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Antenna package and image display device including the same

Abstract

An antenna package according to an embodiment includes an antenna unit and a circuit board bonded to the antenna unit. The circuit board includes a core layer comprising a plurality of portions having different widths from each other in a planar view, the core layer having a first surface and a second surface opposing each other, and a circuit wiring disposed on the first surface of the core layer and electrically connected to the antenna unit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION AND CLAIM OF PRIORITY (1) The present application is a continuation application to International Application No. PCT/KR2021/006805 with an International Filing Date of Jun. 1, 2021, which claims the benefit of Korean Patent Application No. 10-2020-0067482 filed on Jun. 4, 2020 at the Korean Intellectual Property Office, the disclosures of which are incorporated by reference herein in their entirety.

BACKGROUND

1. Field

(1) The present invention relates to an antenna package and an image display device including the same. More particularly, the present invention relates to an antenna package including an antenna device and a circuit board and an image display device including the same.

2. Description of the Related Art

(2) As information technologies have been developed, a wireless communication technology such as Wi-Fi, Bluetooth, etc., is combined with an image display device in, e.g., a smartphone form. In this case, an antenna may be combined with the image display device to provide a communication function.

(3) As mobile communication technologies have been rapidly developed, an antenna capable of operating a high frequency or ultra-high frequency communication is needed in the image display device.

(4) To implement a radiation driving of the antenna, a circuit board for a feeding and a control signal transmission may be connected to the antenna. The circuit board may be bent to be connected to, e.g., a driving integrated circuit chip. In this case, damages to circuit wirings and a connection failure with the antenna may be caused due to a bending stress.

(5) Further, as a thickness of the image display device to which the antenna is combined recently decreases, a degree of bending of the circuit board may increase. In this case, the above-described bending defects may be further intensified. Accordingly, an antenna package design to enhance reliability of the bonding of the circuit board and the circuit connection while maintaining or improving radiation properties of the antenna.

(6) For example, Korean Patent Application Publication No. 2013-0095451 discloses an antenna integrated with a display panel, but fails to suggest or provide any efficient circuit connection.

SUMMARY

(7) According to an aspect of the present invention, there is provided an antenna package having improved electrical and mechanical reliability.

(8) According to an aspect of the present invention, there is provided an image display device

including an antenna package with improved electrical and mechanical reliability. (1) An antenna package, including: an antenna unit; and a circuit board bonded to the antenna unit, wherein the circuit board includes: a core layer including a plurality of portions having different widths from each other in a planar view, the core layer having a first surface and a second surface opposing each other; and a circuit wiring disposed on the first surface of the core layer and electrically connected to the antenna unit. (2) The antenna package of the above (1), wherein the core layer includes an antenna connection portion adjacent to the antenna unit and a circuit extension portion having a width smaller than that of the antenna connection portion. (3) The antenna package of the above (2), wherein the antenna connection portion includes a bonding portion bonded to the antenna unit, and an intermediate portion disposed between the bonding portion and the circuit extension portion. (4) The antenna package of the above (3), wherein the intermediate portion has a width smaller than that of the bonding portion and has a larger width than that of the circuit extension portion. (5) The antenna package of the above (4), wherein the intermediate portion includes a first intermediate portion and a second intermediate portion which are sequentially positioned in a direction from the bonding portion to the circuit connection portion, and the second intermediate portion has a width smaller than that of the first intermediate portion. (6) The antenna package of the above (5), wherein the antenna unit includes a plurality of antenna units, the circuit wiring includes first merge wirings coupling a predetermined number of antenna units among the plurality of the antenna units to each other, and a second merge wiring coupling the first merge wirings, and the first merge wirings are disposed on the first intermediate portion, and the second merge wiring is disposed on the second intermediate portion. (7) The antenna package of the above (2), wherein the antenna unit includes a plurality of antenna units, and the circuit wiring includes a plurality of circuit wirings, each of which is independently connected to each of the plurality of the antenna units to continuously extend on the antenna connection portion and the circuit extension portion. (8) The antenna package of the above (2), wherein the circuit wiring includes a plurality of circuit wirings, and the circuit board includes an opening formed in the antenna connection portion between the plurality of the circuit wirings. (9) The antenna package of the above (2), wherein the circuit wiring includes a plurality of circuit wirings, and the circuit board includes a separation slit formed in the circuit extension portion between the plurality of the circuit wirings. (10) The antenna package of the above (2), wherein the circuit board includes an open area continuously formed along the antenna connection portion and the circuit extension portion. (11) The antenna package of the above (10), wherein the circuit wiring includes a plurality of circuit wirings, and the circuit board includes strip lines separated by the open area, and each of the plurality of the circuit wirings extends in each of the strip lines. (12) The antenna package of the above (2), wherein the circuit wiring includes a plurality of circuit wirings disposed on the first surface of the core layer, and a distance between circuit wirings neighboring each other is at least three times each width of the plurality of the circuit wirings. (13) The antenna package of the above (1), wherein the circuit wiring includes a plurality of circuit wirings, and the circuit board further includes a ground layer formed on the second surface of the core layer to commonly cover the plurality of the circuit wirings in a planar view. (14) The antenna package of the above (1), wherein the antenna unit includes: a radiator; a transmission line extending from the radiator; a signal pad formed at an end portion of the transmission line and electrically connected to the circuit wiring of the circuit board; and a ground pad disposed around the signal pad to be separated from the signal pad and the transmission line. (15) The antenna package of the above (14), wherein the circuit board further includes a bonding pad disposed around the circuit wiring on the first surface of the core layer. (16) The antenna package of the above (15), wherein the bonding pad and the ground pad are bonded to each other. (17) An image display device including the antenna package according to exemplary embodiments as described above.

(9) According to exemplary embodiments of the present invention, a circuit board connected to an antenna unit may have a variable width. For example, a bending portion of the circuit board may

have a relatively small width, and thus may be easily bent to be electrically connected to a driving integrated circuit chip.

(10) In some embodiments, the circuit board may include an antenna connection portion having a large width and a circuit extension portion having a small width. A bonding stability with the antenna unit may be achieved by the antenna connection portion, and a bending stability may be improved by the circuit extension portion. The circuit board may include an open region, and bending property may be further improved.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIGS. **1** and **2** are a schematic top planar view and a schematic cross-sectional view, respectively, illustrating an antenna package in accordance with exemplary embodiments.

(2) FIG. **3** is a schematic top planar view illustrating an antenna package in accordance with exemplary embodiments.

(3) FIGS. **4** and **5** are schematic top planar views illustrating antenna packages in accordance with some exemplary embodiments.

(4) FIGS. **6** to **8** are schematic top planar views illustrating antenna packages in accordance with some exemplary embodiments.

(5) FIG. **9** is a schematic top planar view illustrating an antenna package in accordance with some exemplary embodiments.

(6) FIG. **10** is a schematic top planar view illustrating an image display device in accordance with exemplary embodiments.

DETAILED DESCRIPTION OF THE EMBODIMENTS

(7) According to exemplary embodiments of the present invention, there is provided an antenna package including an antenna unit and a circuit board having a variable width. An image display device including the antenna package is also provided.

(8) Hereinafter, the present invention will be described in detail with reference to the accompanying drawings. However, those skilled in the art will appreciate that such embodiments described with reference to the accompanying drawings are provided to further understand the spirit of the present invention and do not limit subject matters to be protected as disclosed in the detailed description and appended claims.

(9) The terms “first”, “second”, “upper”, “lower”, “top”, “bottom”, etc., used in this application are not intended to designate an absolute position, but to relatively distinguish between different elements and positions.

(10) FIGS. **1** and **2** are a schematic top planar view and a schematic cross-sectional view, respectively, illustrating an antenna package in accordance with exemplary embodiments.

(11) Referring to FIG. **1**, the antenna package may include an antenna device **100** and a circuit board **200**. The circuit board **200** may include a core layer **210** and a circuit wiring **220** formed on the core layer **210**. The circuit wiring **220** and an antenna unit **120** included in the antenna device **100** may be electrically connected with each other.

(12) The antenna device **100** may include an antenna dielectric layer **110** and the antenna unit **120** disposed on the antenna dielectric layer **110**.

(13) The antenna dielectric layer **110** may include, e.g., a transparent resin film such as a polyester-based resin such as polyethylene terephthalate, polyethylene isophthalate, polyethylene naphthalate and polybutylene terephthalate; a cellulose-based resin such as diacetyl cellulose and triacetyl cellulose; a polycarbonate-based resin; an acrylic resin such as polymethyl (meth)acrylate and polyethyl (meth)acrylate; a styrene-based resin such as polystyrene and an acrylonitrile-styrene copolymer; a polyolefin-based resin such as polyethylene, polypropylene, a cycloolefin or

polyolefin having a norbornene structure and an ethylene-propylene copolymer; a vinyl chloride-based resin; an amide-based resin such as nylon and an aromatic polyamide; an imide-based resin; a polyethersulfone-based resin; a sulfone-based resin; a polyether ether ketone-based resin; a polyphenylene sulfide resin; a vinyl alcohol-based resin; a vinylidene chloride-based resin; a vinyl butyral-based resin; an allylate-based resin; a polyoxymethylene-based resin; an epoxy-based resin; a urethane or acrylic urethane-based resin; a silicone-based resin, etc. These may be used alone or in a combination of two or more thereof.

(14) The antenna dielectric layer **110** may include an adhesive material such as an optically clear adhesive (OCA), an optically clear resin (OCR), or the like. In some embodiments, the antenna dielectric layer **110** may include an inorganic insulating material such as glass, silicon oxide, silicon nitride, silicon oxynitride, etc.

(15) In some embodiments, a dielectric constant of the antenna dielectric layer **110** may be adjusted in a range from about 1.5 to about 12. When the dielectric constant exceeds about 12, a driving frequency may be excessively decreased, so that driving in a desired high frequency or ultrahigh frequency band may not be implemented.

(16) The antenna unit **120** may be formed on a top surface of the antenna dielectric layer **110**. For example, a plurality of the antenna units **120** may be arranged in an array form along a width direction of the antenna dielectric layer **110** or the antenna package to form an antenna unit row.

(17) The antenna unit **120** may include a radiator **122** and a transmission line **124**. The radiator **122** may have, e.g., a polygonal plate shape, and the transmission line **124** may extend from one side of the radiator **122**. The transmission line **124** may be formed as a single member substantially integral with the radiator **122**.

(18) The antenna unit **120** may further include a signal pad **126**. The signal pad **126** may be connected to an end portion of the transmission line **124**. In an embodiment, the signal pad **126** may be formed as a member substantially integral with the transmission line **124**, and the end portion of the transmission line **124** may serve as the signal pad **126**.

(19) In some embodiments, a ground pad **128** may be disposed around the signal pad **126**. For example, a pair of the ground pads **128** may face each other with the signal pad **126** interposed therebetween.

(20) For example, the ground pad **128** may be electrically and physically separated from the transmission line **124** around the signal pad **126**.

(21) In exemplary embodiments, the antenna unit **120** or the radiator **122** may provide signal transmission/reception in a high frequency or ultra-high frequency band (e.g., a 3G, 4G, 5G or higher communication). In a non-limiting example, a resonance frequency of the antenna unit **120** may be from about 20 to 30 GHz (e.g., about 28 GHz) or from about 30 to 40 GHz (e.g., about 38 GHz).

(22) The antenna unit **120** may include silver (Ag), gold (Au), copper (Cu), aluminum (Al), platinum (Pt), palladium (Pd), chromium (Cr), titanium (Ti), tungsten (W), niobium (Nb), tantalum (Ta), vanadium (V), iron (Fe), manganese (Mn), cobalt (Co), nickel (Ni), zinc (Zn), tin (Sn), molybdenum (Mo), calcium (Ca) or an alloy containing at least one of the metals. These may be used alone or in combination thereof.

(23) In an embodiment, the antenna unit **120** may include silver (Ag) or a silver alloy (e.g., silver-palladium-copper (APC)), or copper (Cu) or a copper alloy (e.g., a copper-calcium (CuCa)) to implement a low resistance and a fine line width pattern.

(24) The antenna unit **120** may include a transparent conductive oxide such as indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnOx), indium zinc tin oxide (IZTO), etc.

(25) In some embodiments, the antenna unit **120** may include a stacked structure of a transparent conductive oxide layer and a metal layer. For example, the antenna unit **120** may include a double-layered structure of a transparent conductive oxide layer-metal layer, or a triple-layered structure of a transparent conductive oxide layer-metal layer-transparent conductive oxide layer. In this case,

flexible property may be improved by the metal layer, and a signal transmission speed may also be improved by a low resistance of the metal layer. Corrosive resistance and transparency may be improved by the transparent conductive oxide layer.

(26) In some embodiments, the radiator **122** and the transmission line **124** may include a mesh-pattern structure to improve transmittance. In this case, a dummy mesh pattern (not illustrated) may be formed around the radiator **122** and the transmission line **124**.

(27) The signal pad **126** and the antenna ground pad **125** may be solid patterns formed of the above-described metal or alloy in consideration of reduction of a feeding resistance, improvement of noise absorption efficiency, etc.

(28) The circuit board **200** may include the core layer **210** and the circuit wirings **220** formed on a surface of the core layer **210**. For example, the circuit board **200** may be a flexible printed circuit board (FPCB).

(29) The core layer **210** may include, e.g., a flexible resin such as polyimide resin, Modified Polyimide (MPI), epoxy resin, polyester, cycloolefin polymer (COP), liquid crystal polymer (LCP), or the like. The core layer **210** may include an inner insulation layer included in the circuit board **200**.

(30) The circuit wiring **220** may be arranged on a first surface **210a** of the core layer **210** (e.g., a bottom surface of the core layer **210** in FIG. 2). For example, the circuit board **200** may further include a coverlay film that may be formed on the first surface **210a** of the core layer **210** to cover the circuit wiring **220**.

(31) The circuit wiring **220** may serve as an antenna feed wiring. For example, the coverlay film of the circuit board **200** may be partially removed to expose an end portion of the circuit wiring **220**. The exposed end portion of the circuit wiring **220** may be bonded onto the signal pad **126**.

(32) For example, a conductive intermediate structure **150** such as an anisotropic conductive film (ACF) may be attached commonly on the signal pads **126** and the ground pads **128**, and then a bonding region BR of the circuit board **200** in which the exposed end portions of the circuit wirings **220** are located may be disposed on the conductive intermediate structure **150**. Thereafter, the bonding region BR of the circuit board **200** may be attached to the antenna device **100** through a heat treatment/pressurization process, such that the circuit wiring **220** may be electrically connected to each signal pad **126**.

(33) The ground pads **128** may be arranged around the signal pad **126**, so that an adhesion to the anisotropic conductive film (ACF) may be enhanced and bonding stability may be improved.

(34) As illustrated in FIG. 1, the circuit wirings **220** may each be individually and independently connected to each antenna unit **120**. Accordingly, a power supply/driving control may be independently performed for each of the plurality of the antenna units **120**. For example, different phase signals may be applied to the antenna units **120** through the circuit wirings **220** connected to each of the antenna units **120**.

(35) The circuit board **200** or the core layer **210** may have a variable width. In exemplary embodiments, the circuit board **200** or the core layer **210** may include an antenna connection portion **210a** and a circuit extension portion **210b** having different widths.

(36) One end portion of the antenna connection portion **210a** may include the bonding region BR, and may be bonded to the pads **126** and **128** of the antenna device **100** via the bonding region BR.

(37) The circuit wirings **220** may extend from the bonding region BR toward an opposite end portion of the circuit board **200**. For example, the circuit wiring **220** may include a bent portion (as indicated by a dashed ellipse in FIG. 1) on the antenna connection portion **210a** to enter the circuit extension portion **210b**.

(38) In exemplary embodiments, the circuit extension portion **210b** may have a width smaller than that of the antenna connection portion **210a**. As described above, the circuit wirings **220** may extend on the circuit extension portion **210b** by the bent portions with a relatively narrow interval therebetween.

(39) An antenna driving integrated circuit (IC) chip **290** may be mounted on the circuit extension portion **210b** or the opposite end portion of the circuit board **200** to be electrically connected to the circuit wirings **220**. Accordingly, feeding and driving signals may be applied to the antenna unit **120** via the circuit wiring **220** by the antenna driving IC chip **290**.

(40) In some embodiments, an intermediate circuit board **280** is disposed on the opposite end portion of the circuit extension portion **210b**, and an antenna driving IC chip **290** may be disposed on the intermediate circuit board **280** using, e.g., a surface mounting technology (SMT).

(41) For example, the intermediate circuit board **280** may have a higher strength or a lower ductility than that of the circuit board **200**. Accordingly, a mounting stability of the antenna driving IC chip **290** may be improved. For example, the intermediate circuit board **280** may include a core layer formed of a resin impregnated with an inorganic material such as glass fiber (e.g., a prepreg), and intermediate circuits formed in the core layer.

(42) As described above, the circuit board **200** may include a plurality of portions having different widths. In exemplary embodiments, sufficient bonding stability with the antenna device **100** may be achieved through the antenna connection portion **210a** having a relatively large width. Additionally, a sufficient spacing between the circuit wirings **220** in the antenna connection portion **210a** may be maintained, so that the independence of the feeding/signal applied to each antenna unit **120** may be improved.

(43) Further, flexible and circuit connection properties of the antenna package may be improved through the circuit extension portion **210b** having a relatively small width. For example, the antenna driving IC chip **290** may be disposed at a rear side of the image display device, and the antenna device **100** may be disposed on a front side of the image display device.

(44) In this case, the circuit extension portion **210b** may be bent toward the rear side of the image display device to facilitate a circuit connection with the antenna driving IC chip **290**. Further, mechanical damages to the circuit wirings **220** due to a stress propagation caused by an excessive increase of a bent area may be prevented, and thus the feeding and signal application with low resistance may be implemented with high reliability.

(45) As illustrated in FIG. 2, a ground layer **230** may be disposed on the second surface **210b** of the core layer **210**. The ground layer **230** may commonly cover the circuit wirings **220** in a planar view. Noise and signal interference around the circuit wiring **220** may be absorbed or shielded by the ground layer **230**. Additionally, generation of an electric field from the circuit wiring **220** may be promoted by the ground layer **230**, thereby improving a signal transmission efficiency.

(46) While reducing the width of the circuit extension portion **210b** as described above, a gap between the circuit wirings **220** may be maintained to implement the sufficient electric field generation by the ground layer **230**. In some embodiments, a distance between the circuit wirings **220** neighboring each other on the circuit extension portion **210b** may be three times or more of a line width of each circuit wiring **220**.

(47) In some embodiments, an antenna ground layer **130** may be formed on a bottom surface of the antenna dielectric layer **110**. The antenna ground layer **130** may overlap the radiator **122** of the antenna unit **120** in a thickness direction. A substantially vertical radiation antenna may be implemented by generating an electric field or inductance between the radiator **122** and the antenna ground layer **130**.

(48) In an embodiment, the antenna ground layer **130** may entirely cover the radiator **122** in a planar view and may not overlap the pads **126** and **128**.

(49) The circuit wiring **220**, the ground layer **230** and the antenna ground layer **130** described above may include the above-described metal and/or alloy.

(50) In an embodiment, a conductive member of a display device to which the antenna package is applied may serve as the antenna ground layer **130**.

(51) The conductive member may include, e.g., a gate electrode of a thin film transistor (TFT) included in a display panel, various wirings such as a scan line or a data line or various electrodes

such as a pixel electrode or a common electrode.

(52) In an embodiment, a metallic member such as a SUS plate, a sensor member such as a digitizer, a heat dissipation sheet, etc., disposed at a rear portion of the display device may serve as the antenna ground layer **130**.

(53) FIG. **3** is a schematic top planar view illustrating an antenna package in accordance with exemplary embodiments.

(54) Referring to FIG. **3**, a plurality of the antenna units **120** may be coupled by a circuit wiring. For example, the circuit wiring may include merge wirings **222** and **224** and a driving signal wiring **226**.

(55) The merge wirings **222** and **224** may be disposed on the antenna connection portion **210a** of the circuit board **200** and may include a first merge wiring **222** and a second merge wiring **224**. The first merge wiring **222** may be bonded with the signal pad **126** of the antenna unit **120**. For example, two radiators **120** may be coupled by the first merge wiring **222** to form a radiation group. The second merge wiring **224** may be connected to a plurality of the first merge wirings **222** to combine the plurality of the radiation groups with each other.

(56) An end portion of the driving signal wiring **226** may be branched from the second merge wiring **224**. The driving signal wiring **226** may extend on the circuit extension portion **210b**, and an opposite end portion of the driving signal wiring **226** may be electrically connected to the antenna driving IC chip **290**.

(57) The coupling construction of the antenna units **110** illustrated in FIG. **3** is an example, and may be appropriately changed in consideration of a size and a radiation type of the antenna device.

(58) FIGS. **4** and **5** are schematic top planar views illustrating antenna packages in accordance with some exemplary embodiments.

(59) Referring to FIG. **4**, the antenna connection portion **210a** described above may also include a plurality of portions having different widths. In exemplary embodiments, the antenna connection portion may include a bonding portion **211a** and an intermediate portion **211b**.

(60) The bonding portion **211a** may include the bonding region BR illustrated in FIG. **1** and may have a sufficient width to cover all of the pads **126** and **128** included in the antenna device **100**.

(61) The intermediate portion **211b** may have a width smaller than that of the bonding portion **211a**. In exemplary embodiments, bent portions of the circuit wirings **220** indicated by a dotted ellipse may be disposed on the intermediate portion **211b**. In exemplary embodiments, the intermediate portion **211b** may have a larger width than that of the circuit extension portion **210b**.

(62) Referring to FIG. **5**, as also described with reference to FIG. **3**, the circuit wirings may include the merge wirings **222** and **224** and the driving signal wiring **226**. The antenna connection portion of the circuit board **200** may include the bonding portion **211a** and the intermediate portion as described with reference to FIG. **4**.

(63) In exemplary embodiments, the intermediate portion may also include a plurality of portions having different widths. For example, the intermediate portion may include a first intermediate portion **211b1** and a second intermediate portion **211b2**.

(64) The first intermediate portion **211b1** may extend from the bonding portion **211a** and may have a width smaller than that of the bonding portion **211a**. In an embodiment, the first merge wiring **222** may be disposed on the first intermediate portion **211b1**.

(65) The second intermediate portion **211b2** may be disposed between the first intermediate portion **211b1** and the circuit extension portion **210b**. The second intermediate portion **211b2** may have a width smaller than that of the first intermediate portion **211b1** and may have a larger width than the circuit extension portion **210b**. In an embodiment, the second merge wiring **224** may be disposed on the second intermediate portion **211b2**.

(66) As described with reference to embodiments of FIGS. **4** and **5**, the intermediate portion may be disposed between the bonding portion **211a** and the circuit extension portion **210b** of the circuit board **200** to sequentially decrease the width of the circuit board. For example, as illustrated in

FIG. 5, the circuit board **200** may have a stepped structure in a planar view.

(67) Accordingly, a bending stress may be sequentially distributed and buffered in the circuit board **200**, and mechanical stability against the bending stress may be further improved.

(68) FIGS. **6** to **8** are schematic top planar views illustrating antenna packages in accordance with some exemplary embodiments.

(69) Referring to FIGS. **6** to **8**, a portion of the circuit board **200** between the circuit wirings **220** neighboring each other may be removed.

(70) As illustrated in FIG. **6**, an opening **240** penetrating the core layer **210** may be formed in the antenna connection portion **210a** of the circuit board **200**. For example, a plurality of the openings **240** may be formed between portions of the circuit wirings **220** formed on the antenna connection portion **210a**.

(71) In some embodiments, the opening **240** may be formed throughout the intermediate portion **211b** and the bonding portion **211a**, and may extend to an end portion of the circuit board **200**.

(72) As illustrated in FIG. **7**, a separation slit **250** may be formed in the circuit extension portion **210b** of the circuit board **200**. For example, a plurality of the separation slits **250** may be formed between portions of the circuit wirings **220** formed on the circuit extension portion **210b**. In an embodiment, the separation slit **250** may extend to an opposite end portion of the circuit board **200**.

(73) The opening **240** and the separation slit **250** may be formed by cutting or removing a portion of the circuit board **200** between the circuit wirings **220** through a cutting process such as laser cutting. In some embodiments, the ground layer **230** may be removed together with the core layer **210** in the opening **240** and the separation slit **250**.

(74) Referring to FIG. **8**, an open area **260** may be continuously formed throughout the antenna connection portion **210a** and the circuit extension portion **210b**. For example, the opening **240** illustrated in FIG. **6** and the separation slit **250** illustrated in FIG. **7** may be merged together to form the open area **260**. In this case, the circuit board **200** may include a strip line **215** on which each circuit wiring **220** may independently extend. The strip lines **215** may be separated from each other by the open area **260**.

(75) As described with reference to in embodiments illustrated in FIGS. **6** to **8**, bending and flexible properties may be further improved by at least partially removing portions of the circuit board **200** between the circuit wirings **220**.

(76) FIG. **9** is a schematic top planar view illustrating an antenna package in accordance with some exemplary embodiments

(77) Referring to FIG. **9**, the circuit board **200** may further include a bonding pad **225** formed around the circuit wiring **220**. The bonding pad **225** may be included in the antenna connection portion **210a** or the bonding portion **211a** of the circuit board **200**.

(78) The bonding pad **225** may be formed on the first surface **210a** (see FIG. **2**) of the core layer **210** together with the circuit wiring **220**. For example, a pair of the bonding pads **225** may be disposed with one circuit wiring **220** interposed therebetween.

(79) The bonding pad **225** may be electrically and physically separated from the circuit wiring **220**, and may be bonded to the ground pad **128** included in the antenna device **100** via the conductive intermediate structure **150** (see FIG. **2**). The bonding pad **225** may be included in the bonding region BR of the circuit board **200**, so that bonding stability of the circuit board **200** and the antenna device **100** may be further improved.

(80) FIG. **10** is a schematic top planar view illustrating an image display device in accordance with exemplary embodiments.

(81) Referring to FIG. **10**, an image display device **300** may be fabricated in the form of, e.g., a smart phone, and FIG. **10** shows a front face portion or a window surface of the image display device **300**. The front face portion of the image display device **300** may include a display area **310** and a peripheral area **320**. The peripheral area **320** may correspond to, e.g., a light-shielding portion or a bezel portion of an image display device.

(82) The antenna device **100** included in the above-described antenna package may be disposed toward the front face portion of the image display device **300**, and may be disposed on, e.g., a display panel. In an embodiment, the radiators **122** may be at least partially superimposed over the display area **310** in a planar view.

(83) In this case, the radiator **122** may have a mesh-pattern structure, and a decrease in transmittance due to the radiator **122** may be prevented. The antenna driving IC chip **290** included in the antenna package may be disposed in the peripheral area **320** to prevent degradation of an image quality in the display area **310**.

(84) In some embodiments, the antenna package may be bent by the circuit board **200** so that, e.g., the antenna driving IC chip **280** may be disposed at a rear portion of the image display device **300**.

(85) As described above, a bending stability in the peripheral area **320** may be improved using the variable width structure of the circuit board **200**. Even when the image display device **300** becomes thinner and a bending curvature of the circuit board **200** increases, high-reliability circuit connection may be implemented without mechanical damages of the circuit wiring **220**.

Claims

1. An antenna package comprising: an antenna device comprising an antenna dielectric layer and an antenna unit disposed directly on a top surface of the antenna dielectric layer; an anisotropic conductive film on a portion of the antenna unit; and a circuit board bonded to the antenna unit, the circuit board electrically connected to the antenna unit via the anisotropic conductive film and physically separated from the antenna unit, the circuit board comprising: a core layer comprising a plurality of portions having different widths from each other in a planar view, the core layer having a first surface and a second surface opposing each other; and a circuit wiring disposed on the first surface of the core layer and electrically connected to the antenna unit via the anisotropic conductive film, wherein the antenna unit comprises: a radiator; a transmission line extending from the radiator; a signal pad formed at an end portion of the transmission line and electrically connected to the circuit wiring of the circuit board; and a ground pad disposed around the signal pad to be separated from the signal pad and the transmission line, wherein the ground pad and the signal pad are disposed at the same level on the top surface of the antenna dielectric layer.
2. The antenna package of claim 1, wherein the core layer comprises an antenna connection portion adjacent to the antenna unit and a circuit extension portion having a width smaller than that of the antenna connection portion.
3. The antenna package of claim 2, wherein the antenna connection portion comprises a bonding portion bonded to the antenna unit, and an intermediate portion disposed between the bonding portion and the circuit extension portion.
4. The antenna package of claim 3, wherein the intermediate portion has a width smaller than that of the bonding portion and has a larger width than that of the circuit extension portion.
5. The antenna package of claim 4, wherein the intermediate portion comprises a first intermediate portion and a second intermediate portion which are sequentially positioned in a direction from the bonding portion to the circuit connection portion; and the second intermediate portion has a width smaller than that of the first intermediate portion.
6. The antenna package of claim 5, wherein the antenna unit includes a plurality of antenna units; the circuit wiring includes first merge wirings coupling a predetermined number of antenna units among the plurality of the antenna units to each other, and a second merge wiring coupling the first merge wirings; and the first merge wirings are disposed on the first intermediate portion, and the second merge wiring is disposed on the second intermediate portion.
7. The antenna package of claim 2, wherein the antenna unit includes a plurality of antenna units; and the circuit wiring includes a plurality of circuit wirings, each of which is independently connected to each of the plurality of the antenna units to continuously extend on the antenna

connection portion and the circuit extension portion.

8. The antenna package of claim 2, wherein the circuit wiring includes a plurality of circuit wirings; and the circuit board includes an opening formed in the antenna connection portion between the plurality of the circuit wirings.

9. The antenna package of claim 2, wherein the circuit wiring includes a plurality of circuit wirings; and the circuit board includes a separation slit formed in the circuit extension portion between the plurality of the circuit wirings.

10. The antenna package of claim 2, wherein the circuit board includes an open area continuously formed along the antenna connection portion and the circuit extension portion.

11. The antenna package of claim 10, wherein the circuit wiring includes a plurality of circuit wirings; and the circuit board includes strip lines separated by the open area, and each of the plurality of the circuit wirings extends in each of the strip lines.

12. The antenna package of claim 2, wherein the circuit wiring includes a plurality of circuit wirings disposed on the first surface of the core layer; and a distance between circuit wirings neighboring each other is at least three times each width of the plurality of the circuit wirings.

13. The antenna package of claim 1, wherein the circuit wiring includes a plurality of circuit wirings; and the circuit board further comprises a ground layer formed on the second surface of the core layer to commonly cover the plurality of the circuit wirings in a planar view.

14. The antenna package of claim 1, wherein the circuit board further comprises a bonding pad disposed around the circuit wiring on the first surface of the core layer.

15. The antenna package of claim 14, wherein the bonding pad and the ground pad are bonded to each other.

16. An image display device comprising the antenna package of claim 1.
