The magnetic field may cause the inductor L to generate a current. However, embodiments according to the present disclosure are not limited thereto or thereby. As an example, when the pen PN operates as an active type, the pen PN may generate a current even though the pen PN does not receive a magnetic field from the outside. The generated current may be transmitted to the capacitor C. The capacitor C may be charged with current from the inductor L and may discharge the charged current to the inductor L. Then, the inductor L may emit the magnetic field of the resonant frequency. The induced current may flow through the sensor layer **200** by the magnetic field emitted by the pen PN, and the induced current may be transmitted to the sensor driver **2000** as a reception signal (or a sensing signal, a signal).

[0129] The main driver **1000**C may control an overall operation of the electronic device **1000**. For example, the main driver **1000**C may control an operation of the display driver **100**C and the sensor driver **2000**. The main driver **1000**C may include at least one microprocessor and may further include a graphics controller. The main driver **1000**C may be referred to as an application processor, a central processing unit, or a main processor.

[0130] The display driver **1000** may drive the display layer **100**. The display driver **100**C may receive image data and a control signal from the main driver **1000**C. The control signal may include a variety of signals. As an example, the control signal may include an input vertical synchronization signal, an input horizontal synchronization signal, a main clock, a data enable signal, or the like.

[0131] The sensor driver **2000** may drive the sensor layer **200**. The sensor driver **2000** may receive a control signal from the main driver **1000**C. The control signal may include a clock signal of the sensor driver **2000**. In addition, the control signal may further include a mode determination signal that determines a driving mode of the sensor driver **2000** and the sensor layer **200**.

[0132] The sensor driver **2000** may be implemented by an integrated circuit (IC) and may be electrically connected to the sensor layer **200**. As an example, the sensor driver **2000** may be directly mounted on an area (e.g., a set or predetermined area) of the display panel or may be electrically connected to the sensor layer **200** after being mounted on a separated printed circuit board in a chip-on-film (COF) manner.

[0133] The sensor driver **2000** and the sensor layer **200** may be selectively operated in a first mode or a second mode. As an example, the first mode may be a mode in which a touch input, e.g., the first input **2000**, is sensed. The second mode may be a mode in which the input generated by the pen PN, e.g., the second input **3000**, is sensed. The first mode may be referred to as a touch sensing mode, and the second mode may be referred to as a pen sensing mode.

[0134] The first mode and the second mode may be switched in a variety of ways. As an example, the sensor driver **2000** and the sensor layer **200** may operate as a time-sharing scheme in the first mode and the second mode and may sense the first input **2000** and the second input **3000**. In addition, a transition between the first mode and the second mode may occur by a user's selection or a user's specific action (or input), or one of the first mode and the second mode may be activated or deactivated or one of the first mode and the second mode may be switched to the other by activating or deactivating a specific application. When the first input **2000** is sensed while the sensor driver **2000** and the sensor layer **200** are alternately operated in the first mode and the second mode, the first mode may be maintained, and when the second input **3000** is sensed while the sensor driver **2000** and the sensor layer **200** are alternately operated in the first mode and the second mode, the second mode may be maintained.

[0135] The sensor driver **2000** may calculate input coordinate information based on the signal applied thereto from the sensor layer **200** and may provide a coordinate signal with the input coordinate information to the main driver **1000**C. The main driver **1000**C may operate an operation corresponding to the user's input based on the coordinate signal. For instance, the main driver **1000**C may drive the display driver **100**C so that a new application image is displayed through the display layer **100**.

[0136] The power circuit **1000**P may include a power management integrated circuit (PMIC). The power circuit **1000**P may generate a plurality of driving voltages to drive the display layer **100**, the sensor layer **200**, the display driver **100**C, and the sensor driver **2000**. As an example, the driving voltages may include a gate high voltage, a gate low voltage, a first driving voltage (e.g., an ELVSS voltage), a second driving voltage (e.g., an ELVDD voltage), an initialization voltage, etc., however, the present disclosure should not be particularly limited.

[0137] FIG. **6**A is a cross-sectional view of the display panel DP according to some embodiments of the present disclosure.

[0138] Referring to FIG. **6**A, at least one buffer layer BFL may be formed on an upper surface of the base layer **110**. The buffer layer BFL may increase an adhesive force between the base layer **110** and the semiconductor pattern. The buffer layer BFL may be formed in multiple layers. The display layer **100** may further include a barrier layer. The buffer layer BFL may include at least one of silicon oxide, silicon nitride, or silicon oxynitride. For example, the buffer layer BFL may have a stack structure in which a silicon oxide layer and a silicon nitride layer are alternately stacked with each other.
[0139] The semiconductor pattern SC, AL, DR, and SCL may be located on the buffer layer BFL. The semiconductor pattern SC, AL, DR, and SCL may include polysilicon, however, it should not be limited thereto or thereby. The semiconductor pattern SC, AL, DR, and SCL may include amorphous silicon, low temperature polycrystalline silicon, or oxide semiconductor.
[0140] FIG. **6**A shows only a portion of the semiconductor pattern SC, AL, DR, and SCL, and the semiconductor pattern SC, AL, DR, and SCL may be further located in other areas. The semiconductor pattern SC, AL, DR, and SCL may be arranged with a specific rule over pixels. The semiconductor pattern SC, AL, DR, and SCL may have different electrical properties depending on whether it is doped or not. The semiconductor pattern SC, AL, DR, and SCL may include a first region SC, DR, and SCL having a relatively high conductivity and a second region AL having a relatively low conductivity. The first region SC, DR, and SCL may be doped with an N-type dopant or a P-type dopant. A P-type transistor may include a doped region doped with the P-type dopant, and an N-type transistor may include a doped region doped with the N-type dopant. The second region AL may be a non-doped region or a region doped at a concentration lower than that of the first region SC, DR, and SCL.
[0141] The first region SC, DR, and SCL may have a conductivity greater than that of the second region AL and may substantially serve as an electrode or signal line. The second region AL may substantially correspond to an active area AL (or a channel) of a transistor **100**PC. In other words, a portion AL of the semiconductor pattern SC, AL, DR, and SCL may be the active area AL of the transistor **100**PC, another portion SC or DR of the semiconductor pattern SC, AL, DR, and SCL may be a source area SC or a drain area DR of the transistor **100**PC, and the other portion SCL of the semiconductor pattern SC, AL, DR, and SCL may be a connection electrode or a connection signal line SCL.
[0142] Each of the pixels may have an equivalent circuit that includes a plurality of transistors, at least one capacitor, and at least one light emitting element, and the equivalent circuit may be changed in various ways. FIG. **6**A shows a structure in which one transistor **100**PC and one light emitting element **100**PE are included in the pixel as a representative example.
[0143] The source area SC, the active area AL, and the drain area DR of the transistor **100**PC may be formed from the semiconductor pattern SC, AL, DR, and SCL. The source area SC and the drain area DR may extend in opposite directions to each other from the active area AL in a cross-section. FIG. **6**A shows a portion of the connection signal line SCL formed from the semiconductor pattern SC, AL, DR, and SCL. According to some embodiments, the connection signal line SCL may be connected to the drain area DR of the transistor **100**PC in a plane.
[0144] A first insulating layer **10** may be located on the buffer layer BFL. The first insulating layer **10** may commonly overlap the pixels and may cover the semiconductor pattern SC, AL, DR, and SCL. The first insulating layer **10** may be an inorganic layer and/or an organic layer and may have a single-layer or multi-layer structure. The first insulating layer **10** may include at least one of aluminum oxide, titanium oxide, silicon oxide, silicon nitride, silicon oxynitride, zirconium oxide, or hafnium oxide. According to some embodiments, the first insulating layer **10** may have a single-layer structure of a silicon oxide layer. Not only the first insulating layer **10**, but also an insulating layer of the circuit layer **120** described later may be an inorganic layer and/or an organic layer and may have a single-layer or multi-layer structure. The inorganic layer may include at least one of the above-mentioned materials, however, embodiments according to the present disclosure are not

limited thereto or thereby.

[0145] A gate GT of the transistor **100**PC may be located on the first insulating layer **10**. The gate GT may be a portion of a metal pattern. The gate GT may overlap the active area AL. The gate GT may be used as a mask in a process of doping the semiconductor pattern SC, AL, DR, and SCL.

[0146] A second insulating layer **20** may be located on the first insulating layer **10** and may cover the gate GT. The second insulating layer **20** may commonly overlap the pixels. The second insulating layer **20** may be an inorganic layer and/or an organic layer and may have a single-layer or multi-layer structure. The second insulating layer **20** may include at least one of silicon oxide, silicon nitride, or silicon oxynitride. According to some embodiments, the second insulating layer **20** may have a multi-layer structure of a silicon oxide layer and a silicon nitride layer.

[0147] A third insulating layer **30** may be located on the second insulating layer **20**. The third insulating layer **30** may have a single-layer or multi-layer structure. As an example, the third insulating layer **30** may have a multi-layer structure of a silicon oxide layer and a silicon nitride layer.

[0148] A first connection electrode CNE**1** may be located on the third insulating layer **30**. The first connection electrode CNE**1** may be connected to the connection signal line SCL through a contact hole CNT-**1** defined through the first, second, and third insulating layers **10**, **20**, and **30**.

[0149] A fourth insulating layer **40** may be located on the third insulating layer **30**. The fourth insulating layer **40** may have a single-layer structure of a silicon oxide layer. A fifth insulating layer **50** may be located on the fourth insulating layer **40**. The fifth insulating layer **50** may be an organic layer.

[0150] A second connection electrode CNE**2** may be located on the fifth insulating layer **50**. The second connection electrode CNE**2** may be connected to the first connection electrode CNE**1** through a contact hole CNT-**2** defined through the fourth insulating layer **40** and the fifth insulating layer **50**.

[0151] A sixth insulating layer **60** may be located on the fifth insulating layer **50** and may cover the second connection electrode CNE**2**. The sixth insulating layer **60** may be an organic layer.

[0152] The light emitting element layer **130** may be located on the circuit layer **120**. The light emitting element layer **130** may include the light emitting element **100**PE. As an example, the light emitting element layer **130** may include an organic light emitting material, an inorganic light emitting material, an organic-inorganic light emitting material, a quantum dot, a quantum rod, a micro-LED, or a nano-LED. Hereinafter, the organic light emitting element will be described as the light emitting element **100**PE, however, it should not be particularly limited.

[0153] The light emitting element **100**PE may include a first electrode AE, a light emitting layer EL, and a second electrode CE.

[0154] The first electrode AE may be located on the sixth insulating layer **60**. The first electrode AE may be connected to the second connection electrode CNE**2** through a contact hole CNT-**3** defined through the sixth insulating layer **60**.

[0155] A pixel definition layer **70** may be located on the sixth insulating layer **60** and may cover a portion of the first electrode AE. An opening **70**-OP may be defined through the pixel definition layer **70**. At least a portion of the first electrode AE may be exposed through the opening **70**-OP of the pixel definition layer **70**.

[0156] The first display part DA**1**-F (refer to FIG. **1**A) may include a light emitting area PXA and a non-light-emitting area NPXA adjacent to the light emitting area PXA. The non-light-emitting area NPXA may surround the light emitting area PXA. According to some embodiments, the light emitting area PXA may be defined to correspond to the portion of the first electrode AE exposed through the opening **70**-OP.

[0157] The light emitting layer EL may be located on the first electrode AE. The light emitting layer EL may be located in an area corresponding to the opening **70**-OP. FIG. **6**A shows a structure in which the light emitting layer EL is located in the opening **70**-OP as a representative example, however, embodiments according to the present disclosure are not particularly limited thereto. As an example, the light emitting layer EL may extend to cover a side surface of the pixel definition layer **70**, which defines the opening **70**-OP, and a portion of an upper surface of the pixel definition layer **70**.

[0158] The light emitting layer EL may be formed in each of the pixels after being divided into plural portions. When the light emitting layer EL is formed in each of the pixels after being divided into plural portions, each of the light emitting layers EL may emit a light having at least one of blue, red, or green colors, however, embodiments according to the present disclosure are not limited thereto or thereby. The light emitting layer EL may be integrally formed and may be commonly provided to the pixels. In this case, the light emitting layer EL may provide a blue light or a white light.

[0159] The second electrode CE may be located on the light emitting layer EL. The second electrode CE may have an integral shape and may be commonly arranged over the pixels.

[0160] According to some embodiments, a hole control layer may be located between the first electrode AE and the light emitting layer EL. The hole control layer may be commonly arranged in the light emitting area PXA and the non-light-emitting area NPXA. The hole control layer may include a hole transport layer and may further include a hole injection layer. An electron control layer may be located between the light emitting layer EL and the second electrode CE. The electron control layer may include an electron transport layer and may further include an electron injection layer. Each of the hole control layer and the electron control layer may be commonly formed in the plural pixels using an open mask or an inkjet process.

[0161] The encapsulation layer **140** may be located on the light emitting element layer **130**. The encapsulation layer **140** may include an inorganic layer, an organic layer, and an inorganic layer, which are sequentially stacked one on another, however, the layers of the encapsulation layer **140** should not be limited thereto or thereby. The inorganic layers may protect the light emitting element layer **130** from moisture and oxygen, and the organic layer may protect the light emitting element layer **130** from a foreign substance such as dust particles. The inorganic layers may include a silicon nitride layer, a silicon oxynitride layer, a silicon oxide layer, a titanium oxide layer, or an aluminum oxide layer. The organic layer may include an acrylic-based organic layer, however, it should not be limited thereto or thereby.

[0162] The sensor layer **200** may include a base layer **201**, a first conductive layer **202**, an intermediate insulating layer **203**, a second conductive layer **204**, and a cover insulating layer **205**.

[0163] The base layer **201** may be an inorganic layer including at least one of silicon nitride, silicon oxynitride, or silicon oxide. As another way, the base layer **201** may be an organic layer including an epoxy-based resin, an acrylic-based resin, or an imide-based resin. The base layer **201** may have a single-layer structure or a multi-layer structure of layers stacked in the third direction DR**3**. According to some embodiments, the sensor layer **200** may not include the base layer **201**.

[0164] Each of the first conductive layer **202** and the second conductive layer **204** may have a single-layer structure or a multi-layer structure of layers stacked in the third direction DR**3**.

[0165] Each of the first and second conductive layers **202** and **204** having the single-layer structure may include a metal layer or a transparent conductive layer. The metal layer may include molybdenum, silver, titanium, copper, aluminum, or alloys thereof. The transparent conductive layer may include a transparent conductive oxide, such as indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), indium zinc tin oxide (ITZO), or the like. In addition, the transparent conductive layer may include conductive polymer such as poly(3,4-ethylenedioxythiophene) (PEDOT), metal nanowire, graphene, or the like.

[0166] Each of the first and second conductive layers **202** and **204** having the multi-layer structure may include metal layers. The metal layers may have a three-layer structure of titanium/aluminum/titanium. The conductive layer having the multi-layer structure may include at least one metal layer and at least one transparent conductive layer.

[0167] The first conductive layer **202** may have a thickness equal to or greater than a thickness of the second conductive layer **204**. When the thickness of the first conductive layer **202** is greater than the thickness of the second conductive layer **204**, a resistance of components, e.g., an electrode, a sensing pattern, or a bridge pattern, included in the first conductive layer **202** may be reduced. In addition, because the first conductive layer **202** is located at a position lower than the second conductive layer **204**, a probability that the components included in the first conductive layer is recognized due to a reflection of external light may be lower than a probability that components included in the second conductive layer **204** is recognized even though the thickness of the first conductive layer **202** increases.
[0168] At least one of the intermediate insulating layer **203** or the cover insulating layer **205** may include an inorganic layer. The inorganic layer may include at least one of aluminum oxide, titanium oxide, silicon oxide, silicon nitride, silicon oxynitride, zirconium oxide, or hafnium oxide.
[0169] At least one of the intermediate insulating layer **203** or the cover insulating layer **205** may include an organic layer. The organic layer may include at least one of an acrylic-based resin, a methacrylic-based resin, a polyisoprene-based resin, a vinyl-based resin, an epoxy-based resin, a urethane-based resin, a cellulose-based resin, a siloxane-based resin, a polyimide-based resin, a polyamide-based resin, or a perylene-based resin.
[0170] In the above descriptions, it is explained that the sensor layer **200** includes the first conductive layer **202** and the second conductive layer **204**, that is, a total of two conductive layers, however, the present disclosure should not be limited thereto or thereby. As an example, the sensor layer **200** may include three or more conductive layers.
[0171] FIG. **6**B is a cross-sectional view of the sensor layer **200** according to some embodiments of the present disclosure.
[0172] Referring to FIGS. **6**A and **6**B, a second mesh line MS**2** included in the second conductive layer **204** may have a second width **204***wt* that is equal to or greater than a first width **202***wt* of a first mesh line MS**1** included in the first conductive layer **202**. When a user USR is looking at the first mesh line MS**1** and the second mesh line MS**2** from a side of the sensor layer **200**, a probability that the user USR recognizes the first mesh line MS**1** may be reduced because the width of the first mesh line MS**1** is smaller than that of the second mesh line MS**2**.
[0173] Each of the first mesh line MS**1** and the second mesh line MS**2** may include first metal layers M**1** and a second metal layer M**2** located between the first metal layers M**1**. As an example, the first metal layers M**1** may include titanium (Ti), and the second metal layer M**2** may include aluminum (AI), however, this is merely an example.
[0174] According to some embodiments, a first thickness TK**1** of the second metal layer M**2** of the first mesh line MS**1** and a second thickness TK**2** of the second metal layer M**2** of the second mesh line MS**2** may be substantially the same as each other, however, the present disclosure should not be particularly limited. As an example, the first thickness TK**1** may be greater than the second thickness TK**2**, or the second thickness TK**2** may be greater than the first thickness TK**1**. Because the first mesh line MS**1** is located at a position lower than the second mesh line MS**2**, a probability that the first mesh line MS**1** is recognized due to the reflection of external light may be lower than a probability that the second mesh line MS**2** is recognized due to the reflection of external light even though the thickness of the first mesh line MS**1** increases. According to some embodiments, each of the first thickness TK**1** and the second thickness TK**2** may be about 1000 angstroms or more, e.g., about 6000 angstroms.
[0175] FIG. **7**A is a plan view of the display panel DP according to some embodiments of the present disclosure.
[0176] Referring to FIG. **7**A, the display panel DP may include a first area AA**1**, a bending area BA, and a second area AA**2**. The bending area BA may be defined between the first area AA**1** and the second area AA**2** spaced apart from the first area AA**1** in the second direction DR**2**. A width (or a length) in the first direction DR**1** of the bending area BA and a width (or a length) in the first

direction DR**1** of the second area AA**2** may be smaller than a width (or a length) in the first direction DR**1** of the first area AA**1**. An area having a relatively short length in a bending axis direction may be relatively easily bent.

[0177] FIG. **7**A is a plan view showing the unfolded state of the display panel DP before the display panel DP is assembled with other components, that is, before the display panel DP is modularized. A portion of the display panel DP may be bent to be modularized. As an example, the bending area BA may be bent to allow the second area AA**2** to be located under the first area AA**1**.

[0178] The display panel DP may include the sensor layer **200**. The sensor layer **200** may include the sensing area **200**A and the peripheral area **200**NA adjacent to the sensing area **200**A, which are defined therein.

[0179] The first area AA**1** may overlap the sensing area **200**A and a portion of the peripheral area **200**NA. The bending area BA and the second area AA**2** may overlap the other portion of the peripheral area **200**NA.

[0180] The sensor layer **200** may include a plurality of first electrodes **210**, a plurality of second electrodes **220**, a plurality of third electrodes **230**, and a plurality of fourth electrodes **240**, which are arranged in the first area AA**1** and sensing area **200**A.

[0181] Each of the first electrodes **210** may intersect the second electrodes **220**. Each of the first electrodes **210** may extend in the second direction DR**2**, and the first electrodes **210** may be arranged spaced apart from each other in the first direction DR**1**. Each of the second electrodes **220** may extend in the first direction DR**1**, and the second electrodes **220** may be arranged spaced apart from each other in the second direction DR**2**. A sensing unit SU of the sensor layer **200** may be an area where one first electrode **210** intersect one second electrode **220**.

[0182] FIG. **7**A shows six first electrodes **210**, eight second electrodes **220**, and forty-eight sensing units SU as a representative example, however, the number of the first electrodes **210** and the number of the second electrodes **220** should not be limited thereto or thereby. According to some embodiments, a width in the first direction DR**1** of the sensing area **200**A may be equal to or smaller than a width in the second direction DR**2** of the sensing area **200**A. Accordingly, the number of the first electrodes **210** arranged in the first direction DR**1** may be smaller than the number of the second electrodes **220** arranged in the second direction DR**2**.

[0183] The third electrodes **230** may extend in the second direction DR**2**, and the third electrodes **230** may be arranged spaced apart from each other in the first direction DR**1**. One third electrode **230** may overlap one first electrode **210**. As an example, one third electrode **230** may overlap at least a portion of the first electrode **210**. In the present disclosure, the expression “Component A overlaps component B.” means that a portion of component A overlaps a portion of component B, an entire portion of component A overlaps a portion of component B, an entire portion of component B overlaps a portion of component A, or an entire portion of component A overlaps an entire portion of component B.

[0184] According to some embodiments, a capacitance (or a coupling capacitance) between one first electrode **210** and one third electrode **230** may be controlled by adjusting the overlap area between the one first electrode **210** and the one third electrode **230**.

[0185] The fourth electrodes **240** may be arranged in the second direction DR**2**, and the fourth electrodes **240** may extend in the first direction DR**1**. One fourth electrode **240** may overlap at least a portion of one second electrode **220**. According to some embodiments, a capacitance (or a coupling capacitance) between the one second electrode **220** and the one fourth electrode **240** may be controlled by adjusting the overlap area between the one second electrode **220** and the one fourth electrode **240**. The fourth electrodes **240** may be referred to as sensing auxiliary electrodes or second auxiliary electrodes.

[0186] At least some electrodes of the fourth electrodes **240** may be electrically connected to each other to form one electrode group. As an example, FIG. **7**A shows a structure in which four fourth electrodes **240** are connected to the same trace line, for example, an auxiliary trace line **240***t*, to form one electrode group as a representative example. Accordingly, FIG. **7**A shows a structure in which two electrode groups are arranged in the second direction DR**2**. However, the number of the fourth electrodes **240** that form one electrode group should not be limited thereto or thereby. As an example, the number of the fourth electrodes **240** that form one electrode group may be eight, and in this case, the sensor layer **200** may include one electrode group.

[0187] The sensor layer **200** may further include a plurality of first trace lines **210***t* and a plurality of second trace lines **220***t*, which are arranged in the peripheral area **200**NA. The first trace lines **210***t* and the second trace lines **220***t* may be arranged to overlap the non-display area **100**NA of the display layer **100** (refer to FIG. **4**). The first trace lines **210***t* may be electrically connected to the first electrodes **210** in a one-to-one correspondence. The second trace lines **220***t* may be electrically connected to the second electrodes **220** in a one-to-one correspondence.

[0188] The first trace lines **210***t* and the second trace lines **220***t* may serve as a portion of the sensing electrode, e.g., a portion of the first electrode **210** or a portion of the second electrode **220**, during a mode in which the pen PN (refer to FIG. **5**) is sensed. Accordingly, the first trace lines **210***t* and the second trace lines **220***t* may be arranged in the peripheral area **200**NA. As a result, deformation of the first electrodes **210** and the second electrodes **220** may be reduced, and thus, a coordinate distortion when the pen PN is sensed may be reduced.

[0189] The sensor layer **200** may further include a plurality of first auxiliary trace lines **230***rt***1**, a second auxiliary trace line **230***rt***2**, and a plurality of auxiliary trace lines **240***t*.

[0190] At least one of the third electrodes **230**, at least one of the first auxiliary trace lines **230***rt***1**, or the second auxiliary trace line **230***rt***2** may form one loop. A magnetic field may be formed due to a current path defined by the one loop. An external input device, e.g., the pen, may be charged with the magnetic field. Accordingly, the first auxiliary trace lines **230***rt***1** may be referred to as first loop trace lines, and the second auxiliary trace line **230***rt***2** may be referred to as a second loop trace line. The third electrodes **230** may be referred to as charging electrodes, loop electrodes, or first auxiliary electrodes.

[0191] The first auxiliary trace lines **230***rt***1** may be connected to the third electrodes **230** in a one-to-one correspondence. That is, the number of the first auxiliary trace lines **230***rt***1** may correspond to the number of the third electrodes **230**. FIG. **7**A shows six first auxiliary trace lines **230***rt***1** and six third electrodes **230** as a representative example.

[0192] According to some embodiments, one first auxiliary trace line may be electrically connected to plural third electrodes. The plural third electrodes connected to the one first auxiliary trace line may be referred to as one electrode group. As the number of the third electrodes included in one electrode group and connected to each other in parallel increases, a resistance of the one electrode group may decrease. Accordingly, a power efficiency may be relatively improved, and a sensing sensitivity may be relatively improved. On the contrary, as the number of the third electrodes included in one electrode group decreases, a coil pattern formed using one electrode group may be implemented in more diverse forms.

[0193] The second auxiliary trace line **230***rt***2** may be electrically connected to the third electrodes **230**. The second auxiliary trace line **230***rt***2** may be electrically connected to all the third electrodes **230**.

[0194] The second auxiliary trace line **230***rt***2** may include a first line portion **231***t* extending in the first direction DR**1** and electrically connected to the third electrodes **230**, a second line portion **232***t* extending from a first end of the first line portion **231***t* in a direction parallel to the second direction DR**2**, and a third line portion **233***t* extending from a second end of the first line portion **231***t* to the direction parallel to the second direction DR**2**.

[0195] According to the present disclosure, each of a resistance of the second line portion **232***t* and a resistance of the third line portion **233***t* may be substantially the same as a resistance of one third electrode among the third electrodes **230**. A width in the first direction DR**1** of each of the second line portion **232***t* and the third line portion **233***t* may be adjusted to relatively improve the resistance of the second line portion **232***t* and the resistance of the third line portion **233***t*. However, this is merely an example, and the first, second, and third line portions **231***t*, **232***t*, and **233***t* may have substantially the same width as each other.

[0196] The second auxiliary trace line **230***rt***2** may be provided in a shape surrounding areas in which the first trace lines **210***t*, the second trace lines **220***t*, the auxiliary trace line **240***t*, and the first auxiliary trace lines **230***rt***1** are arranged. The second line portion **232***t* and the third line portion **233***t* may act as the third electrodes **230**, and thus, the same effect as if the third electrodes **230** are located in the peripheral area **200**NA may be achieved with the second line portion **232***t* and the third line portion **233***t*. As an example, one of the second line portion **232***t* and the third line portion **233***t* and one of the third electrodes **230** may form a coil. Therefore, the pen placed at an area adjacent to the peripheral area **200**NA may be sufficiently charged by a current loop that includes the second line portion **232***t* or the third line portion **233***t*.

[0197] The auxiliary trace lines **240***t* may be spaced apart from each other with the sensing area **200**A interposed therebetween. FIG. **7**A shows the structure in which two electrode groups are arranged as a representative example. The auxiliary trace line **240***t* connected to four fourth electrodes **240** located at an upper side and the auxiliary trace line **240***t* connected to four fourth electrodes **240** located at a lower side may be spaced apart from each other with the sensing area **200**A interposed therebetween, however, the present disclosure should not be particularly limited.

[0198] Each of the auxiliary trace lines **240***t* may include a first portion **240***t***1**, a second portion **240***t***2**, and a third portion **240***t***3**. The first portion **240***t***1** may extend from at least one of the fourth electrodes **240** and may be located in the peripheral area **200**NA. The second portion **240***t***2** may extend from the first portion **240***t***1** and may be located in the sensing area **200**A. The third portion **240***t***3** may extend from the second portion **240***t***2** and may be located in the peripheral area **200**NA. Referring to FIG. **4**, the second portion **240***t***2** may overlap the display area **100**A, and the first portion **240***t***1** and the third portion **240***t***3** may overlap the non-display area **100**NA.

[0199] At least a portion of a first auxiliary trace line **230***rt***1***a* (hereinafter, referred to as a first-first auxiliary trace line) among the first auxiliary trace lines **230***rt***1** may be located in the sensing area **200**A. That is, the portion of the first-first auxiliary trace line **230***rt***1***a* may overlap the display area **100**A.

[0200] The third electrodes **230** and the fourth electrodes **240** may be floated when the pen PN is sensed. Accordingly, even though a portion of the first-first auxiliary trace line **230***rt***1***a* connected to the third electrodes **230** and a portion of each of the auxiliary trace lines **240***t* connected to the fourth electrodes **240** are located in the sensing area **200**A, changes in shape, resistance, or routing location of the first-first auxiliary trace line **230***rt***1***a* and the auxiliary trace lines **240***t* may have little to no effect on the sensing operation for the pen.

[0201] Among the trace lines located in an area, e.g., an area between the sensing area **200**A and the bending area BA, where the trace lines are intensively arranged in the peripheral area **200**NA, at least a portion of some trace lines may be located in the sensing area **200**A. Therefore, a size of the area where the trace lines are arranged in the peripheral area **200**NA may be reduced, and a size of an area where the trace lines are not arranged (hereinafter referred to as an unused area) in the peripheral area **200**NA may increase.

[0202] According to some embodiments, the area occupied by the peripheral area **200**NA in a total area of the display panel DP may be reduced by removing (for example, by cutting) the unused area, and thus, a narrow bezel may be implemented. According to some embodiments, a line width may be adjusted to relatively improve the resistance of each of the first trace lines **210***t* or the second trace lines **220***t* by utilizing the unused area. As an example, the resistance may be reduced by increasing the line width of the first trace lines **210***t* or the second trace lines **220***t*. In this case, the sensing sensitivity of the sensor layer **200** may be relatively improved.

[0203] The sensor layer **200** may further include a plurality of guard lines **200***tg* located in the peripheral area **200**NA. Each of the guard lines **200***tg* may be grounded, may be floated, or may receive a signal (e.g., a set or predetermined signal) depending on the operation mode of the sensor layer **200**. As an example, when the sensor layer **200** operates in a mutual capacitance detection mode or a pen sensing driving mode, the guard lines **200***tg* may be grounded. When the sensor layer **200** operates in a self-capacitance detection mode, the guard lines **200***tg* may receive the same signal as a signal applied to the trace lines adjacent thereto. Accordingly, a parasitic capacitance formed between the trace lines may be reduced or prevented by the guard lines **200***tg*. When the sensor layer **200** operates in a pen charging driving mode, the guard lines **200***tg* may be floated.

[0204] The sensor layer **200** may further include a plurality of pads PD located in the second area AA**2**. FIG. **7**A shows a structure in which the pads PD are arranged in one row along the first direction DR**1** as a representative example, however, the present disclosure should not be limited thereto or thereby. As an example, the pads PD may be arranged in multiple rows. The pads PD may be electrically connected to both ends of the first trace lines **210***t*, the second trace lines **220***t*, the first auxiliary trace lines **230***rt***1**, and the second auxiliary trace line **230***rt***2**, the auxiliary trace lines **240***t*, and the guard lines **200***tg* in a one-to-one correspondence.

[0205] FIG. **7**B is a plan view of a display panel DPa according to some embodiments of the present disclosure. In FIG. **7**B, the same reference numerals denote the same elements in FIG. **7**A, and thus, detailed descriptions of the same elements will be omitted.

[0206] Referring to FIGS. **4** and **7**B, the display panel DPa may include a sensor layer **200-1**. The sensor layer **200-1** may include a sensing area **200**A-**1** and a peripheral area **200**NA-**1** adjacent to the sensing area **200**A-**1**. A width in the first direction DR**1** of the sensing area **200**A-**1** may be greater than a width in the second direction DR**2** of the sensing area **200**A-**1**. Accordingly, the number of first electrodes **210** arranged in the first direction DR**1** may be greater than the number of second electrodes **220** arranged in the second direction DR**2**.

[0207] A base layer **110** of the display panel DPa may be a rigid glass substrate. Therefore, different from the display panel DP described with reference to FIG. **7**A, the display panel DPa may not include a bending area, however, this is merely an example.

[0208] According to some embodiments, among trace lines located in an area where the trace lines are intensively arranged in the peripheral area **200**NA-**1**, e.g., an area between the sensing area **200**A-**1** and an area in which pads PD are located, at least a portion of some trace lines may be located in the sensing area **200**A-**1**. Therefore, a size of the area where the trace lines are arranged in the peripheral area **200**NA-**1** may be reduced, and a size of an area where the trace lines are not arranged (hereinafter referred to as an unused area) in the peripheral area **200**NA-**1** may increase.

[0209] According to some embodiments, the area occupied by the peripheral area **200**NA-**1** in a total area of the display panel DPa may be reduced by removing (for example, by cutting) the unused area, and thus, a narrow bezel may be implemented. According to some embodiments, a line width may be adjusted to relatively improve the resistance of each of first trace lines **210***t* or second trace lines **220***t* by utilizing the unused area. In this case, the sensing sensitivity of the sensor layer **200-1** may be relatively improved.

[0210] FIG. **8**A is a plan view of a first conductive layer **202**SU-C of a sensing unit (refer to SU of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **8**B is a plan view of a second conductive layer **204**SU-C of the sensing unit (refer to SU of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **9** is a cross-sectional view of the sensor layer **200** taken along a line I-I′ of FIG. **8**A and a line I-I′ of FIG. **8**B according to some embodiments of the present disclosure.

[0211] FIGS. **8**A and **8**B show a shape of the first conductive layer **202**SU-C and a shape of the second conductive layer **204**SU-C of one sensing unit SU that is not adjacent to the boundary BD (refer to FIG. **7**A) and is spaced apart from the boundary BD as a representative example. However, this is merely an example, and the shapes of the first conductive layer **202**SU-C and the second conductive layer **204**SU-C should not be limited thereto or thereby.

[0212] Referring to FIGS. **8**A, **8**B, and **9**, the first electrode **210** may include first sensing patterns

210-*sp* and a first bridge pattern **210**-*bp*. The first sensing patterns **210**-*sp* and the first bridge pattern **210**-*bp* may be electrically connected to each other through a first contact CNa. The second electrode **220** may be located on the same layer as the first sensing patterns **210**-*sp*. As an example, the first sensing patterns **210**-*sp* may be spaced apart from each other with the second electrode **220** interposed therebetween. The first bridge pattern **210**-*bp* may be located on a different layer from the second electrode **220** and may be insulated from the second electrode **220** while intersecting the second electrode **220**.

[0213] The third electrode **230** may be located on the same layer as the first bridge pattern **210**-*bp*. The third electrode **230** may be provided with an opening defined therethrough to surround the first bridge pattern **210**-*bp*. The third electrode **230** may overlap the first sensing patterns **210**-*sp*. Accordingly, a coupling capacitor may be defined between the first electrode **210** and the third electrode **230**.

[0214] The fourth electrode **240** may include second sensing patterns **240**-*sp* and a second bridge pattern **240**-*bp*. The second sensing patterns **240**-*sp* and the second bridge pattern **240**-*bp* may be electrically connected to each other through a second contact CNb. The third electrode **230** may be located on the same layer as the second sensing patterns **240**-*sp*. As an example, the second sensing patterns **240**-*sp* may be spaced apart from each other with the third electrode **230** interposed therebetween. The second bridge pattern **240**-*bp* may be located on a different layer from the third electrode **230** and may be insulated from the third electrode **230** while intersecting the third electrode **230**.

[0215] The first conductive layer **202**SU-C may include the first bridge pattern **210**-*bp*, the third electrode **230**, and the second sensing patterns **240**-*sp*. The second conductive layer **204**SU-C may include the first sensing patterns **210**-*sp*, the second electrode **220**, and the second bridge pattern **240**-*bp*.

[0216] The first conductive layer **202**SU-C may further include dummy patterns DMP. Because the dummy patterns DMP are arranged in a vacant space, the probability of certain patterns being recognized due to the reflection of the external light may be reduced. That is, a visibility of the electronic device **1000** (refer to FIG. **1**A) may be relatively improved. Each of the dummy patterns DMP may be electrically floated or electrically grounded. According to some embodiments, the dummy patterns DMP may be omitted.

[0217] Referring to FIGS. **8**A and **8**B, in the second conductive layer **204**SU-C within one sensing unit SU, an area occupied by the components included in the first electrode **210** and the second electrode **220** may be larger than an area occupied by the components included in the third electrode **230** and the fourth electrode **240**. The variation in capacitance due to the first input **2000** (refer to FIG. **5**) may become larger as a distance decreases. Accordingly, components to detect the first input **2000** (refer to FIG. **5**) may be arranged in a layer closer to a surface of the electronic device **1000** (refer to FIG. **1**A) while occupying a relatively larger area. As a result, a touch sensing performance may be relatively improved.

[0218] FIGS. **6**A to **9** show the structure in which the first, second, third, and fourth electrodes **210**, **220**, **230**, and **240** is arranged in two conductive layers **202**SU-C and **204**SU-C as a representative example, however, the present disclosure should not be limited thereto or thereby. As an example, the first, second, third, and fourth electrodes **210**, **220**, **230**, and **240** may be arranged in three conductive layers or four conductive layers.

[0219] According to some embodiments, the third electrode **230** to which a signal is applied in a charging driving mode may be included in a third conductive layer located under the first and second conductive layers **202**SU-C and **204**SU-C. As an example, the third conductive layer may be located under the base layer **201**. The third conductive layer may be located between the base layer **201** and the display layer **100**, may be located under the display layer **100**, or may be included in the display layer **100**.

[0220] The first, second, and fourth electrodes **210**, **220**, and **240** may be included in the first and second conductive layers **202**SU-C and **204**SU-C. As an example, when the third electrode **230** is implemented as a separate conductive layer as the third conductive layer, the shape of the third electrode **230** may be designed in various ways. As an example, the third electrode **230** may be provided to include a plurality of coils. In addition, the third electrode **230** may be provided more densely by using the third conductive layer, and in this case, a sensitivity to sense the pen may be relatively improved. According to some embodiments, the third conductive layer may include the fourth electrode **240** instead of the third electrode **230**.

[0221] FIG. **10**A is an enlarged plan view of an area AA′ of FIG. **8**A, and FIG. **10**B is an enlarged plan view of an area BB′ of FIG. **8**B.

[0222] Referring to FIGS. **8**A, **8**B, **10**A, and **101**B, each of the first electrodes **210**, the second electrodes **220**, the third electrodes **230**, the fourth electrodes **240**, and the dummy patterns DMP may have a mesh structure. The mesh structure may include a plurality of mesh lines. The mesh lines may have a shape extending in a direction (e.g., a set or predetermined direction) and may be connected to each other. The shape of the mesh lines may have various shapes, such as a straight line, a line with protrusions, and an uneven line. Openings in which the mesh structure is not located may be defined (provided or formed) in each of the first electrodes **210**, the second electrodes **220**, the third electrodes **230**, the fourth electrodes **240**, and the dummy patterns DMP.

[0223] FIGS. **10**A and **10**B show the mesh structure that includes mesh lines extending in a first intersecting direction CDR**1** intersecting the first direction DR**1** and the second direction DR**2** and mesh lines extending in a second intersecting direction CDR**2** intersecting the first intersecting direction CDR**1** as a representative example. However, the extension directions of the mesh lines forming the mesh structure should not be limited to those of FIGS. **10**A and **10**B. As an example, the mesh structure may include only mesh lines extending in the first direction DR**1** and the second direction DR**2** or may include the mesh lines extending in the first direction DR**1**, the second direction DR**2**, the first intersecting direction CDR**1**, and the second intersecting direction CDR**2**. That is, the mesh structure may be changed in various ways.

[0224] FIG. **11**A is a plan view of a first conductive layer **202**SU-E of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **11**B is a plan view of a second conductive layer **204**SU-E of the sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure.

[0225] Referring to FIGS. **7**A, **11**A, and **11**B, one sensing unit SU-E**1** may be adjacent to the boundary BD between the sensing area **200**A and the peripheral area **200**NA. FIG. **11**A shows the first conductive layer **202**SU-E of the one sensing unit SU-E**1**, and FIG. **11**B shows the second conductive layer **204**SU-E of the sensing unit SU-E**1**.

[0226] Among the third electrodes **230**, at least one third electrode **230-1** may include a first electrode portion **230***p***1**, a second electrode portion **230***p***2**, and an auxiliary bridge **230***pb* electrically connected to the first electrode portion **230***p***1** and the second electrode portion **230***p***2**. The auxiliary bridge **230***pb* may be electrically connected to the first electrode portion **230***p***1** and the second electrode portion **230***p***2** through third contacts CNc.

[0227] The first electrode portion **230***p***1** and the second electrode portion **230***p***2** may be spaced apart from each other with the auxiliary trace line **240***t* interposed therebetween. As an example, because the second portion **240***t***2** of the auxiliary trace line **240***t* overlaps the sensing area **200**A, the first electrode portion **230***p***1** and the second electrode portion **230***p***2** may be spaced apart from each other with the second portion **240***t***2** of the auxiliary trace line **240***t* interposed therebetween. The second portion **240***t***2** of the auxiliary trace line **240***t* may be insulated from the auxiliary bridge **230***pb* while intersecting the auxiliary bridge **230***pb*.

[0228] The auxiliary trace line **240***t* may be included in the first conductive layer **202**SU-E and may be covered by the first sensing pattern **210-***sp* included in the second conductive layer **204**SU-E and the second electrode **220**. Accordingly, even though the auxiliary trace line **240***t* overlaps the sensing area **200**A, it may have little to no effect on the sensing sensitivity of the sensor layer **200**.

[0229] FIG. **12**A is an enlarged plan view of a portion of the first conductive layer (refer to **202**SU-E of FIG. **11**A) of the sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **12**B is an enlarged plan view of a portion of the second conductive layer (refer to **204**SU-E of FIG. **11**A) of the sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **12**C is a plan view of the portion of the first conductive layer (refer to **202**SU-E of FIG. **11**A) shown in FIG. **12**A and the portion of the second conductive layer (refer to **204**SU-E of FIG. **11**A).
[0230] FIG. **12**A shows the first electrode portion **230***p***1**, the second electrode portion **230***p***2**, the dummy patterns DMP, and the auxiliary trace line **240***t* shown in FIG. **11**A, and FIG. **12**B shows the first sensing pattern **210**-*sp* of one first electrode **210** and the auxiliary bridge **230***pb* shown in FIG. **11**B.
[0231] The first sensing pattern **210**-*sp* may include a first mesh line **210***ms***1** extending in the first intersecting direction CDR**1** and a second mesh line **210***ms***2** extending in the second intersecting direction CDR**2** intersecting the first intersecting direction CDR**1**. The auxiliary trace line **240***t* may include a third mesh line **240***ms***1** extending in the first intersecting direction CDR**1** and a fourth mesh line **240***ms***2** extending in the second intersecting direction CDR**2**.
[0232] When viewed in the plane, e.g., when viewed in the third direction DR**3**, the first mesh line **210***ms***1** may overlap and intersect the fourth mesh line **240***ms***2**, and the second mesh line **210***ms***2** may overlap and intersect the third mesh line **240***ms***1**.
[0233] The third mesh line **240***ms***1** may include an end portion **240***ms***1**-*e* connected to the fourth mesh line **240***ms***2** and an extension portion **240***ms***1-1** extending from the end portion **240***ms***1**-*e* to the first intersecting direction CDR**1**, and the extension portion **240***ms***1-1** may not overlap the first mesh line **210***ms***1**. That is, the mesh lines extending in the same direction may be designed not to overlap with each other to reduce a coupling capacitance between the auxiliary trace line **240***t* and one first electrode **210**.
[0234] The auxiliary bridge **230***pb* may be electrically connected to the second electrode portion **230***p***2** through two third contacts CNc and may be electrically connected to the first electrode portion **230***p***1** through one third contact CNc.
[0235] FIG. **13**A is an enlarged plan view of a first conductive layer **202**SU-Ea of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **13**B is an enlarged plan view of a second conductive layer **204**SU-Ea of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure.
[0236] Referring to FIGS. **7**A, **13**A, and **13**B, an auxiliary trace line **240***ta* may include a first layer line **240***tl***1** and a second layer line **240***tl***2** located on the first layer line **240***tl***1** and electrically connected to the first layer line **240***tl***1**. The second layer line **240***tl***2** may be electrically connected to the first layer line **240***tl***1** through sixth contacts CNf.
[0237] Among third electrodes **230**, at least one third electrode **230-1** may include a first electrode portion **230***p***1**, a second electrode portion **230***p***2**, and an auxiliary bridge **230***pb* electrically connected to the first electrode portion **230***p***1** and the second electrode portion **230***p***2**. The auxiliary bridge **230***pb* may be electrically connected to the first electrode portion **230***p***1** and the second electrode portion **230***p***2** through third contacts CNc.
[0238] The first electrode portion **230***p***1** and the second electrode portion **230***p***2** may be spaced apart from each other with the first layer line **240***tl***1** interposed therebetween. The first layer line **240***tl***1** of the auxiliary trace line **240***t* and the auxiliary bridge **230***pb* may be insulated from each other while intersecting with each other.
[0239] A first sensing pattern **210**-*sp***1** of at least one first electrode **210** among first electrodes **210** may include a first electrode pattern portion **210***sp***1**, a second electrode pattern portion **210***sp***2**, and a first auxiliary bridge pattern **210***spb*. The first auxiliary bridge pattern **210***spb* may be electrically connected to the first electrode pattern portion **210***sp***1** and the second electrode pattern portion **210***sp***2** through fifth contacts CNe. The first electrode pattern portion **210***sp***1** and the second

electrode pattern portion **210***sp***2** may be spaced apart from each other with the second layer line **240***tl***2** interposed therebetween. The second layer line **240***tl***2** may be insulated from the first auxiliary bridge pattern **210***spb* while intersecting the first auxiliary bridge pattern **210***spb*.

[0240] At least one second electrode **220-1** among second electrodes **220** may include a third electrode pattern portion **220***p***1**, a fourth electrode pattern portion **220***p***2**, and a second auxiliary bridge pattern **220***pb*. The second auxiliary bridge pattern **220***pb* may be electrically connected to the third electrode pattern portion **220***p***1** and the fourth electrode pattern portion **220***p***2** through fourth contacts CNd. The third electrode pattern portion **220***p***1** and the fourth electrode pattern portion **220***p***2** may be spaced apart from each other with the second layer line **240***tl***2** interposed therebetween. The second layer line **240***tl***2** may be insulated from the second auxiliary bridge pattern **220***pb* while intersecting the second auxiliary bridge pattern **220***pb*.

[0241] FIG. **14**A is an enlarged plan view of a first conductive layer **202**SU-Eb of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **14**B is an enlarged plan view of a second conductive layer **204**SU-Eb of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure.

[0242] Referring to FIGS. **7**A, **14**A, and **14**B, the first conductive layer **202**SU-Eb may include first auxiliary trace lines **230***rt***1***a* and an auxiliary trace line **240***t*, which are adjacent to a boundary BD. The first auxiliary trace lines **230***rt***1***a* and the auxiliary trace line **240***t* may be arranged as close to the boundary BD as possible. That is, the first auxiliary trace lines **230***rt***1***a* and the auxiliary trace line **240***t* may be sequentially arranged from an edge of a sensing area **200**A in the first conductive layer **202**SU-Eb.

[0243] Among third electrodes **230**, at least a third electrode **230-1***a* (hereinafter, referred to as a third electrode) may be spaced apart from a peripheral area **200**NA with the first auxiliary trace lines **230***rt***1***a* and the auxiliary trace line **240***t* interposed therebetween. Accordingly, the second conductive layer **204**SU-Eb may further include an auxiliary electrode bridge **230***pba* electrically connected to the third electrode **230-1***a* and insulated from the first auxiliary trace lines **230***rt***1***a* and the auxiliary trace line **240***t* while intersecting the first auxiliary trace lines **230***rt***1***a* and the auxiliary trace line **240***t*.

[0244] When compared to other third electrodes **230**, which do not face the first auxiliary trace lines **230***rt***1***a* or the auxiliary trace line **240***t*, among the third electrodes **230**, the third electrode **230-1***a* may have a shape of which a portion is removed. That is, a length in the second direction DR**2** of the third electrode **230-1***a* may be shorter than a length in the second direction DR**2** of other third electrodes **230**. Because the portion of the third electrode **230-1***a*, which is closest to the boundary BD, is removed, degradation of the performance of a sensor layer **200** may be prevented or reduced.

[0245] FIG. **15**A is an enlarged plan view of a first conductive layer **202**SU-Ec of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **15**B is an enlarged plan view of a second conductive layer **204**SU-Ec of a sensing unit (refer to SU-E**1** of FIG. **7**A) according to some embodiments of the present disclosure.

[0246] Referring to FIGS. **7**A, **15**A, and **15**B, first auxiliary trace lines **230***rt***1***a-a* and an auxiliary trace line **240***ta* may be located in a sensing area **200**A.

[0247] Each of the first auxiliary trace lines **230***rt***1***a-a* may include a first-first layer line **230***rtl***1** and a first-second layer line **230***rtl***2** located on the first-first layer line **230***rtl***1** and electrically connected to the first-first layer line **230***rtl***1**. The auxiliary trace line **240***ta* may include a first layer line **240***tl***1** and a second layer line **240***tl***2** located on the first layer line **240***tl***1** and electrically connected to the first layer line **240***tl***1**.

[0248] A third electrode **230-1***a* may be spaced apart from a peripheral area **200**NA with the first auxiliary trace lines **230***rt***1***a-a* and the auxiliary trace line **240***ta* interposed therebetween. Accordingly, the second conductive layer **204**SU-Ec may further include an auxiliary electrode bridge **230***pba* that is electrically connected to the third electrode **230-1***a* and insulated from the first-first layer line **230***rtl***1** and the first layer line **240***tl***1** while intersecting the first-first layer line **230***rtl***1** and the first layer line **240***tl***1**.

[0249] The second layer line **240***tl***2** may include a first line portion **240***tlp***1** and a second line portion **240***tlp***2** spaced apart from the first line portion **240***tlp***1** with the auxiliary electrode bridge **230***pba* interposed therebetween. A first sensing pattern **210-***spa* adjacent to the second layer line **240***tl***2** may include a protrusion that extends from between the first line portion **240***tlp***1** and the second line portion **240***tlp***2** to a boundary BD.

[0250] FIG. **16**A is an enlarged plan view of a first conductive layer **202**SU-Ed of a sensing unit (refer to SU-E**2** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **16**B is an enlarged plan view of a second conductive layer **204**SU-Ed of a sensing unit (refer to SU-E**2** of FIG. **7**A) according to some embodiments of the present disclosure.

[0251] Referring to FIGS. **7**A, **16**A, and **16**B, the sensing unit SU-E**2** may be located adjacent to a corner of a sensing area **200**A. As an example, the sensing unit SU-E**2** may be located adjacent to portions of a boundary BD, which extend in different directions from each other. An auxiliary trace line **240***t* that overlaps the sensing area **200**A may be spaced apart from the boundary BD by a distance (e.g., a set or predetermined distance).

[0252] One third electrode **230-2** located at an outermost position among third electrodes **230** is shown in FIGS. **16**A and **16**B. The third electrode **230-2** may include a first electrode portion **230***p***1**, a second electrode portion **230***p***2***a*, and an auxiliary bridge **230***pb* electrically connected to the first electrode portion **230***p***1** and the second electrode portion **230***p***2***a*. The first electrode portion **230***p***1** and the second electrode portion **230***p***2***a* may be spaced apart from each other with the auxiliary trace line **240***t* interposed therebetween. The auxiliary trace line **240***t* may be insulated from the auxiliary bridge **230***pb* while intersecting the auxiliary bridge **230***pb*.

[0253] Among first auxiliary trace lines **230***rt***1**, a portion of a first auxiliary trace line **230***rt***1***a-b* electrically connected to the third electrode **230-2** may be located in the sensing area **200**A. In addition, a portion of the first auxiliary trace line **230***rt***1***a-b* may overlap a display area (refer to **100**A of FIG. **4**). The portion of the first auxiliary trace line **230***rt***1***a-b* may be located between the auxiliary trace line **240***t* and a peripheral area **200**NA.

[0254] A second sensing pattern **240-***sp***1** of one fourth electrode **240** among fourth electrodes **240** may include a first electrode portion **240***sp***1**, a second electrode portion **240***sp***2**, and an auxiliary bridge **240***spb* electrically connected to the first electrode portion **240***sp***1** and the second electrode portion **240***sp***2**. The first electrode portion **240***sp***1** and the second electrode portion **240***sp***2** may be spaced apart from each other in the first direction DR**1** with the auxiliary trace line **240***t* interposed therebetween. The auxiliary bridge **240***spb* may be insulated from the auxiliary trace line **240***t* while intersecting the auxiliary trace line **240***t*.

[0255] FIG. **17**A is an enlarged plan view of a first conductive layer **202**SU-Ee of a sensing unit (refer to SU-E**2** of FIG. **7**A) according to some embodiments of the present disclosure. FIG. **17**B is an enlarged plan view of a second conductive layer **204**SU-Ee of a sensing unit (refer to SU-E**2** of FIG. **7**A) according to some embodiments of the present disclosure.

[0256] Referring to FIGS. **7**A, **17**A, and **17**B, the sensing unit SU-E**2** may be located adjacent to a corner of a sensing area **200**A. As an example, the sensing unit SU-E**2** may be located adjacent to portions of a boundary BD, which extend in different directions from each other. An auxiliary trace line **240***tb* that overlaps the sensing area **200**A may be located adjacent to the boundary BD.

[0257] An end of one third electrode **230-2***a* located at an outermost position among third electrodes **230** may be spaced apart from the boundary BD by a distance (e.g., a set or predetermined distance) DTs. Therefore, a length in the second direction DR**2** of the third electrode **230-2***a* may be equal to or smaller than a length in the second direction DR**2** of another third electrode that does not face the auxiliary trace line **240***tb*.

[0258] A portion of a first auxiliary trace line **230***rt***1***a-c*, which is electrically connected to the third electrode **230-2***a*, among first auxiliary trace lines **230***rt***1** may be located in the sensing area **200**A.

In addition, the portion of the first auxiliary trace line **230***rt***1***a-c* may overlap a display area **100**A (refer to FIG. **4**). The portion of the first auxiliary trace line **230***rt***1***a-c* may be spaced apart from a peripheral area **200**NA with the auxiliary trace line **240***tb* interposed therebetween. That is, the auxiliary trace line **240***tb* may be located between the first auxiliary trace line **230***rt***1***a-c* and the peripheral area **200**NA.

[0259] FIG. **18** is a plan view of a display panel DPb according to some embodiments of the present disclosure. FIG. **19**A is an enlarged plan view of a first conductive layer **202**SU-Ef of a sensing unit (refer to SU-Ea of FIG. **18**) according to some embodiments of the present disclosure. FIG. **19**B is an enlarged plan view of a second conductive layer **204**SU-Ef of a sensing unit (refer to SU-Ea of FIG. **18**) according to some embodiments of the present disclosure.

[0260] Referring to FIGS. **18**, **19**A, and **19**B, the display panel DPb may include a sensor layer **200-2**. The sensor layer **200-2** may include first, second, third, and fourth electrodes **210**, **220**, **230**, and **240** arranged in a sensing area **200**A.

[0261] The sensor layer **200-2** may further include first trace lines **210***t* electrically connected to the first electrodes **210** in a one-to-one correspondence and arranged in a peripheral area **200**NA and second trace lines **220***t* electrically connected to the second electrodes **220** in a one-to-one correspondence and arranged in the peripheral area **200**NA.

[0262] The sensor layer **200-2** may further include first auxiliary trace lines **230***rt***1** electrically connected to the third electrodes **230** in a one-to-one correspondence, a second auxiliary trace line **230***rt***2** electrically connected to the third electrodes **230**, and auxiliary trace lines **240***t-ct* electrically connected to the fourth electrodes **240**.

[0263] One auxiliary trace line **240***t-ct* may be electrically connected to four fourth electrodes **240**. As an example, the auxiliary trace line **240***t-ct* may be connected to a portion **240***ct* of one fourth electrode **240** in an area overlapping a display area (refer to **100**A of FIG. **4**). The auxiliary trace line **240***t-ct* may be connected to the one fourth electrode **240** in the sensing area **200**A, and a portion of the auxiliary trace line **240***t-ct* may be arranged in the sensing area **200**A.

[0264] The sensor layer **200-2** may further include an additional auxiliary trace line **240***t-ad*. The additional auxiliary trace line **240***t-ad* may be provided to electrically connect four fourth electrodes **240** to each other. The additional auxiliary trace line **240***t-ad* may be located in the peripheral area **200**NA.

[0265] According to some embodiments, a portion of at least one first auxiliary trace line **230***rt***1***a* (hereinafter, referred to as a first-first auxiliary trace line) of the first auxiliary trace lines **230***rt***1** may be located in the sensing area **200**A. That is, the portion of the first-first auxiliary trace line **230***rt***1***a* may overlap the display area **100**A.

[0266] FIG. **20** is a plan view of a display panel DPc according to some embodiments of the present disclosure.

[0267] Referring to FIG. **20**, the display panel DPc may include a sensor layer **200-3**. The sensor layer **200-3** may include first, second, third, and fourth electrodes **210**, **220**, **230**, and **240** arranged in a sensing area **200**A.

[0268] The sensor layer **200-3** may further include first trace lines **210***t* electrically connected to the first electrodes **210** in a one-to-one correspondence and arranged in a peripheral area **200**NA and second trace lines **220***t* electrically connected to the second electrodes **220** in a one-to-one correspondence and arranged in the peripheral area **200**NA.

[0269] The sensor layer **200-3** may include first auxiliary trace lines **230***rt***1** electrically connected to the third electrodes **230** in a one-to-one correspondence, a second auxiliary trace line **230***rt***2** electrically connected to the third electrodes **230**, and auxiliary trace lines **240***t-cta* electrically connected to the fourth electrodes **240**.

[0270] According to some embodiments, one auxiliary trace line **240***t-cta* may be electrically connected to four fourth electrodes **240**. As an example, the auxiliary trace line **240***t-ct* may be connected to portions **240***ct* of the four fourth electrodes **240** in an area overlapping a display area (refer to **100**A of FIG. **4**).

[0271] Referring to FIGS. **18** and **20**, the third electrodes **230** and the fourth electrodes **240** may be floated when a pen PN (refer to FIG. **5**) is sensed. Accordingly, even though the portion of the first-first auxiliary trace line **230***rt***1***a* connected to the third electrodes **230** and the fourth electrodes **240** and the portion of each of the auxiliary trace lines **240***t-ct* or **240***t-cta* are arranged in the sensing area **200**A, changes in shape, resistance, or routing location of the first-first auxiliary trace line **230***rt***1***a* and the auxiliary trace lines **240***t-ct* or **240***t-cta* may have little to no effect on the sensing operation for the pen.

[0272] Among the trace lines located in an area, e.g., an area adjacent to pads PD, where the trace lines are intensively arranged in the peripheral area **200**NA, at least a portion of some trace lines may be located in the sensing area **200**A. Therefore, a size of the area where the trace lines are arranged in the peripheral area **200**NA may be reduced, and a size of an area where the trace lines are not arranged (hereinafter referred to as an unused area) in the peripheral area **200**NA may increase.

[0273] According to some embodiments, the area occupied by the peripheral area **200**NA in a total area of the display panel DPb or DPc may be reduced by removing (for example, by cutting) the unused area, and thus, a narrow bezel may be implemented. According to some embodiments, a line width may be adjusted to relatively improve the resistance of each of the first trace lines **210***t* or the second trace lines **220***t* by utilizing the unused area. In this case, the sensing sensitivity of the sensor layer **200-2** or **200-3** may be relatively improved.

[0274] FIG. **21** is a plan view of a display panel DPd according to some embodiments of the present disclosure. FIG. **22**A is an enlarged plan view of a portion of a first conductive layer **202**SU-Eg of a sensor layer according to some embodiments of the present disclosure. FIG. **22**B is an enlarged plan view of a portion of a second conductive layer **204**SU-Eg of a sensor layer according to some embodiments of the present disclosure. FIGS. **22**A and **22**B correspond to an area CC′ of FIG. **21**.

[0275] Referring to FIGS. **21**, **22**A, and **22**B, the display panel DPd may include a sensor layer **200-4**. The sensor layer **200-4** may include first, second, third, and fourth electrodes **210**, **220**, **230**, and **240** arranged in a sensing area **200**A.

[0276] The sensor layer **200-4** may include first trace lines **210***t* electrically connected to the first electrodes **210** in a one-to-one correspondence and arranged in a peripheral area **200**NA and second trace lines **220***t* electrically connected to the second electrodes **220** in a one-to-one correspondence and arranged in the peripheral area **200**NA.

[0277] The sensor layer **200-4** may further include first auxiliary trace lines **230***rt***1** electrically connected to the third electrodes **230** in a one-to-one correspondence, a second auxiliary trace line **230***rt***2** electrically connected to the third electrodes **230**, and auxiliary trace lines **240***t-a* electrically connected to the fourth electrodes **240**.

[0278] One auxiliary trace line **240***t-a* of the auxiliary trace lines **240***t-a* may be insulated from at least some second trace lines **220***t* among the second trace lines **220***t* while intersecting the at least some second trace lines **220***t*. As an example, one auxiliary trace line **240***t-a* electrically connected to the fourth electrodes **240** included in the electrode group arranged at the top among the two electrode groups may be insulated from some second trace lines **220***t* routed in the same direction as the one auxiliary trace line **240***t-a* while intersecting the some second trace lines **220***t*.

[0279] Referring to FIGS. **22**A and **22**B, one auxiliary trace line **240***t-a* may include a first layer line **240***tl***1***a* and a second layer line **240***tl***2***a* located on and electrically connected to the first layer line **240***tl***1***a*. The first layer line **240***tl***1***a* may include a first portion **240***tl***1***p***1** extending from at least one of the fourth electrodes **240** and overlapping the peripheral area **200**NA and a second portion **240***tl***1***p***2** extending from the first portion **240***tl***1***p***1** to the sensing area **200**A. The second trace lines **220***t* may be insulated from the second portion **240***tl***1***p***2** while intersecting the second portion **240***tl***1***p***2**.

[0280] According to some embodiments, the trace lines may have a multi-layer structure. As an example, each of the second trace lines **220***t* may include a first layer trace line **220***tl***1** and a second layer trace line **220***tl***2** located on and electrically connected to the first layer trace line **220***t***1**. A second line portion **232***t* may include a first layer portion **232***tl***1** and a second layer portion **232***tl***2** located on and electrically connected to the first layer portion **232***tl***1**. A guard line **200***tg* may include a first layer guard line **200***tgl***1** and a second layer guard line **200***tgl***2** located on and electrically connected to the first layer guard line **200***tgl***1**.
[0281] FIG. **23** is a view illustrating an operation of the sensor driver **2000** according to some embodiments of the present disclosure.
[0282] Referring to FIGS. **5** and **23**, the sensor driver **2000** may be selectively driven in one of a first operation mode DMD**1**, a second operation mode DMD**2**, and a third operation mode DMD**3**.
[0283] The first operation mode DMD**1** may be referred to as a touch and pen standby mode, the second operation mode DMD**2** may be referred to as a touch activation and pen standby mode, and the third operation mode DMD**3** may be referred to as a pen activation mode. The first operation mode DMD**1** may refer to a mode of waiting for the first input **2000** and the second input **3000**. The second operation mode DMD**2** may refer to a mode of sensing the first input **2000** and waiting for the second input **3000**. The third operation mode DMD**3** may refer to a mode of sensing the second input **3000**.
[0284] According to some embodiments, the sensor driver **2000** may be driven first in the first operation mode DMD**1**. When the first input **2000** is sensed in the first operation mode DMD**1**, the operation mode of the sensor driver **2000** may be switched (or changed) to the second operation mode DMD**2**. When the second input **3000** is sensed in the first operation mode DMD**1**, the operation mode of the sensor driver **2000** may be switched (or changed) to the third operation mode DMD**3**.
[0285] When the second input **3000** is sensed in the second operation mode DMD**2**, the operation mode of the sensor driver **2000** may be switched (or changed) to the third operation mode DMD**3**. When the first input **2000** is released (or not detected) in the second operation mode DMD**2**, the operation mode of the sensor driver **2000** may be switched to the first operation mode DMD**1**. When the second input **3000** is released (or not detected) in the third operation mode DMD**3**, the operation mode of the sensor driver **2000** may be switched to the first operation mode DMD**1**.
[0286] FIG. **24** is a view illustrating an operation of the sensor driver according to some embodiments of the present disclosure.
[0287] Referring to FIGS. **5**, **23**, and **24**, operations in the first, second, and third operation modes DMD**1**, DMD**2**, and DMD**3** are shown in time (t) order.
[0288] In the first operation mode DMD**1**, the sensor driver **2000** may be repeatedly driven in a second mode MD**2**-*d* and a first mode MD**1**-*d*. During the second mode MD**2**-*d*, the sensor layer **200** may be scan-driven to detect the second input **3000**. During the first mode MD**1**-*d*, the sensor layer **200** may be scan-driven to detect the first input **2000**. FIG. **24** shows an operation that the sensor driver **2000** is continuously driven in the first mode MD**1**-*d* after the second mode MD**2**-*d* as a representative example, however, the order of the operation of the sensor driver **2000** should not be limited thereto or thereby.
[0289] In the second operation mode DMD**2**, the sensor driver **2000** may be repeatedly driven in the second mode MD**2**-*d* and a first mode MD**1**. During the second mode MD**2**-*d*, the sensor layer **200** may be scan-driven to detect the second input **3000**. During the first mode MD**1**, the sensor layer **200** may be scan-driven to detect coordinates of the first input **2000**.
[0290] In the third operation mode DMD**3**, the sensor driver **2000** may be driven in a second mode MD**2**. During the second mode MD**2**, the sensor layer **200** may be scan-driven to detect coordinates of the second input **3000**. In the third operation mode DMD**3**, the sensor driver **2000** may not be driven in the first mode MD**1**-*d* or MD**1** before the second input **3000** is released (or not detected).
[0291] FIG. **25** is a view illustrating the first mode according to some embodiments of the present

disclosure.
[0292] Referring to FIGS. **5**, **24**, and **25**, the first mode MD**1**-*d* of the first operation mode DMD**1** and the first mode MD**1** of the second operation mode DMD**2** may include a mutual capacitance detection mode. FIG. **25** is a view to illustrate the mutual capacitance detection mode in the first mode MD**1**-*d* of the first operation mode DMD**1** and the first mode MD**1** of the second operation mode DMD**2**.
[0293] In the mutual capacitance detection mode, the sensor driver **2000** may sequentially apply a transmission signal TX to the first electrodes **210** and may detect coordinates of the first input **2000** using a reception signal RX detected through the second electrodes **220**. As an example, the sensor driver **2000** may sense a variation in mutual capacitance between the first electrodes **210** and the second electrodes **220** to calculate input coordinates.
[0294] FIG. **25** shows a structure in which the transmission signal TX is applied to one first electrode **210** and the reception signal RX is output from the second electrodes **220** as a representative example. The one first electrode **210** to which the transmission signal TX is provided is shown in bold in FIG. **25** to clearly display the signal. The sensor driver **2000** may sense a variation in capacitance between the first electrode **210** and each of the second electrodes **220** to detect the input coordinates of the first input **2000**.
[0295] According to some embodiments, at least one of the first mode MD**1**-*d* of the first operation mode DMD**1** or the first mode MD**1** of the second operation mode DMD**2** may further include a self-capacitance detection mode. The sensor driver **2000** may output driving signals to the first electrodes **210** and the second electrodes **220** in the self-capacitance detection mode and may sense a variation in capacitance of each of the first electrodes **210** and the second electrodes **220** to calculate the input coordinates. In the self-capacitance detection mode, the third electrodes **230** and the fourth electrodes **240** may be grounded, and the guard lines **200***tg* may receive the same signal as the signal applied to the trace lines adjacent thereto. Accordingly, a parasitic capacitance formed between the trace lines may be reduced (or prevented) by the guard lines **200***tg*.
[0296] In the first mode MD**1**-*d* of the first operation mode DMD**1** and the first mode MD**1** of the second operation mode DMD**2**, the third electrodes **230**, the fourth electrodes **240**, and the guard lines **200***tg* may be grounded. Therefore, a touch noise entering through the third electrodes **230** and the fourth electrodes **240** may be prevented or reduced.
[0297] FIG. **26** is a view illustrating the second mode according to some embodiments of the present disclosure. FIG. **27**A is a graph illustrating a waveform of a first signal SG**1** according to some embodiments of the present disclosure. FIG. **27**B is a graph illustrating a waveform of a second signal SG**2** according to some embodiments of the present disclosure.
[0298] Referring to FIGS. **26**, **27**A, and **27**B, the second mode MD**2** may include the charging driving mode. The charging driving mode may include a searching charging driving mode and a tracking charging driving mode.
[0299] The searching charging driving mode may be a driving mode before the location of the pen is sensed. Accordingly, the first signal SG**1** or the second signal SG**2** may be applied to entire channels included in the sensor layer **200**. That is, an entire area of the sensor layer **200** may be scanned during the searching charging driving mode. When the pen PN (refer to FIG. **5**) is sensed in the searching charging driving mode, the sensor layer **200** may be driven in the tracking charging driving mode. As an example, the sensor driver **2000** may sequentially output the first signal SG**1** and the second signal SG**2** to an area overlapping a point where the pen PN is sensed rather than the entire sensor layer **200** in the tracing charging driving mode.
[0300] In the charging driving mode, the sensor driver **2000** may apply the first signal SG**1** to one pad and may apply the second signal SG**2** to another pad. The second signal SG**2** may be a reverse signal of the first signal SG**1**. As an example, the first signal SG**1** may be a sinusoidal signal.
[0301] Because the first signal SG**1** and the second signal SG**2** are applied to at least two pads, a current RFS may flow a current path from one pad to another pad. In addition, because the first

signal SG**1** and the second signal SG**2** are sinusoidal signals in reverse-phase with each other, a direction of the current RFS may be changed periodically. According to some embodiments of the present disclosure, the first signal SG**1** and the second signal SG**2** may be square wave signals in reverse-phase with each other.

[0302] When the first signal SG**1** and the second signal SG**2** are in reverse-phase with each other, noises caused by the first signal SG**1** in the display layer **100** (refer to FIG. **4**) may be cancelled out by noises caused by the second signal SG**2**. Accordingly, a flicker phenomenon occurring in the display layer **100** may be prevented or reduced, and a display quality of the display layer **100** may be relatively improved.

[0303] According to some embodiments, the first signal SG**1** may be a sinusoidal signal. However, embodiments according to the present disclosure are not limited thereto or thereby, and the first signal SG**1** may be a square wave signal. The second signal SG**2** may have a certain constant voltage. As an example, the second signal SG**2** may be a ground voltage. That is, the pad to which the second signal SG**2** is applied may be considered grounded. In this case, the current RFS may flow from one pad to another pad. In addition, even though the another pad is grounded, the direction of the current RFS may be periodically changed because the first signal SG**1** is the sinusoidal signal or the square wave signal.

[0304] FIG. **26** shows a structure in which the first signal SG**1** is applied to one pad connected to one first auxiliary trace line **230***rt***1** and the second signal SG**2** is applied to one pad connected to the second auxiliary trace line **230***rt***2**. The current RFS may flow through the current path defined by one first auxiliary trace line **230***rt***1**, one third electrode **230** connected to the one first auxiliary trace line **230***rt***1**, and a portion of the second auxiliary trace line **230***rt***2**. The current path may have a coil shape. Accordingly, a resonant circuit of the pen PN may be charged by a magnetic field formed by the current path in the charging driving mode of the second mode.

[0305] According to the present disclosure, the current path with a loop coil pattern may be implemented by components included in the sensor layer **200**. Therefore, the electronic device **1000** (refer to FIG. **1**A) may charge the pen PN using the sensor layer **200**. Thus, because there is no need to add a separate component with a coil used to charge the pen PN, the thickness and weight of the electronic device **1000** may not increase, and the flexibility of the electronic device **1000** may not be deteriorated.

[0306] In the charging driving mode, the first electrodes **210**, the second electrodes **220**, the fourth electrodes **240**, and the guard lines **200***tg* may be grounded, may receive a constant voltage, or may be electrically floated. In particular, the first electrodes **210**, the second electrodes **220**, the fourth electrodes **240**, and the guard lines **200***tg* may be floated. In this case, the current RFS may not flow through the first electrodes **210**, the second electrodes **220**, the fourth electrodes **240**, and the guard lines **200***tg*.

[0307] FIG. **28** is a view illustrating the second mode according to some embodiments of the present disclosure. FIG. **29** is a view illustrating the second mode with respect to the sensing unit according to some embodiments of the present disclosure.

[0308] Referring to FIGS. **28** and **29**, the second mode may include a charging driving mode and a pen sensing driving mode. FIGS. **28** and **29** are views to illustrate the pen sensing driving mode. FIG. **29** shows one sensing unit SU through which first, second, third, and fourth induction currents Ia, Ib, Ic, and Id generated by the pen PN (refer to FIG. **5**) flow.

[0309] In the pen sensing driving mode, the sensor driver **2000** may receive first reception signals PRX**1** from first electrodes **210** and second reception signals PRX**2** from second electrodes **220**.

[0310] A routing direction of one electrode and a routing direction of another electrode overlapping the one electrode of a sensor layer **200** may be different from each other. As an example, a routing direction of the first electrode **210** may be different from a routing direction of a third electrode **230**. In addition, the routing direction of the second electrode **220** may be different from a routing direction of a fourth electrode **240**. As an example, as shown in FIG. **29**, the first electrode **210** may be connected to a first trace line **210***t* at a lower side of the sensing unit SU, and the third electrode **230** may be connected to a second auxiliary trace line **230***rt***2** at an upper side of the sensing unit SU. The second electrode **220** may be connected to a second trace line **220***t* at a right side of the sensing unit SU, and the fourth electrode **240** may be connected to an auxiliary trace line **240***t* at a left side of the sensing unit SU.

[0311] An RLC resonant circuit of the pen PN may emit a magnetic field of resonant frequency while discharging charges charged therein. Due to the magnetic field provided from the pen PN, the first induction current Ia may be generated in the first electrode **210**, and the second induction current Ib may be generated in the second electrode **220**. In addition, the third induction current Ic may be generated in the third electrode **230**, and the fourth induction current Id may be generated in the fourth electrode **240**.

[0312] A first coupling capacitance Ccp**1** may be formed between the third electrode **230** and the first electrode **210**, and a second coupling capacitance Ccp**2** may be formed between the fourth electrode **240** and the second electrode **220**. The third induction current Ic may be supplied to the first electrode **210** through the first coupling capacitance Ccp**1**, and the fourth induction current Id may be supplied to the second electrode **220** through the second coupling capacitance Ccp**2**.

[0313] The sensor driver **2000** may receive a first reception signal PRX**1***a* from the first electrode **210** based on the first induction current Ia and the third induction current Ic and may receive a second reception signal PRX**2***a* from the second electrode **220** based on the second induction current Ib and the fourth induction current Id. The sensor driver **2000** may detect input coordinates of the pen PN based on the first reception signal PRX**1***a* and the second reception signal PRX**2***a*.

[0314] When the sensor driver **2000** receives the first reception signal PRX**1***a* from the first electrode **210** and receives the second reception signal PRX**2***a* from the second electrode **220**, one ends of the third and fourth electrodes **230** and **240** may be floated. Accordingly, compensation for the sensing signal may be maximized by the coupling between the first electrode **210** and the third electrode **230** and the coupling between the second electrode **220** and the fourth electrode **240**.

[0315] In addition, the other ends of the third and fourth electrodes **230** and **240** may be grounded or floated. Accordingly, the third induction current Ic and the fourth induction current Id may be sufficiently supplied to the first electrode **210** and the second electrode **220** by the coupling between the first electrode **210** and the third electrode **230** and the coupling between the second electrode **220** and the fourth electrode **240**. In the case where all the one ends and the other ends of the third and fourth electrodes **230** and **240** are floated, even though the third electrode **230** is charged with charges in the charging driving mode, a potential may not be changed rapidly because the third and fourth electrodes **230** and **240** are floated during the pen sensing operation. Accordingly, noises caused by the change in the driving mode may be reduced.

[0316] Although aspects of some embodiments of the present disclosure have been described, it is understood that the present disclosure should not be limited to these embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of embodiments according to the present disclosure as hereinafter claimed. Therefore, the disclosed subject matter should not be limited to any single embodiment described herein, and the scope of the present inventive concept shall be determined according to the attached claims.

Claims

1. An electronic device comprising: a display layer comprising a display area and a non-display area adjacent to the display area; and a sensor layer on the display layer, the sensor layer comprising: a plurality of first electrodes arranged in a first direction; a plurality of second electrodes arranged in a second direction intersecting the first direction and intersecting the plurality of first electrodes; a plurality of third electrodes arranged in the first direction and overlapping the plurality of first electrodes; a plurality of fourth electrodes arranged in the second direction and overlapping the plurality of second electrodes; and an auxiliary trace line electrically connected to at least one fourth electrode among the plurality of fourth electrodes, wherein at least a portion of the auxiliary trace line overlaps the display area.

2. The electronic device of claim 1, wherein the auxiliary trace line comprises: a first portion extending from the at least one fourth electrode and overlapping the non-display area; a second portion extending from the first portion and overlapping the display area; and a third portion extending from the second portion and overlapping the non-display area.

3. The electronic device of claim 1, wherein at least one third electrode among the plurality of third electrodes comprises: a first electrode portion; a second electrode portion; and an auxiliary bridge electrically connected to the first electrode portion and the second electrode portion, the first electrode portion and the second electrode portion are spaced apart from each other with the auxiliary trace line interposed therebetween in the second direction, and the auxiliary trace line is insulated from the auxiliary bridge while intersecting the auxiliary bridge.

4. The electronic device of claim 1, wherein the auxiliary trace line comprises: a first layer line; and a second layer line on the first layer line and electrically connected to the first layer line, wherein at least one third electrode among the plurality of third electrodes comprises: a first electrode portion; a second electrode portion; and an auxiliary bridge electrically connected to the first electrode portion and the second electrode portion, the first electrode portion and the second electrode portion are spaced apart from each other with the first layer line interposed between, the first layer line is insulated from the auxiliary bridge while intersecting the auxiliary bridge, at least one first electrode among the first electrodes comprises a first electrode pattern portion, a second electrode pattern portion, and an auxiliary bridge pattern electrically connected to the first electrode pattern portion and the second electrode pattern portion, the first electrode pattern portion is spaced apart from the second electrode pattern portion with the second layer line interposed therebetween, and the second layer line is insulated from the auxiliary bridge pattern while intersecting the auxiliary bridge pattern.

5. The electronic device of claim 1, wherein a length in the second direction of at least one third electrode among the plurality of third electrodes is shorter than a length in the second direction of another third electrode among the plurality of third electrodes.

6. The electronic device of claim 5, wherein the at least one third electrode is spaced apart from the non-display area with the auxiliary trace line interposed therebetween in a plan view.

7. The electronic device of claim 5, wherein the sensor layer further comprises an auxiliary electrode bridge electrically connected to the at least one third electrode and insulated from the auxiliary trace line while intersecting the auxiliary trace line.

8. The electronic device of claim 7, wherein the auxiliary trace line comprises a first layer line and a second layer line on the first layer line and electrically connected to the first layer line, the auxiliary electrode bridge is insulated from the first layer line while intersecting the first layer line, and the second layer line comprises a first line portion and a second line portion spaced apart from the first line portion with the auxiliary electrode bridge interposed therebetween.

9. The electronic device of claim 1, wherein the auxiliary trace line is connected to the at least one fourth electrode in an area overlapping the display area.

10. The electronic device of claim 9, wherein the sensor layer further comprises an additional auxiliary trace line that electrically connects the at least one fourth electrode to at least another fourth electrode among the plurality of fourth electrodes, and the additional auxiliary trace line overlaps the non-display area.

11. The electronic device of claim 9, wherein the auxiliary trace line is electrically connected to at least another fourth electrode among the plurality of fourth electrodes in the area overlapping the display area.

12. The electronic device of claim 1, wherein the sensor layer further comprises a plurality of first auxiliary trace lines electrically connected to the plurality of third electrodes, and a portion of at

least one first auxiliary trace line of the plurality of first auxiliary trace lines overlaps the display area.
13. The electronic device of claim 12, wherein a length in the second direction of at least one third electrode electrically connected to the at least one first auxiliary trace line among the plurality of third electrodes is equal to or smaller than a length in the second direction of another third electrode among the plurality of third electrodes.
14. The electronic device of claim 12, wherein the auxiliary trace line is between the at least one first auxiliary trace line and the non-display area in a plan view.
15. The electronic device of claim 12, wherein the at least one first auxiliary trace line is between the auxiliary trace line and the non-display area in a plan view.
16. The electronic device of claim 15, wherein another fourth electrode among the plurality of fourth electrodes comprises a first electrode portion, a second electrode portion, and an auxiliary bridge electrically connected to the first electrode portion and the second electrode portion, the first electrode portion and the second electrode portion are spaced apart from each other with the auxiliary trace line interposed therebetween in the first direction, and the auxiliary trace line is insulated from the auxiliary bridge while intersecting the auxiliary bridge.
17. The electronic device of claim 1, wherein the sensor layer further comprises: a plurality of first trace lines electrically connected to the plurality of first electrodes; and a plurality of second trace lines electrically connected to the plurality of second electrodes, and the auxiliary trace line is insulated from at least one second trace line among the plurality of second trace lines while intersecting the at least one second trace line.
18. The electronic device of claim 17, wherein the auxiliary trace line comprises: a first portion extending from the at least one of the plurality of fourth electrodes and overlapping the non-display area; and a second portion extending from the first portion to the display area, and the at least one second trace line is insulated from the second portion while intersecting the second portion.
19. The electronic device of claim 1, wherein the auxiliary trace line overlaps at least one first electrode among the plurality of first electrodes, the at least one first electrode comprises a first mesh line extending in a first intersecting direction and a second mesh line extending in a second intersecting direction intersecting the first intersecting direction, and the auxiliary trace line comprises a third mesh line extending in the first intersecting direction and a fourth mesh line extending in the second intersecting direction.
20. The electronic device of claim 19, wherein the first mesh line intersects and overlaps the fourth mesh line in a plan view, and the second mesh line intersects and overlaps the third mesh line in the plan view.
21. The electronic device of claim 19, wherein the third mesh line comprises: an end portion connected to the fourth mesh line; and an extension portion extending from the end portion to the first intersecting direction, and the extension portion does not overlap the first mesh line.
22. The electronic device of claim 11, wherein each of the plurality of first electrodes comprises: a plurality of sensing patterns spaced apart from each other in the second direction; and a plurality of bridge patterns electrically connected to the plurality of sensing patterns, and the auxiliary trace line is closer to the display layer than the plurality of sensing patterns.
23. An electronic device comprising: a display layer comprising a display area and a non-display area adjacent to the display area; and a sensor layer on the display layer, the sensor layer comprising: a plurality of first electrodes arranged in a first direction; a plurality of second electrodes arranged in a second direction intersecting the first direction and intersecting the plurality of first electrodes; a sensing auxiliary electrode comprising a plurality of auxiliary electrodes extending in the first direction and arranged in the second direction; and an auxiliary trace line electrically connected to the sensing auxiliary electrode, wherein at least a portion of the auxiliary trace line overlaps the display area.
24. The electronic device of claim 23, wherein the sensor layer further comprises an additional

auxiliary trace line that electrically connects the plurality of auxiliary electrodes and overlaps the non-display area.
25. The electronic device of claim 23, wherein the auxiliary trace line comprises: a first portion extending from the sensing auxiliary electrode and overlapping the non-display area; a second portion extending from the first portion and overlapping the display area; and a third portion extending from the second portion and overlapping the non-display area.
26. The electronic device of claim 23, wherein the sensor layer further comprises: a plurality of charging electrodes extending in the second direction and arranged in the first direction; a plurality of first trace lines electrically connected to the plurality of first electrodes; a plurality of second trace lines electrically connected to the plurality of second electrodes; and a plurality of first auxiliary trace lines electrically connected to the plurality of charging electrodes.
27. The electronic device of claim 26, wherein a portion of at least one first auxiliary trace line among the plurality of first auxiliary trace lines overlaps the display area, and the portion of the at least one first auxiliary trace line is between the auxiliary trace line and the non-display area.
28. The electronic device of claim 26, wherein the sensor layer further comprises a second auxiliary trace line electrically connected to the plurality of charging electrodes, the second auxiliary trace line surrounds an area in which the plurality of first trace lines, the plurality of second trace lines, the auxiliary trace line, and the plurality of first auxiliary trace lines are arranged.
29. The electronic device of claim 23, wherein the auxiliary trace line overlaps at least one first electrode among the plurality of first electrodes, the at least one first electrode comprises a first mesh line extending in a first intersecting direction and a second mesh line extending in a second intersecting direction intersecting the first intersecting direction, the auxiliary trace line comprises a third mesh line extending in the first intersecting direction and a fourth mesh line extending in the second intersecting direction, the first mesh line overlaps and intersects the fourth mesh line in a plan view, and the second mesh line overlaps and intersects the third mesh line in the plan view.
30. An electronic device comprising: a sensor layer comprising a sensing area and a peripheral area adjacent to the sensing area; and a sensor driver driving the sensor layer and configured to be selectively driven in a first mode in which a touch input is sensed or a second mode in which a pen input is sensed, the sensor layer comprising: a plurality of first electrodes on the sensor layer; a plurality of second electrodes on the sensor layer; a sensing auxiliary electrode on the sensor layer; and an auxiliary trace line electrically connected to the sensing auxiliary electrode and partially in the sensing area, wherein the sensing auxiliary electrode is floated or grounded in the first mode.
31. The electronic device of claim 30, wherein the auxiliary trace line comprises: a first portion extending from the sensing auxiliary electrode and overlapping the peripheral area; a second portion extending from the first portion and overlapping the sensing area; and a third portion extending from the second portion and overlapping the peripheral area.
32. The electronic device of claim 30, wherein the auxiliary trace line is connected to the sensing auxiliary electrode in the sensing area.
33. The electronic device of claim 30, wherein the auxiliary trace line overlaps at least one first electrode among the plurality of first electrodes, the at least one first electrode comprises: a first mesh line extending in a first intersecting direction; and a second mesh line extending in a second intersecting direction intersecting the first intersecting direction, wherein the auxiliary trace line comprises: a third mesh line extending in the first intersecting direction; and a fourth mesh line extending in the second intersecting direction, the first mesh line overlaps and intersects the fourth mesh line in a plan view, and the second mesh line overlaps and intersects the third mesh line in the plan view.
34. The electronic device of claim 30, wherein the second mode comprises a charging driving mode and a pen sensing driving mode, and the sensing auxiliary electrode is floated in the pen sensing

driving mode.

35. The electronic device of claim 30, wherein the electronic device is a mobile phone.