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Wiring board, package for containing electronic component, electronic device, and electronic module

Abstract

A wiring board includes a base, a signal conductor, two first ground conductors, a second ground conductor, and connection conductors. The base is composed of a dielectric and includes a first surface and a second surface opposite to the first surface. The signal conductor is disposed on the first surface and extends to an end portion of the base. The two first ground conductors are disposed on the first surface and extend to the end portion with the signal conductor disposed between the first ground conductors. The second ground conductor is disposed in the base or on the second surface. The second ground conductor faces the signal conductor and extends to the end portion. The connection conductors electrically connect respective ones of the first ground conductors to the second ground conductor. The signal conductor and the second ground conductor are separated from each other by a distance H.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates to a wiring board, a package for containing an electronic component, an electronic device, and an electronic module.

BACKGROUND OF INVENTION

(2) A known wiring board includes a signal conductor, first ground conductors, and a second

ground conductor (for example, a relay substrate described in Japanese Unexamined Patent Application Publication No. 2006-086146). The signal conductor extends to an end portion of a substrate surface. The first ground conductors extend to the end portion of the substrate surface with the signal conductor disposed between the first ground conductors. The second ground conductor faces the signal conductor and extends to an end portion of a substrate. This structure enables low-loss transmission of a high-frequency signal to an end portion of the wiring board.

SUMMARY

Solution to Problem

(3) In the present disclosure, a wiring board includes a base, a signal conductor, two first ground conductors, a second ground conductor, and connection conductors. The base is composed of a dielectric and includes a first surface and a second surface opposite to the first surface. The signal conductor is disposed on the first surface and extends to an end portion of the base. The two first ground conductors are disposed on the first surface and extend to the end portion with the signal conductor disposed between the first ground conductors. The second ground conductor is disposed in the base or on the second surface. The second ground conductor faces the signal conductor and extends to the end portion. The connection conductors electrically connect respective ones of the first ground conductors to the second ground conductor. The signal conductor and the second ground conductor are separated from each other by a distance H. At least one selected from the group consisting of the signal conductor and the first ground conductors includes a pattern disposed at a distance of equal to or greater than ⅓ of the distance H and equal to or less than the distance H from the end portion. The pattern is inductive.

(4) In the present disclosure, a package for containing an electronic component includes the above-described wiring board and a metal case configured to contain an electronic component.

(5) In the present disclosure, an electronic device includes the above-described package for containing an electronic component and an electronic component mounted in the package for containing an electronic component.

(6) In another aspect of the present disclosure, an electronic device includes the above-described wiring board and an electronic component electrically connected to the wiring board.

(7) In the present disclosure, an electronic module includes the above-described electronic device and a module substrate. The electronic device is mounted on the module substrate.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view of a package for containing an electronic component and an electronic device according to an embodiment of the present disclosure.

(2) FIG. **2**A is a perspective view of a wiring board according to the embodiment.

(3) FIG. **2**B is a cutaway perspective view of the wiring board according to the embodiment that is vertically cut.

(4) FIG. **3**A is a perspective view of a relevant part removed from the wiring board according to the embodiment and viewed from above.

(5) FIG. **3**B is a perspective view of the relevant part removed from the wiring board according to the embodiment and viewed from below.

(6) FIG. **4**A is a perspective view of patterns according to a first reference example.

(7) FIG. **4**B is a perspective view of patterns according to a first embodiment.

(8) FIG. **4**C is a perspective view of patterns according to a second embodiment.

(9) FIG. **4**D is a perspective view of patterns according to a third embodiment.

(10) FIG. **4**E is a perspective view of patterns according to a second reference example.

(11) FIG. **5**A is a graph illustrating return loss characteristics of the first and second reference

examples and the first to third embodiments.
(12) FIG. **5**B is a graph illustrating insertion loss characteristics of the first and second reference examples and the first to third embodiments.
(13) FIG. **6**A is a perspective view of a pattern according to a fourth embodiment.
(14) FIG. **6**B is a perspective view of patterns according to a fifth embodiment.
(15) FIG. **6**C is a perspective view of patterns according to a sixth embodiment.
(16) FIG. **7**A is a graph illustrating return loss characteristics of the first reference example and the fourth to sixth embodiments.
(17) FIG. **7**B is a graph illustrating insertion loss characteristics of the first reference example and the fourth to sixth embodiments.
(18) FIG. **8**A is a perspective view of a pattern according to a seventh embodiment.
(19) FIG. **8**B is a perspective view of a pattern according to an eighth embodiment.
(20) FIG. **8**C is a perspective view of patterns according to a ninth embodiment.
(21) FIG. **9**A is a graph illustrating return loss characteristics of the first reference example and the seventh to ninth embodiments.
(22) FIG. **9**B is a graph illustrating insertion loss characteristics of the first reference example and the seventh to ninth embodiments.
(23) FIG. **10**A is a perspective view of patterns according to a tenth embodiment.
(24) FIG. **10**B is a perspective view of patterns according to an eleventh embodiment.
(25) FIG. **10**C is a perspective view of patterns according to a twelfth embodiment.
(26) FIG. **10**D is a perspective view of patterns according to a thirteenth embodiment.
(27) FIG. **11**A is a graph illustrating return loss characteristics of the first reference example and the tenth to thirteenth embodiments.
(28) FIG. **11**B is a graph illustrating insertion loss characteristics of the first reference example and the tenth to thirteenth embodiments.
(29) FIG. **12** illustrates an electronic device and an electronic module according to an embodiment of the present disclosure.
(30) FIG. **13** is an exploded perspective view of an electronic device according to another embodiment of the present disclosure.
(31) FIG. **14**A is a sectional view of an electronic device according to another embodiment of the present disclosure.
(32) FIG. **14**B is a plan view of an electronic device according to another embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

(33) Embodiments of the present disclosure will be described in detail with reference to the drawings.
(34) FIG. **1** is a perspective view of a package for containing an electronic component and an electronic device according to an embodiment of the present disclosure. In the present disclosure, a package **1** for containing an electronic component includes a metal case **4**, wiring boards **7**, non-high-frequency wiring boards **8**, and a lid **5**. The metal case **4** includes a recess U**1** and is made of a metal. The wiring boards **7** and the non-high-frequency wiring boards **8** are attached to the metal case **4**. The lid **5** covers an opening of the recess U**1**. The metal case **4** includes a wall **4**B and a bottom **4**C. The wall **4**B surrounds the recess U**1**. The recess U**1** accommodates an electronic component **101**. Bonding wires serving as connection members w electrically connect terminals of the electronic component **101** to the wiring boards **7** and the non-high-frequency wiring boards **8**.
(35) The metal case **4** includes through holes h**4***a* to h**4***d* extending through the wall **4**B. The wiring boards **7** and the non-high-frequency wiring boards **8** are fitted to the through holes h**4***a* to h**4***d* and block the through holes h**4***a* to h**4***d*. Thus, the wiring boards **7** and the non-high-frequency wiring boards **8** are attached to the metal case **4**. The metal case **4** may include a mount base **4**D. The mount base **4**D supports the wiring boards **7** and the non-high-frequency wiring boards **8** from

below in a region outside the wall **4**B. The mount base **4**D and the bottom **4**C may be an integral plate. In such a case, the mount base **4**D may be an outer edge portion of the bottom **4**C protruding outward from the wall **4**B. The wiring boards **7** and the non-high-frequency wiring boards **8** are disposed on the bottom **4**C in a region inside the wall **4**B and on the mount base **4**D in a region outside the wall **4**B. The recess U**1** is sealed when the lid **5** is joined to the metal case **4**.

(36) The wiring boards **7** transmit a high-frequency signal. The non-high-frequency wiring boards **8** guide, for example, a non-high-frequency signal or voltage, such as a power supply voltage. In the following description, end portions of the wiring boards **7** and the non-high-frequency wiring boards **8** disposed in the recess U**1** are referred to as “inner end portions”, and end portions on the exterior of the package are referred to as “outer end portions”. The end portions are portions including ends and regions around the ends. The wiring boards **7** correspond to a wiring board according to the present disclosure.

(37) Each of the non-high-frequency wiring boards **8** includes an insulative base **8**A and wiring conductors **8**B. The wiring conductors **8**B extend from an inner end portion to an outer end portion of the base **8**A and are exposed on an upper surface of the base **8**A in regions inside and outside the recess U**1**. The wiring conductors **8**B exposed on the upper surface of the base **8**A include inner end portions to which respective ones of the connection members w, such as bonding wires, are connectable. The wiring conductors **8**B include outer end portions to which terminal members, such as lead terminals for providing external connections, are connectable.

(38) FIG. **2**A is a perspective view of a wiring board according to the embodiment. FIG. **2**B is a cutaway perspective view of the wiring board that is vertically cut. FIGS. **3**A and **3**B illustrate a relevant part removed from the wiring board according to the embodiment. FIG. **3**A is a perspective view of the relevant part viewed from above. FIG. **3**B is a perspective view of the relevant part viewed from below. In FIGS. **1**, **2**A, and **2**B and structural drawings described below, the hatched regions are film-shaped conductors. In FIGS. **2**A and **2**B, the thick solid lines are ends of the film-shaped conductors at an end surface or a cross section of a base **7**A.

(39) As illustrated in FIGS. **2**A and **2**B, each wiring board **7** includes a signal conductor **70**, first ground conductors **71**, a second ground conductor **72**, a third ground conductor **73**, connection conductors **75**, connection conductors **76**, and the base **7**A. The connection conductors **75** electrically connect the first ground conductors **71** to the second ground conductor **72**. The connection conductors **76** electrically connect the first ground conductors **71** to the third ground conductor **73**. The conductors are disposed in and/or on the base **7**A.

(40) The base **7**A is composed of a dielectric. The base **7**A may include a multilayer structure including a plurality of dielectric layers **7***a*. The dielectric may be a ceramic. The base **7**A includes a plate-shaped portion **7**A**1** and a step portion **7**A**2**. The plate-shaped portion **7**A**1** is plate-shaped and includes a first surface S**1**. The step portion **7**A**2** is step-shaped and projects from the plate-shaped portion **7**A**1**. The step portion **7**A**2** is disposed on the first surface S**1** at a location between an inner end portion and an outer end portion of the plate-shaped portion **7**A**1**. The step portion **7**A**2** is in contact with the wall **4**B of the metal case **4** and insulates the wall **4**B and the signal conductor **70** from each other.

(41) The signal conductor **70**, the first ground conductors **71**, the second ground conductor **72**, and the third ground conductor **73** are film-shaped conductors. The shapes of the signal conductor **70**, the first ground conductors **71**, the second ground conductor **72**, and the third ground conductor **73** may be, but are not particularly limited to, a flat shape.

(42) The width and thickness of the signal conductor **70**, the interval between each first ground conductor **71** and the signal conductor **70**, the interval between the signal conductor **70** and the second ground conductor **72**, the interval between the signal conductor **70** and the third ground conductor **73**, and the intervals between the connection conductors **75** and **76** are designed to match a predetermined impedance in accordance with the frequency of a transmission signal and the relative dielectric constant of the base **7**A. The interval between each first ground conductor **71** and

the third ground conductor **73** is designed to be ¼ or less of the effective wavelength of the high-frequency signal. The interval between the connection conductors **75** disposed on both sides of the signal conductor **70** is designed to be ½ or less of the effective wavelength of the high-frequency signal. The frequency of the signal may be in the 80 GHz band or higher than the 80 GHz band.

(43) The signal conductor **70** extends from the inner end portion to the outer end portion along the first surface S**1** of the plate-shaped portion **7**A**1**. The signal conductor **70** may extend along a straight line.

(44) The first ground conductors **71** extend from the inner end portion to the outer end portion along the first surface S**1** of the plate-shaped portion **7**A**1**. The signal conductor **70** is disposed between and spaced from two first ground conductors **71** in a transverse direction of the signal conductor **70**.

(45) The second ground conductor **72** extends from the inner end portion to the outer end portion of the plate-shaped portion **7**A**1** in the plate-shaped portion **7**A**1**. The second ground conductor **72** faces the signal conductor **70** and is separated from the signal conductor **70** by a constant distance H (see FIG. **2**B) over the entire region of the signal conductor **70** in the longitudinal direction of the signal conductor **70**. The distance between the signal conductor **70** and the second ground conductor **72** is H. The second ground conductor **72** also faces each first ground conductor **71** and is separated from the first ground conductor **71** by the distance H. The second ground conductor **72** may be disposed on a second surface S**2** of the plate-shaped portion **7**A**1**, the second surface S**2** being opposite to the first surface S**1**. The second ground conductor **72** can be regarded as facing each of the signal conductor **70** and the first ground conductors **71** with a dielectric of thickness H disposed between the second ground conductor **72** and each of the signal conductor **70** and the first ground conductors **71**. The second ground conductor **72** extends to positions separated from side surfaces of the base **7**A (FIG. **2**A). However, the second ground conductor **72** may extend to the side surfaces of the base **7**A.

(46) The third ground conductor **73** extends from an inner end portion to an outer end portion of the step portion **7**A**2** in the step portion **7**A**2**. The third ground conductor **73** extends at a constant distance from the signal conductor **70** and the first ground conductors **71**.

(47) As illustrated in FIGS. **3**A and **3**B, each connection conductor **75** includes castellation conductors **75***c* and a plurality of via conductors **75***v*. The castellation conductors **75***c* are disposed on inner and outer sides of the plate-shaped portion **7**A**1** (inside and outside the recess U**1**). Each via conductor **75***v* extends between a corresponding one of the first ground conductors **71** and the second ground conductor **72** in the plate-shaped portion **7**A**1**. The castellation conductors **75***c* are film-shaped conductors disposed on surfaces of grooves (or recesses) K**1** on the inner and outer sides of the plate-shaped portion **7**A**1**. The grooves K**1** and the castellation conductors **75***c* may be omitted. In place of the castellation conductors **75***c*, the via conductors **75***v* may be disposed near the inner and outer end portions of the plate-shaped portion **7**A**1**. As described above, the interval between two connection conductors **75** (two castellation conductors **75***c*) in the direction in which the connection conductors **75** face each other with the signal conductor **70** disposed therebetween is ½ or less of the effective wavelength of the high-frequency signal. The interval between the via conductors **75***v* in the plate-shaped portion **7**A**1** in the direction in which the via conductors **75***v* face each other with the signal conductor **70** disposed therebetween is also ½ or less of the effective wavelength of the high-frequency signal. The intervals between the via conductors **75***v* in the direction in which the via conductors **75***v* are arranged along the signal conductor **70** are ¼ or less of the effective wavelength of the high-frequency signal.

(48) As illustrated in FIGS. **2**A and **2**B, each connection conductor **76** includes castellation conductors and a plurality of via conductors that are not illustrated. The castellation conductors are disposed on inner and outer sides of the step portion **7**A**2** (inside and outside the recess U**1**). Each via conductor extends between a corresponding one of the first ground conductors **71** and the third ground conductor **73** in the step portion **7**A**2**. The castellation conductors are film-shaped

conductors disposed on surfaces of grooves (or recesses) K**2** on the inner and outer sides of the step portion **7**A**2**. The grooves K**2** and the castellation conductors may be omitted. In place of the castellation conductors, the via conductors may be disposed near the inner and outer end portions of the step portion **7**A**2**. The third ground conductor **73** and the connection conductors **76** may be omitted.

(49) <Inductive Patterns>

(50) As illustrated in FIGS. **2**A and **2**B, the signal conductor **70** includes inductive patterns Q**1** located at a distance in the range of H/3 or more and H or less from an end of the first surface S**1**. Here, H is the distance between the signal conductor **70** and the second ground conductor **72**. In FIG. **1**, the patterns Q**1** are simplified, and the positions and sizes thereof differ from the actual positions and sizes. In place of the patterns Q**1** of the signal conductor **70**, the first ground conductors **71** may include inductive patterns at sides adjacent to the signal conductor **70**. An inductive pattern is a pattern that causes an increase in an inductance of the signal conductor **70** compared to that when the pattern is not present in a region including the pattern.

(51) <Effects of Patterns>

(52) At the inner and outer end portions of the plate-shaped portion **7**A**1**, the connection conductors **75** and the second ground conductor **72** are terminated in a signal transmission direction (longitudinal direction of the signal conductor **70**). Accordingly, as illustrated in FIG. **3**A, a current path R**1** is formed along an end surface of the wiring board **7**. When inductance components L**1** are generated on the current path R**1**, current density is reduced in a central portion P**1** of the second ground conductor **72**. Thus, the ground voltage becomes unstable. In the present embodiment, the patterns Q**1** of the signal conductor **70** or the patterns of the first ground conductors **71** at the sides adjacent to the signal conductor **70** generate an inductance component in a region near the end portion of the signal conductor **70**. Accordingly, the inductance component is matched with the inductance components L**1** on the current path R**1**, so that degradation of high-frequency characteristics of signal transmission is reduced. Thus, the high-frequency characteristics of signal transmission can be improved.

(53) FIGS. **5**A and **5**B are graphs illustrating the results of simulations of return loss characteristics and insertion loss characteristics of the wiring board **7** according to a first embodiment. The graphs of FIGS. **5**A and **5**B also illustrate the characteristics of a first reference example illustrated in FIG. **4**A and a second reference example illustrated in FIG. **4**E. In the first reference example illustrated in FIG. **4**A, the signal conductor **70** and the first ground conductors **71** include no inductive patterns. In the second reference example illustrated in FIG. **4**E, inductive patterns Q**80** extend to a location at a distance of H/3 or less from the end portion of the first surface S**1**.

(54) As is clear from the comparison between the curve of the first embodiment and the curve of the first reference example in FIGS. **5**A and **5**B, according to the wiring board **7** of the first embodiment, since the patterns Q**1** are provided, the return loss in a high frequency band is reduced, and the attenuation of an insertion signal in a high frequency band is also reduced.

(55) As is clear from the comparison between the curve of the first embodiment and the curve of the second reference example in FIGS. **5**A and **5**B, when the inductive patterns Q**1** are separated from the end of the first surface S**1** by H/3 or more, the return loss in a high frequency band is reduced, and the attenuation of an insertion signal in a high frequency band is also reduced.

(56) <Examples of Patterns>

(57) Examples of inductive patterns will now be described. FIG. **4**A is a perspective view of patterns according to the first reference example. FIGS. **4**B to **4**D are perspective views of patterns according to first to third embodiments. FIG. **4**E is a perspective view of the patterns according to the second reference example. FIGS. **6**A to **6**C are perspective views of patterns according to fourth to sixth embodiments. FIGS. **8**A to **8**C are perspective views of patterns according to seventh to ninth embodiments. FIGS. **10**A to **10**D are perspective view of patterns according to tenth to thirteenth embodiments. Patterns Q**1** to Q**13** according to the first to thirteenth embodiments are

located at a distance in the range of H/3 or more and H or less from the end of the first surface S**1**. In the following description, a direction that is along a film surface of the signal conductor **70** and orthogonal to the longitudinal direction of the signal conductor is referred to as a transverse direction of the signal conductor **70**.

(58) The patterns Q**1** of the first embodiment illustrated in FIG. **4**B are cutouts, and are provided on the signal conductor **70**. The patterns Q**1** are cutouts having the shape of a recess (which may be an angular or rounded recess). Each cutout may have a constant width from a front end to a rear end in a depth direction of the cutout (transverse direction of the signal conductor **70**). The front end of each cutout means the open side of the cutout that is partially open. The rear end of each cutout means the side opposite to the open side of the cutout that is partially open. The signal conductor **70** includes the patterns Q**1** on one and the other sides of the signal conductor **70** in the transverse direction, but may include only the pattern Q**1** on one side of the signal conductor **70**. The patterns Q**1** provide an effect of thinning the signal conductor **70** (reducing the cross-sectional area of the current path). When the signal conductor **70** includes a thin portion, the current density increases in the thin portion, and the magnetic flux density increases in a region around the thin portion. Therefore, the inductance component increases. According to the patterns Q**1**, the distances between the signal conductor **70** and the first ground conductors **71** increase, so that the capacitance component decreases in this region. Thus, the patterns Q**1** effectively generate an inductance component in the signal conductor **70**.

(59) The patterns Q**2** of the second embodiment illustrated in FIG. **4**C are cutouts, and are provided on the first ground conductors **71** at the sides adjacent to the signal conductor **70**. The patterns Q**2** are cutouts having the shape of a recess (which may be an angular or rounded recess). Each cutout may have a constant width from the front end to the rear end in the depth direction of the cutout (transverse direction of the signal conductor **70**). The first ground conductors **71** include the patterns Q**2** on one and the other sides of the signal conductor **70**, but may include only the pattern Q**2** on one side of the signal conductor **70**. According to the patterns Q**2**, the distances between the signal conductor **70** and the first ground conductors **71** increase, so that the capacitance component decreases in this region. Thus, an inductance component can be generated in the signal conductor **70**.

(60) The patterns Q**3** of the third embodiment illustrated in FIG. **4**D are combinations of the patterns Q**1** of the first embodiment and the patterns Q**2** of the second embodiment. This structure also provides an effect the same as and/or similar to those of the first and second embodiments, so that an inductance component can be generated in the signal conductor **70** in a region including the patterns Q**3**.

(61) The pattern Q**4** of the fourth embodiment illustrated in FIG. **6**A is a cutout, and is provided only on one side of the signal conductor **70** in the transverse direction. The cutout is shaped as in the first embodiment. Since the cutout is provided only on one side, the cutout may have a depth equal to or greater than half the width of the signal conductor **70**. The pattern Q**4** provides an effect the same as and/or similar to that of the first embodiment, so that an inductance component can be generated in the signal conductor **70**.

(62) The patterns Q**5***a* and Q**5***b* of the fifth embodiment illustrated in FIG. **6**B are two cutouts, one being provided on the signal conductor **70** at one side in the transverse direction and the other being provided on the first ground conductor **71** at the other side in the transverse direction. The cutouts (Q**5***a* and Q**5***b*) have a shape the same as and/or similar to that of the patterns Q**1** of the first embodiment, but may have a shape the same as and/or similar to that of any of the patterns Q**10** to Q**13** of the tenth to thirteenth embodiments described below.

(63) The patterns Q**5***a* and Q**5***b* of the fifth embodiment also provide an effect the same as and/or similar to those of the first and second embodiments, so that an inductance component can be generated in the signal conductor **70**. The results of simulations imply that when the signal conductor **70** and one of the first ground conductors **71** include respective ones of cutouts (Q**5***a* and

Q**5**b), high-frequency characteristics of signal transmission can be improved by disposing the cutouts (Q**5**a and Q**5**b) at opposite sides of the signal conductor **70** in the transverse direction.
(64) The patterns Q**6**a and Q**6**b of the sixth embodiment illustrated in FIG. **6**C are two cutouts, one being provided on the signal conductor **70** at one side in the transverse direction and the other being provided on the first ground conductor **71** at the same side in the transverse direction. Therefore, the patterns Q**6**a and Q**6**b face each other with a gap therebetween. The cutouts (Q**6**a and Q**6**b) have a shape the same as and/or similar to that of the patterns Q**1** of the first embodiment, but may have a shape the same as and/or similar to that of any of the patterns Q**10** to Q**13** of the tenth to thirteenth embodiments described below. The patterns Q**6**a and Q**6**b of the sixth embodiment also provide an effect the same as and/or similar to those of the first and second embodiments, so that an inductance component can be generated in the signal conductor **70**.
(65) The pattern Q**7** of the seventh embodiment illustrated in FIG. **8**A is a through hole positioned in a central region of the signal conductor **70** in the transverse direction. The through hole of the pattern Q**7** may have a rectangular shape, a rounded shape, or any other shape. The pattern Q**7** provides an effect of thinning the signal conductor **70**, and an inductance component can be generated in this region.
(66) The pattern Q**8** according to the eighth embodiment illustrated in FIG. **8**B is a hole extending in the signal conductor **70** and the base **7**A (plate-shaped portion **7**A**1**). The hole may be disposed in a central region of the signal conductor **70** in the transverse direction and have a depth of about half the distance to the second ground conductor **72** (H/2). The pattern Q**8** provides an effect of thinning the current path of the signal conductor **70** and an effect of reducing the capacitance component in a region including the pattern Q**8**. Thus, an inductance component can be generated in this region.
(67) The patterns Q**9**a and Q**9**b of the ninth embodiment illustrated in FIG. **8**C include a dividing portion (Q**9**a) and connection members (Q**9**b). The dividing portion (Q**9**a) divides the signal conductor **70** into two sections in the longitudinal direction. The connection members Q**9**b are, for example, bonding wires, and provide electrical connection between the two sections into which the signal conductor **70** is divided. The patterns Q**9**a and Q**9**b provide an effect of thinning the current path in this region, and the capacitance component decreases because the patterns Q**9**b (connection members) are separated from the base **7**A (plate-shaped portion **7**A**1**) that is a dielectric. Therefore, an inductance component can be generated in this region of the signal conductor **70**.
(68) The patterns Q**10** of the tenth embodiment illustrated in FIG. **10**A are cutouts having the shape of a recess. Each cutout has a width that is greater at the rear end than at the front end. In each pattern Q**10**, the cutout has a width that gradually increases over the entire region of the cutout in the depth direction, but may include a portion wider at the rear end than at the front end. The signal conductor **70** includes the patterns Q**10** on both sides thereof in the transverse direction, but may include only the pattern Q**10** on one side thereof.
(69) The patterns Q**10** provide an effect of thinning the signal conductor **70**, and the distances between the signal conductor **70** and the first ground conductors **71** increase, so that the capacitance component decreases. Therefore, an inductance component can be effectively generated. Since the cutout of each pattern Q**10** is narrow at the front end, influence on coupling between the signal conductor **70** and the first ground conductors **71** in high-frequency transmission can be reduced. Since the cutout of each pattern Q**10** is wide at the rear and, the length of the thin portion of the signal conductor **70** can be increased. Therefore, variations in characteristics due to impedance mismatching in a frequency band for signal transmission can be reduced, and transmission characteristics can be improved.
(70) The patterns Q**11** of the eleventh embodiment illustrated in FIG. **10**B are cutouts having the shape of a recess. Each cutout has a width that is smaller at the rear end than at the front end. In each pattern Q**11**, the cutout has a width that gradually decreases over the entire region of the cutout in the depth direction, but may include a portion narrower at the rear end than at the front

end. The signal conductor **70** includes the patterns Q**11** on both sides thereof in the transverse direction, but may include only the pattern Q**11** on one side thereof. The patterns Q**11** also provide an effect of thinning the signal conductor **70** and an effect of reducing the capacitance component of the signal conductor **70**. Therefore, an inductance component can be generated in this region.
(71) The patterns Q**12** of the twelfth embodiment illustrated in FIG. **10**C are cutouts having the shape of a recess, and are provided on the first ground conductors **71** at the sides adjacent to the signal conductor **70**. Each cutout has a width that is greater at the rear end than at the front end. In each pattern Q**12**, the cutout has a width that gradually increases over the entire region of the cutout in the depth direction, but may include a portion that is wider at the rear end than at the front end. The first ground conductors **71** include the patterns Q**12** on one and the other sides of the signal conductor **70**, but may include only the pattern Q**12** on one side of the signal conductor **70**. The patterns Q**12** also provide an effect the same as and/or similar to that of the patterns Q**2** according to the second embodiment, so that an inductance component can be generated in the signal conductor **70** at a location near the patterns Q**12**.
(72) The patterns Q**13** of the thirteenth embodiment illustrated in FIG. **10**D are cutouts having the shape of a recess, and are provided on the first ground conductors **71** at the sides adjacent to the signal conductor **70**. Each cutout has a width that is smaller at the rear end than at the front end. In each pattern Q**13**, the cutout has a width that gradually decreases over the entire region of the cutout in the depth direction, but may include a portion that is narrower at the rear end than at the front end. The first ground conductors **71** include the patterns Q**13** on one and the other sides of the signal conductor **70**, but may include only the pattern Q**13** on one side of the signal conductor **70**. The patterns Q**13** also provide an effect the same as and/or similar to that of the patterns Q**2** according to the second embodiment, so that an inductance component can be generated in the signal conductor **70** at a location near the patterns Q**13**.
(73) FIGS. **5**A and **5**B are graphs illustrating return loss characteristics and insertion loss characteristics of the first and second reference examples and the first to third embodiments. FIGS. **7**A, **9**A, and **11**A and FIGS. **7**B, **9**B, and **11**B are graphs illustrating return loss characteristics and insertion loss characteristics of the first reference example and the fourth to thirteenth embodiments. As is clear from the graphs, according to the wiring boards **7** of the first to thirteenth embodiments including the patterns Q**1** to Q**13**, the return loss and the attenuation of an insertion signal in a high frequency region are less than those in the first reference example including no patterns (FIG. **4**A).
(74) As described above, according to the wiring boards **7** of the first to thirteenth embodiments, the patterns Q**1** to Q**13** enable an improvement of the high-frequency characteristics of signal transmission. According to the package **1** for containing an electronic component including the wiring boards **7**, the wiring boards **7** allow transmission of a high-frequency signal inside and outside the recess U**1**, and the patterns Q**1** to Q**13** enable an improvement of the high-frequency characteristics of signal transmission.
(75) (Electronic Device and Electronic Module)
(76) FIG. **12** illustrates an electronic device and an electronic module according to an embodiment of the present disclosure. As illustrated in FIGS. **1** and **12**, an electronic device **100** according to the present embodiment includes the package **1** for containing an electronic component, the electronic component **101**, and the lid **5**. The electronic component **101** is mounted in the recess U**1**. The lid **5** covers the opening of the recess U**1**. The electronic component **101** inputs and outputs a high-frequency signal. The electronic component **101** may be, for example, a semiconductor device or an optical communication device, and the type thereof is not particularly limited. The electronic component **101** includes signal electrodes and ground electrodes at a height that is the same as and/or similar to the height of the first surface S**1** (FIG. **2**A) of the base **7**A. The connection members w, such as bonding wires, electrically connect the signal electrodes to respective ones of the signal conductors **70** of the wiring boards **7**, and the ground electrodes to respective ones of the

first ground conductors **71** disposed on one and the other sides of each signal conductor **70**. The electronic component **101** also includes power supply electrodes. The connection members w, such as bonding wires, also electrically connect the power supply electrodes to respective ones of the wiring conductors **8**B of the non-high-frequency wiring boards **8**.

(77) Each wiring board **7** may include a conductor film on an upper surface or a lower surface of the wiring board **7**, the conductor film being electrically connected to the first ground conductors **71**, the second ground conductor **72**, and the third ground conductor **73**. The conductor film may be electrically connected to the metal case **4**. In such a case, the connection between the electronic component **101** and the first ground conductors **71** by the corresponding connection members w may be omitted.

(78) FIG. **13** illustrates an electronic device according to another embodiment of the present disclosure. An electronic device **130** according to the present embodiment includes a wiring board **17** and an electronic component **101**B mounted on the wiring board **17**. The wiring board **17** includes a base **17**A, signal conductors **170**, first ground conductors **171**, a second ground conductor **172**, and connection conductors **175**. The base **17**A includes a first surface S**11** and a second surface S**12** opposite to the first surface S**11**. The signal conductors **170** are disposed on the first surface S**11** and extend to outer end portions. The first ground conductors **171** are disposed on the first surface S**11** and extend to the outer end portions. The second ground conductor **172** extends to the outer end portions of the base **17**A in the base **17**A. The connection conductors **175** electrically connect the first ground conductors **171** to the second ground conductor **172**. Each signal conductor **170** is disposed between and spaced from two first ground conductors **171** in the transverse direction of the signal conductor **170**. The second ground conductor **172** may be disposed on the second surface S**12**. The base **17**A is composed of a dielectric, and may include a multilayer structure including a plurality of dielectric layers.

(79) The structures of the signal conductors **170**, the first ground conductors **171**, the second ground conductor **172**, and the connection conductors **175** are the same as and/or similar to those of the signal conductor **70**, the first ground conductors **71**, the second ground conductor **72**, and the connection conductors **75** in the above-described embodiment. However, although the signal conductor **70** and the first ground conductors **71** described above extend from one end portion to the other end portion of the base **7**A, each of the signal conductors **170** and the first ground conductors **171** extends to one end portion (outer end portion) of the base **17**A while the other end (inner end portion) thereof terminates on the first surface S**11**. Each pattern Q**1** is disposed near one end portion of the base **17**A. In FIG. **13**, the patterns Q**1** are simplified, and the positions and sizes thereof differ from the actual positions and sizes.

(80) The signal conductors **170** and the first ground conductors **171** terminate at locations near the region in which the electronic component **101**B is mounted, and are electrically connected to respective electrodes of the electronic component **101**B by connection members w, such as bonding wires.

(81) The wiring board **17** may include structures that are the same as and/or similar to the third ground conductor **73** and the connection conductors **76** of the above-described embodiment.

(82) The wiring board **17** and the base **17**A may include a recess U**2** that accommodates the electronic component **101**B. A lid **15** may cover an opening of the recess U**2**. Alternatively, the wiring board **17** may include no recess U**2** and include a plate-shaped structure with the first surface S**11** serving as a plate surface.

(83) FIG. **14**A is a sectional view of an electronic device according to another embodiment of the present disclosure. FIG. **14**B is a plan view of the electronic device. The sectional view of FIG. **14**A is taken along line A-A in FIG. **14**B. In FIG. **14**B, a lid **25** is omitted.

(84) An electronic device **140** according to the embodiment illustrated in FIGS. **14**A and **14**B includes a metal case **24**, a wiring board **27**, an electronic component **101**C, a lid **25**, a coaxial component **28**, and a window member **29**. The wiring board **27** serves as a relay substrate. The

coaxial component **28** includes a central conductor and an outer peripheral conductor, and transmits a high-frequency signal. The window member **29** transmits an optical signal. The metal case **24** includes a wall **24**B, a bottom **24**C, and a recess U**3** surrounded by the wall **24**B and the bottom **24**C. A block M**1** is disposed in the recess U**3**. The block M**1** matches the heights of the wiring board **27** and the electronic component **101**C with the heights of signal paths. The wiring board **27** and the electronic component **101**C are mounted on the block M**1**. The block M**1** may be integrated with the metal case **24**. Alternatively, depending on the height of the wiring board **27** and the height of the electronic component **101**C, the block M**1** may be omitted. The lid **25** is joined to the top surface of the wall **24**B and seals the recess U**3**. The wall **24**B includes a through hole h**24***a* and a through hole h**24***b*. The through hole h**24***a* accommodates the coaxial component **28**. The through hole h**24***b* transmits the optical signal. The coaxial component **28** is accommodated in the through hole h**24***a*, and the outer peripheral conductor of the coaxial component **28** is joined to the wall **24**B with a conductive joining material. The window member **29** is light transmissive, and is fixed with a fixation member **29***a* to block the through hole h**24***b*. The electronic component **101**C is an optical semiconductor device that receives a high frequency electric signal and outputs an optical signal.
(85) The wiring board **27** corresponds to an embodiment of a wiring board according to the present disclosure. The overall structure of the wiring board **27** may be the structure illustrated in FIG. **3** (relevant part of the wiring board **7** according to the first embodiment). The wiring board **27** includes a base **27**A that is a dielectric, a signal conductor **270**, first ground conductors **271**, a second ground conductor **272**, and connection conductors **275**. The base **27**A is plate-shaped. The structures of the signal conductor **270**, the first ground conductors **271**, the second ground conductor **272**, and the connection conductors **275** are the same as and/or similar to those of the signal conductor **70**, the first ground conductors **71**, the second ground conductor **72**, and the connection conductors **75** according to the first embodiment. The signal conductor **270** may include the patterns Q**1** according to the first embodiment. Any of the above-described patterns of various examples may be provided. The pattern or patterns may be provided on at least one selected from the group consisting of the signal conductor **270** and the first ground conductors **271**. The base **27**A may include a dielectric layer disposed below the second ground conductor **272** (at a side opposite to the side provided with the signal conductor **270**).
(86) One end portion of the signal conductor **270** is electrically connected to the central conductor of the coaxial component **28** with a conductive joining material or the like. The other end portion of the signal conductor **270** is connected to a signal terminal of the electronic component **101**C by a corresponding connection member w, such as a bonding wire. The signal conductor **270** includes patterns Q**1** at a location near the other end portion, and includes no patterns Q**1** at a location near the one end portion. The first ground conductors **271**, the second ground conductor **272**, and the connection conductors **275** are electrically connected to the outer peripheral conductor of the coaxial component **28** through the metal case **24** and the block M**1**. An other end portion of each first ground conductor **271** is connected to a ground terminal of the electronic component **101**C by a corresponding connection member w, such as a bonding wire. One end portion of each first ground conductor **271** may be connected to a portion of the wall **24**B close to the coaxial component **28** by a conductive connection member. In such a case, the signal conductor **270** may additionally include the patterns Q**1** at a location near the one end portion.
(87) The structure of the electronic device **140** excluding the electronic component **101**C corresponds to an example of a package **1**C for containing an electronic component according to an embodiment of the present disclosure.
(88) In the example illustrated in FIGS. **14**A and **14**B, the package **1**C for containing an electronic component and the electronic device **140** output an optical signal. However, the package for containing an electronic component and the electronic device may include no structure for receiving and outputting an optical signal, and may receive and output an electric signal or a radio

signal. In such a case, the wiring board **27** according to the embodiment may be used as a relay substrate.

(89) As illustrated in FIG. **12**, in the present embodiment, an electronic module **200** includes a module substrate **201** and the electronic device **100** mounted on the module substrate **201**. In addition to the electronic device **100**, an electric device, an electronic element, an electric element, an optical device, and the like may also be mounted on the module substrate **201**. The electronic device **100** may be electrically connected to a signal line or a ground conductor on the module substrate **201** through a relay substrate **202**. Instead of the electronic device **100** illustrated in FIG. **12**, the electronic device **130** illustrated in FIG. **13** or the electronic device **140** illustrated in FIG. **14** may be mounted on the module substrate **201** in the same and/or similar manner.

(90) According to the electronic devices **100**, **130**, and **140** and the electronic module **200** of the present embodiment, since the wiring boards **7** and **17** having good high-frequency characteristics are provided, the electronic devices **100**, **130**, and **140** and the electronic module **200** can have improved high-frequency characteristics.

(91) Embodiments of the present disclosure have been described. However, the wiring board, the package for containing an electronic component, the electronic device, and the electronic module according to the present disclosure are not limited to the above-described embodiments. For example, when the patterns are provided on the signal conductors **70**, **170**, and **270** at both sides in the transverse direction, the patterns at one and the other sides may be patterns of different structures (for example, patterns Q**1**, Q**10**, and Q**11**). When the patterns are provided on the ground conductors **71**, **171**, and **271** disposed on one and the other sides of the signal conductors **70**, **170**, and **270**, the patterns at one and the other sides may be patterns of different structures (for example, patterns Q**2**, Q**12**, and Q**13**). Also when the patterns are provided on both the signal conductors **70**, **170**, and **270** and the first ground conductors **71**, **171**, and **271**, the patterns of different structures may be applied.

(92) In the above-described embodiment, each wiring board **7** includes any of the patterns Q**1** to Q**13** at both a location near the inner end portion and a location near the outer end portion. However, any of the patterns Q**1** to Q**13** may be provided at only one of a location near the outer end portion and a location near the inner end portion. The signal conductor **270** of the wiring board **27** may also include the patterns at both a location near one end portion and a location near the other end portion. The number of wiring boards **7** included in one package for containing an electronic component may be one, or three or more. Although examples of inductive patterns are described in the above-described embodiment, the patterns may include any structure as long as inductance can be applied. In the above-described embodiment, portions of each signal conductor that are closer to and farther from the end than the patterns Q**1** to Q**13** have the same width. However, the portion closer to the end may have a greater width to make an adjustment for an inductance of the connection member (bonding wire) w. Other details described in the embodiments may be changed as appropriate.

INDUSTRIAL APPLICABILITY

(93) The present disclosure is applicable to a wiring board, a package for containing an electronic component, an electronic device, and an electronic module.

REFERENCE SIGNS

(94) **1** package for containing an electronic component **4**, **24** metal case **4**B, **24**B wall **4**C, **24**C bottom **4**D mount base **5**, **15**, **25** lid **7**, **17**, **27** wiring board **7**A, **17**A, **27**A base **7**A**1** plate-shaped portion **7**A**2** step portion **7***a* dielectric layer **70**, **170**, **270** signal conductor **71**, **171**, **271** first ground conductor **72**, **172**, **272** second ground conductor **75**, **175**, **275** connection conductor **75***c* castellation conductor **75***v* via conductor S**1**, S**11** first surface S**2**, S**12** second surface U**1**, U**2**, U**3** recess Q**1** to Q**13** pattern H distance **100**, **130**, **140** electronic device **101**, **101**B, **101**C electronic component **200** electronic module **201** module substrate

Claims

1. A wiring board comprising: a base composed of a dielectric and comprising a first surface and a second surface opposite to the first surface; a signal conductor disposed on the first surface and extending to an end portion of the base; two first ground conductors disposed on the first surface and extending to the end portion with the signal conductor disposed between the first ground conductors; a second ground conductor disposed in the base or on the second surface, the second ground conductor facing the signal conductor and extending to the end portion; and connection conductors electrically connecting respective ones of the first ground conductors to the second ground conductor, wherein the signal conductor and the second ground conductor are separated from each other by a distance H, and wherein the signal conductor and the first ground conductors each comprise a cutout pattern disposed at a distance of equal to or greater than ⅓ of the distance H and equal to or less than the distance H from the end portion, the pattern being inductive.
2. The wiring board according to claim 1, wherein the signal conductor comprises the pattern.
3. The wiring board according to claim 1, wherein the first ground conductors comprise the pattern at a side adjacent to the signal conductor.
4. The wiring board according to claim 1, wherein the cutout comprises a portion wider at a rear end than at a front end.
5. A package for containing an electronic component, the package comprising: the wiring board according to claim 1; and a metal case configured to contain an electronic component.
6. An electronic device comprising: the wiring board according to claim 1 and an electronic component mounted on the wiring board.
7. An electronic module comprising: the electronic device according to claim 6; and a module substrate, the electronic device being mounted on the module substrate.
8. An electronic device comprising: the package for containing an electronic component according to claim 5; and an electronic component mounted in the package for containing an electronic component.