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(54) **RESIN COMPOSITION, RESIN FILM, LAMINATE, MULTILAYER PRINTED WIRING BOARD AND METHOD FOR PRODUCING MULTILAYER PRINTED WIRING BOARD**

(71) Applicant: **HITACHI CHEMICAL COMPANY, LTD.**, Tokyo (JP)

(72) Inventors: **Yuki Nagai**, Tokyo (JP); **Tetsuroh Irino**, Tokyo (JP); **Yuusuke Kondou**, Tokyo (JP); **Tomio Fukuda**, Tokyo (JP); **Etsuo Mizushima**, Tokyo (JP); **Takao Tanigawa**, Tokyo (JP)

(73) Assignee: **SHOWA DENKO MATERIALS CO., LTD.**, Tokyo (JP)

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This patent is subject to a terminal disclaimer.

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C08K 5/14	(2006.01)
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C08L 79/08	(2006.01)

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(58) **Field of Classification Search**

None

See application file for complete search history.

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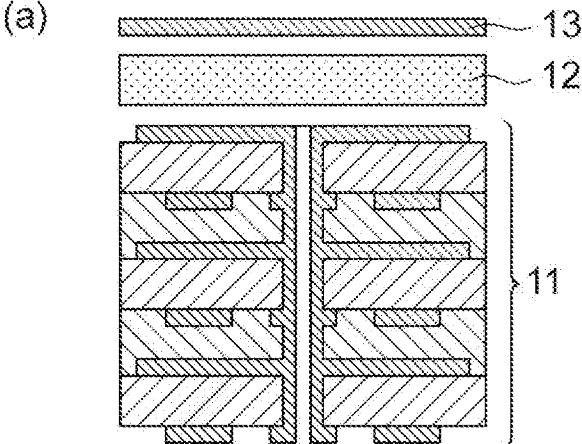
Primary Examiner — Joseph R Kosack
(74) *Attorney, Agent, or Firm* — Fitch, Even, Tabin & Flannery, LLP

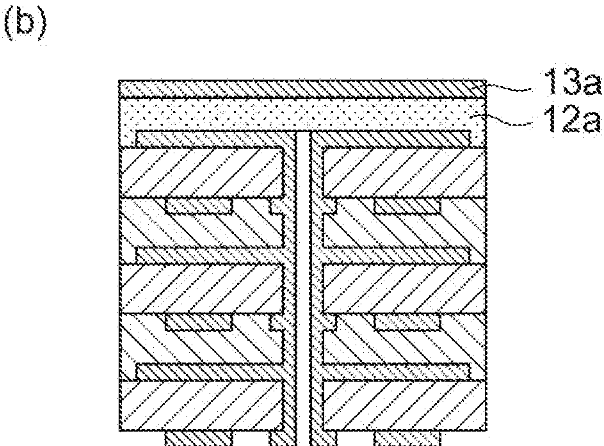
(57) **ABSTRACT**

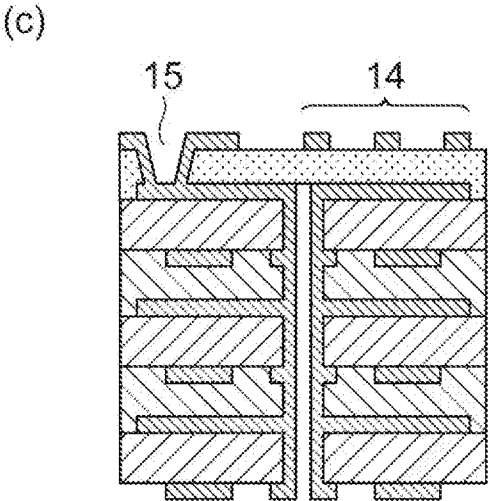
The present invention relates to a resin composition comprising a maleimide compound having a saturated or unsaturated divalent hydrocarbon group and a divalent group having at least two imido bonds; and a catalyst comprising at least one selected from the group consisting of an imidazole compound, a phosphorus compound, an azo compound and an organic peroxide.

20 Claims, 3 Drawing Sheets

Fig.1







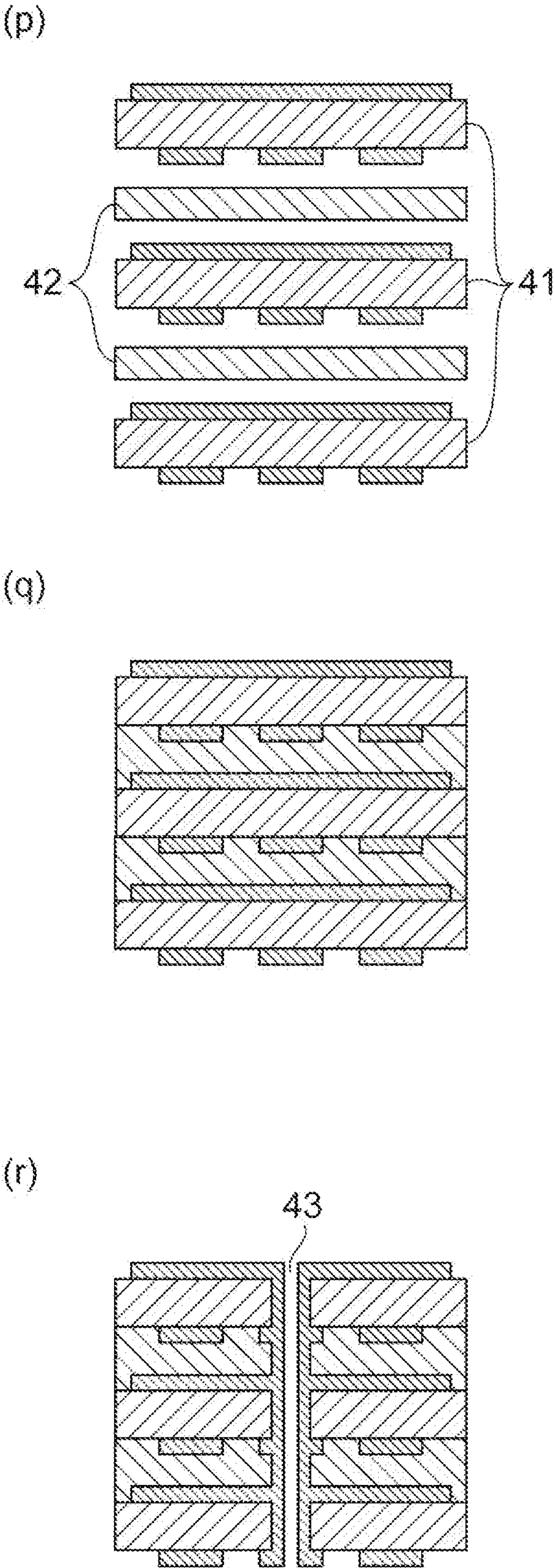
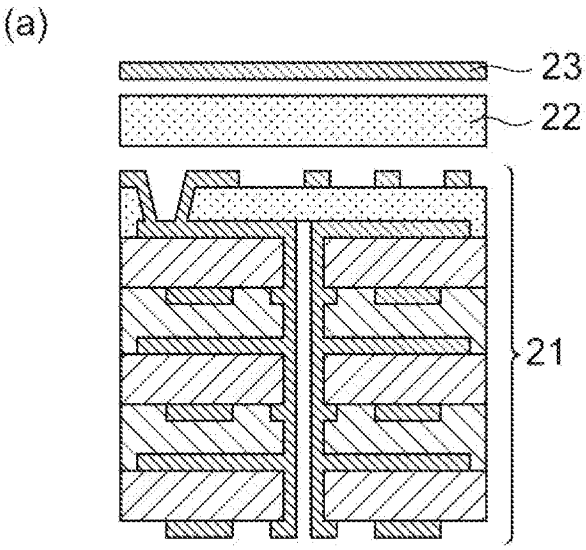


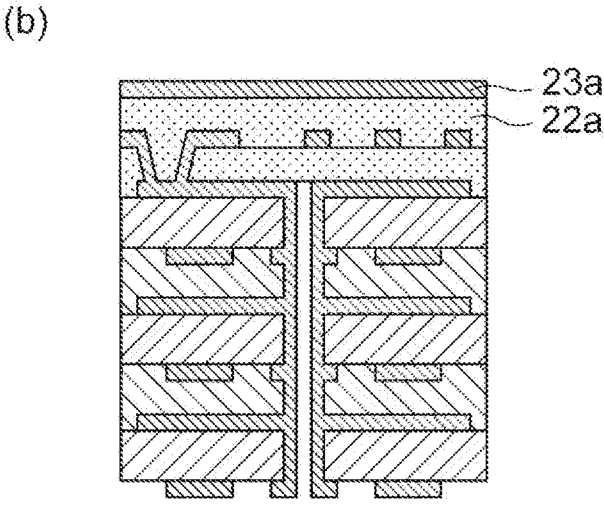
Fig.2
(p)
42
41
(q)
(r)
43

Fig.3

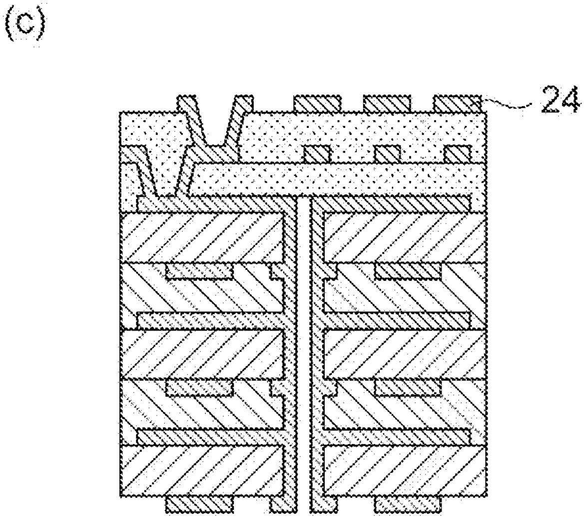
(a)



(b)



(c)



RESIN COMPOSITION, RESIN FILM, LAMINATE, MULTILAYER PRINTED WIRING BOARD AND METHOD FOR PRODUCING MULTILAYER PRINTED WIRING BOARD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. national phase application filed under 35 U.S.C. § 371 of International Application No. PCT/JP2017/024520, filed Jul. 4, 2017, designating the United States, which claims priority from Japanese Patent Application No. 2016-133542, filed Jul. 5, 2016, which are hereby incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present invention relates to a resin composition, a resin film, a laminate, a multilayer printed wiring board, and a method for producing a multilayer printed wiring board.

BACKGROUND ART

In mobile communication devices represented by cell phones, base station apparatuses thereof network infrastructure devices such as severs and routers, and electronic devices such as large computers, signals used are being increased year by year in the speed and the capacity. Along therewith, readiness for higher frequencies becomes necessary for printed wiring boards mounted on these electronic devices, and there are demanded substrate materials having a low relative dielectric constant and a low dielectric loss tangent which enable the transmission loss to be reduced. In recent years, as such applications handling high-frequency signals, besides in the above-mentioned electronic devices, also in ITS fields (automobiles, traffic system fields) and indoor short-distance communication fields, there have advanced the practical uses and practical plans of novel systems handling high-frequency radio signals; and it is supposed that hereafter, low-transmission loss substrate materials are further demanded on printed wiring boards mounted on these devices.

Further since from recent year's environmental problems, there have been demanded the mounting of electronic components by using a lead-free solder, and the flame retardation by the halogen freeness, there become necessary a higher heat resistance and flame retardancy for materials for printed wiring board than hitherto.

For printed wiring boards demanding a low transmission loss, as heat-resistant thermoplastic polymers exhibiting excellent high-frequency characteristics, polyphenylene ether (PPE)-based resins are conventionally used. In uses of polyphenylene ether-based resins, there are proposed, for example, methods of using a polyphenylene ether and a thermosetting resin in combination; and specifically, there are disclosed a resin composition containing a polyphenylene ether and an epoxy resin (for example, see Patent Literature 1), a resin composition using a polyphenylene ether and a cyanate ester resin, which is low in the relative dielectric constant among thermosetting resins, in combination (for example, see Patent Literature 2), and the like.

Further the present inventors propose a resin composition capable of being improved in compatibility, heat resistance, thermal expansion characteristics, adhesiveness to conductors and the like by using a polyphenylene ether resin and a polybutadiene resin as bases and making the resin composition to have a semi-IPN structure in its production stage (A-stage) (for example, see Patent Literature 3).

Further, use of maleimide compounds as a material for printed wiring boards is being studied. For example, Patent Literature 4 discloses a resin composition which has a maleimide compound having at least two maleimide skeletons, an aromatic diamine compound having at least two amino groups and having an aromatic ring structure, a catalyst having a basic group and a phenolic hydroxyl group promoting the reaction of the maleimide compound with the aromatic diamine compound, and a silica.

CITATION LIST

Patent Literature

Patent Literature 1: JP 58-69046 A1
Patent Literature 2: JP 61-18937 A1
Patent Literature 3: JP 2008-95061 A1
Patent Literature 4: JP 2012-255059 A1

SUMMARY OF INVENTION

Technical Problem

For substrate materials for printed wiring boards to be used in the recent year's high-frequency band, however, it is demanded, in addition to high-frequency characteristics and high adhesiveness to conductors, that various types of characteristics be further excellent, such as low thermal expansion coefficient.

The present invention, in consideration of such present situation, has an object to provide a resin composition having excellent high-frequency characteristics (low relative dielectric constant, low dielectric loss tangent), and having also heat resistance and adhesiveness to conductors in high levels, and a resin film, a laminate and a multilayer printed wiring board which are produced by using the resin composition. The present invention also has an object to provide a method for producing a multilayer printed wiring board using the resin film.

Solution to Problem

As a result of exhaustive studies to solve the above problems, the present inventors have found that a resin composition comprising a specific maleimide compound and a specific catalyst can solve the above problems, and this finding has led to the completion of the present invention.

That is, the present invention includes the following aspects.

[1] A resin composition comprising a maleimide compound having a saturated or unsaturated divalent hydrocarbon group and a divalent group having at least two imido bonds; and a catalyst comprising at least one selected from the group consisting of an imidazole compound, a phosphorus compound, an azo compound and an organic peroxide.

[2] The resin composition according to [1], wherein the catalyst comprises an organic peroxide.

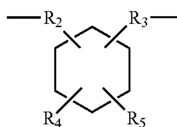
[3] The resin composition according to [1] or [2], wherein a one-hour half-life temperature of the organic peroxide is 110 to 250° C.

[4] The resin composition according to any one of [1] to [3], wherein the number of carbon atoms of the hydrocarbon group is 8 to 100.

[5] The resin composition according to any one of [1] to [4], wherein the hydrocarbon group is a group represented by the following formula (II).

[Chemical Formula 1]

(II)



In the formula (II), R_2 and R_3 each independently represent an alkylene group having 4 to 50 carbon atoms; R_4 represents an alkyl group having 4 to 50 carbon atoms; and R_5 represents an alkyl group having 2 to 50 carbon atoms.

[6] A resin film made by using the resin composition according to any one of [1] to [5].

[7] A laminate comprising a resin layer comprising a cured substance of the resin composition according to any one of [1] to [5], and a conductor layer.

[8] A multilayer printed wiring board comprising a resin layer comprising a cured substance of the resin composition according to any one of [1] to [5], and circuit layers.

[9] A method for producing a multilayer printed wiring board, comprising a step of laminating the resin film according to [6] on an inner layer circuit board to form a resin layer, a step of heating and pressing the resin layer to cure the resin layer, and a step of forming a circuit layer on the cured resin layer.

Advantageous Effects of Invention

The present invention can provide a resin composition having excellent high-frequency characteristics (low relative dielectric constant, low dielectric loss tangent), and having also heat resistance and adhesiveness to conductors in high levels, and a resin film, a laminate and a multilayer printed wiring board which are produced by using the resin composition. Further the present invention can also provide a method for producing a multilayer printed wiring board having excellent high-frequency characteristics (low relative dielectric constant, low dielectric loss tangent) and heat resistance by using the resin film.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic diagram illustrating a production step of a multilayer printed wiring board according to the present embodiment.

FIG. **2** is a schematic diagram illustrating a production step of an inner layer circuit board.

FIG. **3** is a schematic diagram illustrating a production step of a multilayer printed wiring board according to the present embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, as required, by reference to the drawings, a preferred embodiment of the present invention will be described in detail. However, the present invention is not limited to the following embodiment.

Definitions

In the present description, a "high-frequency region" refers to a region of 300 MHz to 300 GHz, and particularly refers to 3 GHz to 300 GHz. In the present description, a numerical value range indicated by "to" indicates a range including numerical values described before and after "to" as the minimum value and the maximum value, respectively. In the numerical value range described stepwise in the present description, the upper limit value or the lower limit value in a numerical value range of a certain stage may be replaced by the upper limit value or the lower limit value of another stage. In the numerical value range described in the present description, the upper limit value or the lower limit value in the numerical value range may be replaced by a value indicated in Examples. "A or B" may include either one of A and B, or may include the both.

[Resin Composition]

A resin composition of the present embodiment comprises a maleimide compound having a saturated or unsaturated divalent hydrocarbon group and a divalent group having at least two imido bonds, and a catalyst comprising at least one selected from the group consisting of an imidazole compound, a phosphorus compound, an azo compound and an organic peroxide.

<(A) Maleimide Compound Having a Saturated or Unsaturated Divalent Hydrocarbon Group and a Divalent Group Having at Least Two Imido Bonds>

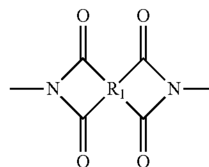
A maleimide compound having a saturated or unsaturated divalent hydrocarbon group and a divalent group having at least two imido bonds according to the present embodiment is referred to as (A) component in some cases. The (A) component is a compound having an (a) maleimide group, a (b) divalent group having at least two imido bonds, and a (c) saturated or unsaturated divalent hydrocarbon group. In some cases, the (a) maleimide group is referred to as a structure (a); the (b) divalent group having at least two imido bonds is referred to as a structure (b); and the (c) saturated or unsaturated divalent hydrocarbon group is referred to as a structure (c). By using the (A) component, there can be obtained a resin composition having high-frequency characteristics and high adhesiveness to conductors.

The (a) maleimido group is not especially limited, and is a common maleimido group. Although the (a) maleimide group may be bonded to an aromatic ring, or may be bonded to an aliphatic chain, from the viewpoint of dielectric characteristics, it is preferable that the (a) maleimide group be bonded to a long-chain aliphatic chain (for example, a saturated hydrocarbon group having 8 to 100 carbon atoms). By making the (A) component to have a structure in which the (a) maleimide group is boded to a long-chain aliphatic chain, the high-frequency characteristics of the resin composition can further be improved.

The structure (b) is not especially limited, but examples thereof include a group represented by the following formula (I).

[Chemical Formula 2]

(I)



In the formula (I), R_1 represents a tetravalent organic group. R_1 is not especially limited as long as being a tetravalent organic group, but for example, from the view-

point of the handleability, may be a hydrocarbon group having 1 to 100 carbon atoms, may be a hydrocarbon group having 2 to 50 carbon atoms, or may be a hydrocarbon group having 4 to 30 carbon atoms.

R_1 may be a substituted or nonsubstituted siloxane site. Examples of the siloxane site include structures originated from dimethylsiloxane, methylphenylsiloxane and diphenylsiloxane.

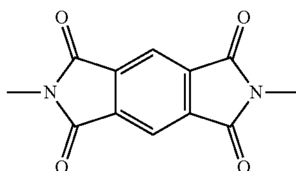
In the case where R_1 is substituted, examples of the substituent include an alkyl group, an alkenyl group, an alkynyl group, a hydroxyl group, an alkoxy group, a mercapto group, a cycloalkyl group, a substituted cycloalkyl group, a heterocycle group, a substituted heterocycle group, an aryl group, a substituted aryl group, a heteroaryl group, a substituted heteroaryl group, an aryloxy group, a substituted aryloxy group, a halogen atom, a haloalkyl group, a cyano group, a nitro group, a nitroso group, an amino group, an amido group, —C(O)H, $—NR_xC(O)—N(R_x)_2$, $—OC(O)—N(R_x)_2$, an acyl group, an oxyacyl group, a carboxyl group, a carbamate group and a sulfonamido group. Here, R_x represents a hydrogen atom or an alkyl group. One or two or more of these substituents can be selected according to the purposes, the applications and the like.

As R_1, preferable is, for example, a tetravalent residue of an acid anhydride having two or more anhydride rings in one molecule thereof, that is, a tetravalent group made by eliminating two acid anhydride groups (—C(═O)OC(═O)—) from the acid anhydride. Examples of the acid anhydride include compounds as described later.

From the viewpoint of the mechanical strength, it is preferable that R_1 be aromatic, and it is more preferable that R_1 be a group made by eliminating two acid anhydride groups from pyromellitic anhydride. That is, it is more preferable that the structure (b) be a group represented by the following formula (III).

[Chemical Formula 3]

(III)

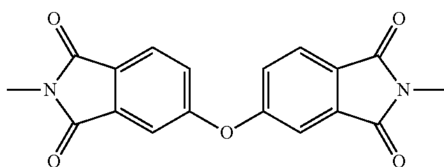


From the viewpoint of the flowability and the circuit embeddability, it is preferable that the structure (b) be present in plural numbers in the (A) component. In this case, the structures (b) may be identical or may be different. It is preferable that the number of the structures (b) in the (A) component be 2 to 40; being 2 to 20 is more preferable; and being 2 to 10 is still more preferable.

From the viewpoint of the dielectric characteristics, the structure (b) may be a group represented by the following formula (IV) or the following formula (V).

[Chemical Formula 4]

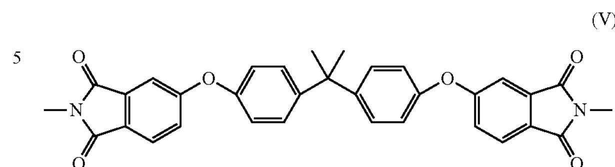
(IV)



-continued

[Chemical Formula 5]

(V)



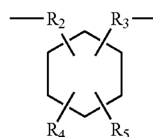
The structure (c) is not especially limited, and may be any of linear, branched and cyclic. From the viewpoint of high-frequency characteristics, it is preferable that the structure (c) be an aliphatic hydrocarbon group. Further the number of carbon atoms of the saturated or unsaturated divalent hydrocarbon group may be 8 to 100, or may be 10 to 70 or 15 to 50. The hydrocarbon group may have a branch. It is preferable that the structure (c) be an alkylene group having 8 to 100 carbon atoms which may have a branch; being an alkylene group having 10 to 70 carbon atoms which may have a branch is more preferable; and being an alkylene group having 15 to 50 carbon atoms which may have a branch is still more preferable. When the structure (c) is an alkylene group having 8 or more carbon atoms which may have a branch, the molecular structure is easily made to be of a three-dimensional one, and the density is easily lowered due to the increase in the free volume of the polymer. That is, since a low dielectric constant can be attained, it becomes easy for the high-frequency characteristics of the resin composition to be improved. Further when the (A) component has the structure (c), the flexibility of the resin composition according to the present embodiment is improved, and the handleability (tackiness, cracking, powder dropping and the like) and the strength of a resin film fabricated from the resin composition can be enhanced.

Examples of the structure (c) include alkylene groups such as a nonylene group, a decylene group, an undecylene group, a dodecylene group, a tetradecylene group, a hexadecylene group, an octadecylene group and a nonadecylene group; arylene groups such as a benzylene group, a phenylene group and a naphthylene group; arylene alkylene groups such as a phenylene methylene group, a phenylene ethylene group, a benzylpropylene group, a naphthylene methylene group and a naphthylene ethylene group; and arylene dialkylene groups such as a phenylene dimethylene group and a phenylene diethylene group.

From the viewpoint of the high-frequency characteristics, the low-thermal expansion characteristics, the adhesiveness to conductors, the heat resistance and the low hygroscopic property, as the structure (c), the group represented by the following formula (II) is especially preferable.

[Chemical Formul 6]

(II)



In the formula (II), R_2 and R_3 each independently represent an alkylene group having 4 to 50 carbon atoms. From the viewpoint of the further improvement of the flexibility and the easiness of the synthesis, it is preferable that R_2 and

R_3 each independently be an alkylene group having 5 to 25 carbon atoms; being an alkylene group having 6 to 10 carbon atoms is more preferable; and being an alkylene group having 7 to 10 carbon atoms is still more preferable.

In the formula (II), R_4 represents an alkyl group having 4 to 50 carbon atoms. From the viewpoint of the further improvement of the flexibility and the easiness of the synthesis, it is preferable that R_4 be an alkyl group having 5 to 25 carbon atoms; being an alkyl group having 6 to 10 carbon atoms is more preferable; and being an alkyl group having 7 to 10 carbon atoms is still more preferable.

In the formula (II), R_5 represents an alkyl group having 2 to 50 carbon atoms. From the viewpoint of the further improvement of the flexibility and the easiness of the synthesis, it is preferable that R_5 be an alkyl group having 3 to 25 carbon atoms; being an alkyl group having 4 to 10 carbon atoms is more preferable; and being an alkyl group having 5 to 8 carbon atoms is still more preferable.

From the viewpoint of the flowability and the circuit embeddability, the structures (c) may be present in plural numbers in the (A) component. In this case, the structures (c) may be identical or may be different. For example, it is preferable that 2 to 40 structures (c) be present in the (A) component; the presence of 2 to 20 structures (c) is more preferable; and the presence of 2 to 10 structures (c) is still more preferable.

The content of the (A) component in the resin composition is not especially limited. From the viewpoint of the heat resistance, it is preferable that the content of the (A) component be 2 to 98% by mass to the total mass of the resin composition (solid content); being 10 to 50% by mass is more preferable; and being 10 to 30% by mass is still more preferable.

The molecular weight of the (A) component is not especially limited. From the viewpoint of the handleability, the flowability and the circuit embeddability, it is preferable that the weight-average molecular weight (Mw) of the (A) component be 500 to 10000; being 1000 to 9000 is more preferable; being 1500 to 9000 is still more preferable; being 1500 to 7000 is further still more preferable; and being 1700 to 5000 is especially preferable.

Mw of the (A) component can be measured by a gel permeation chromatography (GPC) method.

Here, the measurement condition of GPC is as follows.

Pump: L-6200 type [manufactured by Hitachi High-Technologies Corp.]

Detector: L-3300 type RI [manufactured by Hitachi High-Technologies Corp.]

Column oven: L-655A-52 [manufactured by Hitachi High-Technologies Corp.]

Guard column and columns: TSK Guardcolumn HHR-L+TSKgel G4000HHR+TSKgel G2000HHR [all, manufactured by Tosoh Corp., trade name]

Column size: 6.0×40 mm (guard column), 7.8×300 mm (columns)

Eluent: tetrahydrofuran

Specimen concentration: 30 mg/5 mL

Injection volume: 20 μL

Flow volume: 1.00 mL/min

Measurement temperature: 40° C.

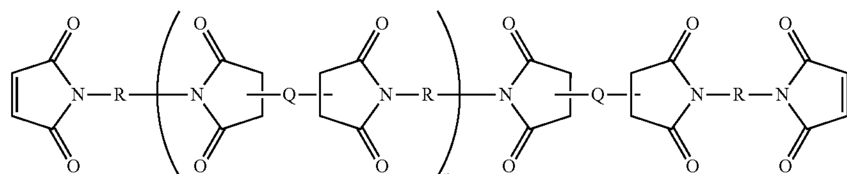
A method for producing the (A) component is not limited. The (A) component may be fabricated, for example, by reacting an acid anhydride with a diamine to thereby synthesize an amine-terminated compound, and thereafter reacting the amine-terminated compound with an excessive amount of maleic anhydride.

Examples of the acid anhydride include pyromellitic anhydride, maleic anhydride, succinic anhydride, 3,3',4,4'-benzophenonetetracarboxylic dianhydride, 3,3',4,4'-biphenyltetracarboxylic dianhydride and 3,3',4,4'-diphenylsulfonetetracarboxylic dianhydride. These acid anhydrides may be used singly or in combinations of two or more according to the purposes, applications and the like. Here, as described above, As R_1 of the above formula (I), there can be used tetravalent organic groups originated from acid anhydrides as cited in the above. From the viewpoint of better dielectric characteristics, it is preferable that the acid anhydride be pyromellitic anhydride.

Examples of the diamine include dimer diamines, 2,2-bis(4-(4-aminophenoxy)phenyl)propane, 1,3-bis(4-aminophenoxy)benzene, 4,4'-bis(4-aminophenoxy)biphenyl, 4,4'-diamino-3,3'-dihydroxybiphenyl, 1,3-bis[2-(4-aminophenyl)-2-propyl]benzene, 1,4-bis[2-(4-aminophenyl)-2-propyl]benzene, polyoxyalkylenediamines, and [3,4-bis(1-aminoheptyl)-6-hexyl-5-(1-octenyl)]cyclohexene. These may be used singly or in combinations of two or more according to the purposes, applications and the like.

The (A) component may be, for example, a compound represented by the following formula (XIII).

[Chemical Formula 7]



In the formula, R and Q each independently represent a divalent organic group. As R, a group having the same structure as the above-mentioned structure (c) can be used, and as Q, the same group as the above-mentioned R_1 can be used. n represents an integer of 1 to 10.

As the (A) component, commercially available compounds can also be used. Examples of commercially available compounds include products manufactured by Designer Molecules Inc., and specifically include BMI-1500, BMI-1700, BMI-3000, BMI-5000 and BMI-9000 (any of which is a trade name). From the viewpoint of acquiring better high-frequency characteristics, it is more preferable that as the (A) component, BMI-3000 be used.

<(B) Catalyst Comprising at Least One Selected from the Group Consisting of an Imidazole Compound, a Phosphorus Compound, an Azo Compound and an Organic Peroxide>

A (B) catalyst comprising at least one selected from the group consisting of an imidazole compound, a phosphorus

compound, an azo compound and an organic peroxide, according to the present embodiment is referred to as (B) component in some cases. The (B) component is a catalyst to promote curing of the (A) component. By making the resin composition of the present embodiment to contain a specific catalyst, the solder heat resistance can be improved.

Examples of the imidazole compound include methylimidazole, phenylimidazole and an isocyanate-masked imidazole. Examples of the isocyanate-masked imidazole include an addition reaction product of a hexamethylene diisocyanate resin with 2-ethyl-4-methylimidazole. The imidazole compound is not especially limited, but from the viewpoint of the storage stability of the resin composition, an isocyanate-masked imidazole is preferable.

The phosphorus compound can be used without being especially limited as long as being a catalyst containing a phosphorus atom. Examples of the phosphorus compound include organophosphines such as triphenylphosphine, diphenyl(alkylphenyl)phosphine, tris(alkylphenyl)phosphine, tris(alkoxyphenyl)phosphine, tris(alkylalkoxyphenyl)phosphine, tris(dialkylphenyl)phosphine, tris(trialkylphenyl)phosphine, tris(tetraalkylphenyl)phosphine, tris(dialkoxyphenyl)phosphine, tris(trialkoxyphenyl)phosphine, tris(tetraalkoxyphenyl)phosphine, trialkylphosphine, dialkylarylphosphine and alkyldiarylphosphine; complexes of organophosphines and organoborons; and adducts of tertiary phosphine with quinones. As the phosphorus compound, from the viewpoint that the curing reaction of the (A) component progresses sufficiently and higher adhesiveness to conductors can be exhibited, the adducts of tertiary phosphine with quinones are preferable.

Examples of the azo compound include 2,2'-azobis-isobutyronitrile, 2,2'-azobis-2-methylbutyronitrile, 1,1'-azobis-1-cyclohexanecarbonitrile, dimethyl-2,2'-azobisisobutyrate and 1,1'-azobis-(1-acetoxy-1-phenylethane).

Examples of the organic peroxide include dicumyl peroxide, dibenzoyl peroxide, 2-butanone peroxide, tert-butyl perbenzoate, di-tert-butyl peroxide, 2,5-bis(tert-butylperoxy)-2,5-dimethylhexane, bis(tert-butylperoxyisopropyl) benzene, tert-butyl hydroperoxide, di(4-methylbenzoyl) peroxide, di(3-methylbenzoyl) peroxide, dibenzoyl peroxide, 1,1,3,3-tetramethylbutyl peroxy-2-ethylhexanoate, dilauroyl peroxide, di(3,5,5-trimethylhexanoyl) peroxide and tert-butyl peroxypivalate.

It is preferable that the (B) component contain an organic peroxide having a one-hour half-life temperature of 110 to 250° C.; containing an organic peroxide having a one-hour half-life temperature of 115 to 250° C. is more preferable; containing an organic peroxide having a one-hour half-life temperature of 120 to 230° C. is still more preferable; and containing an organic peroxide having a one-hour half-life temperature of 130 to 200° C. is especially preferable. When the one-hour half-life temperature is in this range, there can be obtained a resin composition which makes the solder heat resistance good and has a high degree of coating freedom. From the similar viewpoint, it is preferable that the one-minute half-life temperature of the organic peroxide be 150° C. or higher; being 160° C. or higher is more preferable; and being 170° C. or higher is still more preferable. The upper limit value of the one-minute half-life temperature of the organic peroxide is not especially limited, but may be 300° C. Here, the one-hour half-life temperature and the one-minute half-life temperature refer to temperatures at which half-life periods described later become one hour and one minute, respectively.

Here, the half-life period of an organic peroxide is an index to indicate the decomposition speed of the organic peroxide at a constant temperature, and is indicated by a time required until the original organic peroxide decomposes and its amount of active oxygen becomes ½. The half-life period of an organic peroxide can be calculated, for example, as follows.

First, the organic peroxide is dissolved in a solvent (for example, benzene) relatively inactive to radicals to prepare an organic peroxide solution in a dilute concentration, which is then enclosed in a glass tube subjected to nitrogen substitution. Then, the glass tube is immersed in a thermostatic chamber set at a predetermined temperature to pyrolyze the organic peroxide. Generally, since the decomposition of an organic peroxide in a dilute solution can be handled approximately as a first-order reaction, the half-life period can be represented by the following expressions (1) and (2) where x represents the concentration of a decomposing organic peroxide; k, the decomposition speed constant; t, the time; and a, the initial concentration of the organic peroxide.

$$dx/dt=k(a-x) \tag{1}$$

$$\ln a/(a-x)=kt \tag{2}$$

Further the half-life period ($t_{1/2}$), since being a time required until the amount of the organic peroxide reduces to a half of the initial amount, can be represented by the following expression (3).

$$kt_{1/2}=\ln 2 \tag{3}$$

Therefore, the half-life period ($t_{1/2}$) of a certain temperature can be determined from the expression (3) by pyrolyzing the organic peroxide at the constant temperature, plotting the relation between the time t and the ln a/(a−x) and determining k from the gradient of an obtained straight line.

The content of the (B) component in the resin composition is not especially limited, but may be 0.1 to 5% by mass to the total mass of the resin composition. From the viewpoint of sufficiently curing the (A) component, it is preferable that the content of the (B) component be 0.1 to 10 parts by mass with respect to 100 parts by mass of the (A) component; being 1 to 5 parts by mass is more preferable; and being 1.5 to 5 parts by mass is still more preferable.

<(C) Aromatic Maleimide Compound>

The resin composition according to the present embodiment may comprise a (C) aromatic maleimide compound different from the (A) component. The (C) aromatic maleimide compound according to the present embodiment is referred to as (C) component in some cases. Here, a compound capable of corresponding to both of the (A) component and the (C) component is determined to belong to the (A) component, but in the case of comprising two or more kinds of compounds capable of corresponding to both of the (A) component and the (C) component, one out of them is determined to belong to the (A) component and the others the (C) component. By using the (C) component, the resin composition becomes one excellent particularly in the low thermal expansion characteristics. That is, the resin composition of the present embodiment, by using the (A) component and the (C) component in combination, can be further improved in the low thermal expansion characteristics and the like while retaining good dielectric characteristics. It is presumed that the reason therefor is because a cured substance obtained from the resin composition containing the (A) component and the (C) component contains a polymer having a structural unit consisting of the (A) component,

which has low dielectric characteristics, and a structural unit consisting of the (C) component, which is low in the thermal expansion.

That is, it is preferable that the (C) component has a lower thermal expansion coefficient than the (A) component. Examples of the (C) component having a lower thermal expansion coefficient than the (A) component include maleimido group-containing compounds having a lower molecular weight than the (A) component, maleimido group-containing compounds having more aromatic rings than the (A) component, and maleimido group-containing compounds having a shorter main chain than the (A) component.

The content of the (C) component in the resin composition is not especially limited. From the viewpoint of the low thermal expansion property and the dielectric characteristics, it is preferable that the content of the (C) component be 1 to 95% by mass to the total mass of the resin composition (solid content); being 1 to 50% by mass is more preferable; and being 1.5 to 30% by mass is still more preferable.

The blend proportion of the (A) component and the (C) component in the resin composition is not especially limited. From the viewpoint of the dielectric characteristics and the low thermal expansion coefficient, it is preferable that the mass ratio (C)/(A) of the (A) component and the (C) component be 0.01 to 3; being 0.03 to 2 is more preferable; being 0.05 to 1 is still more preferable; and being 0.05 to 0.5 is especially preferable.

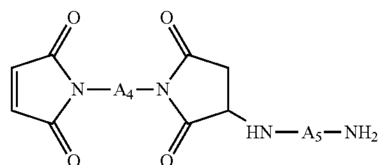
The (C) component is not especially limited as long as having an aromatic ring. Since the aromatic ring is rigid and low in the thermal expansion, by using the (C) component having an aromatic ring, the thermal expansion coefficient of the resin composition can be reduced. Although the maleimide group may be bonded to an aromatic ring or an aliphatic chain, from the viewpoint of the low thermal expansion property, it is preferable that the maleimide group be bonded to an aromatic ring. Further, it is also preferable that the (C) component be a polymaleimide compound containing two or more maleimido groups.

Specific examples of the (C) component include 1,2-dimaleimidoethane, 1,3-dimaleimidopropane, bis(4-maleimidophenyl)methane, bis(3-ethyl-4-maleimidophenyl) methane, bis(3-ethyl-5-methyl-4-maleimidophenyl) methane, 2,7-dimaleimidofluorene, N,N'-(1,3-phenylene) bismaleimide, N,N'-(1,3-(4-methylphenylene)) bismaleimide, bis(4-maleimidophenyl) sulfone, bis(4-maleimidophenyl) sulfide, bis(4-maleimidophenyl) ether, 1,3-bis(3-maleimidophenoxy)benzene, 1,3-bis(3-(3-maleimidophenoxy)phenoxy)benzene, bis(4-maleimidophenyl) ketone, 2,2-bis(4-(4-maleimidophenoxy)phenyl)propane, bis(4-(4-maleimidophenoxy)phenyl) sulfone, bis[4-(4-maleimidophenoxy)phenyl] sulfoxide, 4,4'-bis(3-maleimidophenoxy)biphenyl, 1,3-bis(2-(3-maleimidophenyl)propyl)benzene, 1,3-bis(1-(4-(3-maleimidophenoxy)phenyl)-1-propyl) benzene, bis(maleimidocyclohexyl)methane, 2,2-bis[4-(3-maleimidophenoxy)phenyl]-1,1,1,3,3,3-hexafluoropropane, and bis(maleimidophenyl)thiophene. These may be used singly or in combinations of two or more. Among these, from the viewpoint of more reducing the hygroscopic property and the thermal expansion coefficient, it is preferable to use bis(3-ethyl-5-methyl-4-maleimidophenyl)methane. From the viewpoint of further enhancing the breaking strength of a resin film formed from the resin composition and the metal foil peel strength, as the (C) component, it is preferable to use 2,2-bis(4-(4-maleimidophenoxy)phenyl) propane.

From the viewpoint of the moldability, it is preferable that the (C) component be, for example, a compound represented by the following formula (VI).

[Chemial Formula 8]

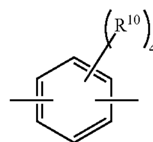
(VI)



In the formula (VI), A_4 represents a residue represented by the following formula (VII), (VIII), (IX) or (X); and A_5 represents a residue represented by the following formula (XI). From the viewpoint of the low thermal expansion property, it is preferable that A_4 be a residue represented by the following formula (VII), (VIII) or (IX).

[Chemical Formula 9]

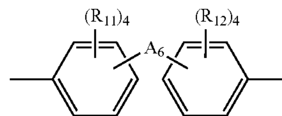
(VII)



In the formula (VII), R_{10} each independently represent a hydrogen atom, an aliphatic hydrocarbon group having 1 to 5 carbon atoms or a halogen atom.

[Chemical Formula 10]

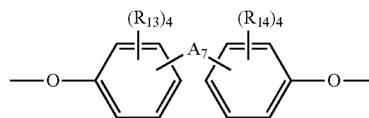
(VIII)



In the formula (VIII), R_{11} and R_{12} each independently represent a hydrogen atom, an aliphatic hydrocarbon group having 1 to 5 carbon atoms or a halogen atom; and A_6 represents an alkylene group or an alkylidene group having 1 to 5 carbon atoms, an ether group, a sulfide group, a sulfonyl group, a carbonyl group, a single bond or a residue represented by the following formula (VIII-1).

[Chemical Formula 11]

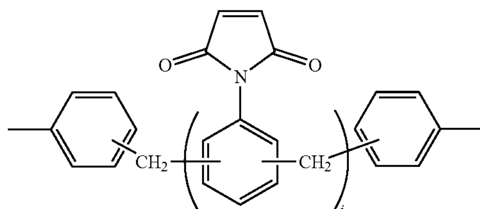
(VIII-I)



In the formula (VIII-1), R_{13} and R_{14} each independently represent a hydrogen atom, an aliphatic hydrocarbon group having 1 to 5 carbon atoms or a halogen atom; and A_7 represents an alkylene group having 1 to 5 carbon atoms, an isopropylidene group, an ether group, a sulfide group, a sulfonyl group, a carbonyl group or a single bond.

[Chemical Formula 12]

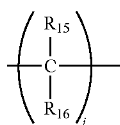
(IX)



In the formula (IX), i is an integer of 1 to 10.

[Chemical Formula 13]

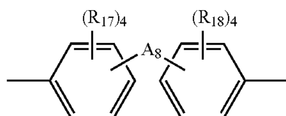
(X)



In the formula (X), R_{15} and R_{16} each independently represent a hydrogen atom or an aliphatic hydrocarbon group having 1 to 5 carbon atoms; and j is an integer of 1 to 8.

[Chemical Formula 14]

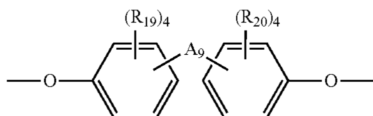
(XI)



In the formula (XI), R_{17} and R_{18} each independently represent a hydrogen atom, an aliphatic hydrocarbon group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, a hydroxyl group or a halogen atom; and A_8 represents an alkylene group or an alkylidene group having 1 to 5 carbon atoms, an ether group, a sulfide group, a sulfonyl group, a carbonyl group, a fluorenylene group, a single bond, a residue represented by the following formula (XI-1) or a residue represented by the following formula (XI-2).

[Chemical Formula 15]

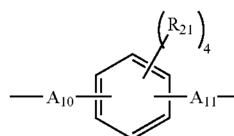
(XI-I)



In the formula (XI-1), R_{19} and R_{20} each independently represent a hydrogen atom, an aliphatic hydrocarbon group having 1 to 5 carbon atoms or a halogen atom; and A_9 represents an alkylene group having 1 to 5 carbon atoms, an isopropylidene group, a m-phenylenediisopropylidene group, a p-phenylenediisopropylidene group, an ether group, a sulfide group, a sulfonyl group, a carbonyl group or a single bond.

[Chemical Formula 16]

(XI-2)



In the formula (XI-2), R_{21} each independently represent a hydrogen atom, an aliphatic hydrocarbon group having 1 to 5 carbon atoms or a halogen atom; and A_{10} and A_{11} each independently represent an alkylene group having 1 to 5 carbon atoms, an isopropylidene group, an ether group, a sulfide group, a sulfonyl group, a carbonyl group or a single bond.

It is preferable, from the viewpoint of the solubility to organic solvents, the high-frequency characteristics and the high adhesiveness to conductors, that a polyaminobismaleimide compound is used as the (C) component. The polyaminobismaleimide compound can be obtained, for example, by subjecting a compound having two maleimido groups on terminals thereof and an aromatic diamine compound having two primary amino groups in the molecule to a Michael addition reaction in an organic solvent.

The aromatic diamine compound having two primary amino groups in the molecule is not especially limited, but examples thereof include 4,4'-diaminodiphenylmethane, 4,4'-diamino-3,3'-dimethyl-diphenylmethane, 2,2'-dimethyl-4,4'-diaminobiphenyl, 2,2-bis(4-(4-aminophenoxy)phenyl)propane, 4,4'-[1,3-phenylenebis(1-methylethylidene)]bisaniline, and 4,4'-[1,4-phenylenebis(1-methylethylidene)]bisaniline. These may be used singly or in combinations of two or more.

Further from the viewpoint of the solubility to organic solvents being high, the reaction ratio in the synthesis being high, and the heat resistance being capable of being raised, 4,4'-diaminodiphenylmethane and 4,4'-diamino-3,3'-dimethyl-diphenylmethane are preferable. These may be used singly or in combinations of two or more according to the purposes, applications and the like.

An organic solvent to be used when the polyaminobismaleimide compound is produced is not especially limited, but examples thereof include alcohols such as methanol, ethanol, butanol, butyl cellosolve, ethylene glycol monomethyl ether and propylene glycol monomethyl ether; ketones such as acetone, methyl ethyl ketone, methyl isobutyl ketone and cyclohexanone; aromatic hydrocarbons such as toluene, xylene and mesitylene; esters such as methoxyethyl acetate, ethoxyethyl acetate, butoxyethyl acetate and ethyl acetate; and nitrogen-containing compounds such as N,N-dimethylformamide, N,N-dimethylacetamide and N-methyl-2-pyrrolidone. These may be used singly or as a mixture of two or more. Among these, methyl ethyl ketone, cyclohexanone, propylene glycol monomethyl ether, N,N-dimethylformamide and N,N-dimethylacetamide are preferable from the viewpoint of the solubility.

<Diamine Compound>

The resin composition according to the present embodiment may further comprise a diamine compound. Examples of the diamine compounds include 4,4'-diaminodiphenylmethane, 4,4'-diamino-3,3'-dimethyl-diphenylmethane, 2,2'-dimethyl-4,4'-diaminobiphenyl, 2,2-bis(4-(4-aminophenoxy)phenyl)propane, 4,4'-[1,3-phenylenebis(1-methylethylidene)]bisaniline, 4,4'-[1,4-phenylenebis(1-methylethylidene)]bisaniline and 1,3-bis[2-(4-

aminophenyl)-2-propyl]benzene. These may be used singly or in combinations of two or more.

Further from the viewpoint of the solubility to organic solvents being high, the reaction ratio in the synthesis being high, and the heat resistance being capable of being raised, 1,3-bis[2-(4-aminophenyl)-2-propyl]benzene, 4,4'-diamino-diphenylmethane or 4,4'-diamino-3,3'-dimethyl-diphenyl-methane is preferable. These may be used singly or in combinations of two or more according to the purposes, applications and the like.

<(D) Thermosetting Resin>

The resin composition of the present embodiment can further comprise a (D) thermosetting resin different from the (A) component and the (C) component. Here, compounds capable of corresponding to the (A) component or the (C) component are determined not to belong to the (D) thermosetting resin. Examples of the (D) thermosetting resin include epoxy resins and cyanate ester resins. When the (D) thermosetting resin is contained, the low thermal expansion characteristics and the like of the resin composition can further be improved.

In the case where as the (D) thermosetting resin, an epoxy resin is contained, the epoxy resin is not especially limited. Examples of thereof include bisphenol A epoxy resins, bisphenol F epoxy resins, bisphenol S epoxy resins, alicyclic epoxy resins, aliphatic chain epoxy resins, phenol novolac epoxy resins, cresol novolac epoxy resins, bisphenol A novolac epoxy resins, phenol aralkyl epoxy resins, naphthalene skeleton-containing epoxy resins such as naphthol novolac epoxy resins and naphthol aralkyl epoxy resins, bifunctional biphenyl epoxy resins, biphenyl aralkyl epoxy resins, dicyclopentadiene epoxy resins and dihydroanthracene epoxy resins. These may be used singly or in combinations of two or more. Among these, from the viewpoint of the high-frequency characteristics and the thermal expansion characteristics, it is preferable to use a naphthalene skeleton-containing epoxy resin or a biphenyl aralkyl epoxy resin.

In the case where as the (D) thermosetting resin, a cyanate ester resin is contained, the cyanate ester resin is not especially limited, but examples thereof include 2,2-bis(4-cyanatophenyl)propane, bis(4-cyanatophenyl)ethane, bis(3,5-dimethyl-4-cyanatophenyl)methane, 2,2-bis(4-cyanatophenyl)-1,1,1,3,3,3-hexafluoropropane, α,α'-bis(4-cyanatophenyl)-m-diisopropylbenzene, cyanate ester compounds of phenol-added dicyclopentadiene polymers, phenol novolac cyanate ester compounds, and cresol novolac cyanate ester compounds. These may be used singly or in combinations of two or more. Among these, from the viewpoint of costs and from the viewpoint of high-frequency characteristics, it is preferable to use 2,2-bis(4-cyanatophenyl)propane.

(Curing Agent)

In the case where the resin composition of the present embodiment contains the (D) thermosetting resin, the resin composition may further comprise a curing agent of the (D) thermosetting resin. Thereby, a reaction when a cured substance of the resin composition is obtained can smoothly be advanced, and the physical properties of the obtained cured substance of the resin composition are enabled to be suitably regulated.

In the case of using an epoxy resin, a curing agent is not especially limited, but examples thereof include polyamine compounds such as diethylenetriamine, triethylenetetramine, diaminodiphenylmethane, m-phenylenediamine and dicyandiamide; polyphenol compounds such as bisphenol A, phenol novolac resins, cresol novolac resins, bisphenol A novolac resins and phenol aralkyl resins; acid anhydrides such as phthalic anhydride and pyromellitic anhydride; various carboxylic acid compounds; and various active ester compounds.

In the case of using a cyanate ester resin, a curing agent is not especially limited, but examples thereof include various monophenol compounds, various polyphenol compounds, various amine compounds, various alcohol compounds, various acid anhydrides and various carboxylic acid compounds. These may be used singly or in combinations of two or more.

(Inorganic Filler)

The resin composition of the present embodiment may further comprise an inorganic filler. When optional suitable inorganic fillers are contained, there can be improved the low thermal expansion characteristics, the high elastic modulus property, the heat resistance, the flame retardancy and the like of the resin composition. The inorganic filler is not especially limited, but examples thereof include silica, alumina, titanium oxide, mica, beryllia, barium titanate, potassium titanate, strontium titanate, calcium titanate, aluminum carbonate, magnesium hydroxide, aluminum hydroxide, aluminum silicate, calcium carbonate, calcium silicate, magnesium silicate, silicon nitride, boron nitride, calcined clay, talc, aluminum borate and silicon carbide. These may be used singly or in combinations of two or more.

The shape and the particle diameter of the inorganic filler are not especially limited, and the particle diameter of the inorganic filler may be, for example, 0.01 to 20 μm or 0.1 to 10 μm. Here, the particle diameter refers to an average particle diameter, and is a particle diameter at the point corresponding to 50% in volume when a cumulative frequency distribution curve of particle diameters is determined with the total volume of the particles being taken to be 100%. The average particle diameter can be measured by a particle size distribution analyzer using a laser diffraction scattering method, or the like.

In the case of using an inorganic filler, the use volume thereof is not especially limited, but it is preferable, for example, that the content ratio of the inorganic filler be 3 to 75% by volume with respect to the total volume of the solid content in the resin composition; and being 5 to 70% by volume is more preferable. In the case where the content of the inorganic filler in the resin composition is in the above range, it becomes easy for better curability, moldability and chemical resistance to be attained.

In the case of using an inorganic filler, the use amount thereof is not especially limited, but it is preferable, for example, that the content ratio of the inorganic filler be 5 to 90% by mass with respect to the total volume of the solid content in the resin composition; and being 10 to 80% by mass is more preferable. In the case where the content of the inorganic filler in the resin composition is in the above range, it becomes easy for better curability, moldability and chemical resistance to be attained.

In the case of using an inorganic filler, for the purpose of improving the dispersibility of the inorganic filler, the close adhesiveness to organic components, and the like, as required, a coupling agent can be used concurrently. The coupling agent is not especially limited, and there can be used, for example, various types of silane coupling agents, and titanate coupling agents. These may be used singly or in combinations of two or more. The amount used of the coupling agent also is not especially limited, and may be made to be, with respect to 100 parts by mass of the inorganic filler to be used, 0.1 to 5 parts by mass or 0.5 to 3 parts by mass, for example. When the amount thereof used

is in this range, decreases in various characteristics are small and it becomes easy for advantages by use of the inorganic filler to be effectively exhibited.

In the case of using a coupling agent, although the so-called integral blending system may be used in which after an inorganic filler is blended in the resin composition, the coupling agent is added, it is preferable to use a system in which there is used an inorganic filler previously surface-treated in dry or wet with the coupling agent. By using this method, advantages of the above inorganic filler can be developed more effectively.

(Thermoplastic Resin)

The resin composition of the present embodiment, from the viewpoint of raising the handleability of the resin film, may further comprise a thermoplastic resin. The kind of the thermoplastic resin is not especially limited, and the molecular weight also is not limited, but from the viewpoint of enhancing the compatibility with the (A) component, it is preferable that the number-average molecular weight (Mn) be 200 to 60000.

From the viewpoint of the film formability and the hygroscopic resistance, it is preferable that the thermoplastic resin be a thermoplastic elastomer. The thermoplastic elastomer includes saturated thermoplastic elastomers; and the saturated thermoplastic elastomers include chemically modified saturated thermoplastic elastomers and non-modified saturated thermoplastic elastomers. The chemically modified saturated thermoplastic elastomers include styrene-ethylene-butylene copolymers modified with maleic anhydride. Specific examples of the chemically modified saturated thermoplastic elastomers include Tuftec M1911, M1913 and M1943 (all, manufactured by Asahi Kasei Corp., trade names). On the other hand, the non-modified saturated thermoplastic elastomers include non-modified styrene-ethylene-butylene copolymers. Specific examples of the non-modified saturated thermoplastic elastomers include Tuftec H1041, H1051, H1043 and H1053 (all, manufactured by Asahi Kasei Corp., trade names).

From the viewpoint of the film formability, the dielectric characteristics and the hygroscopic resistance, it is more preferable that the saturated thermoplastic elastomer have a styrene unit in the molecule. Here, in the present description, the "styrene unit" refers to a unit originated from a styrene monomer in a polymer; and the "saturated thermoplastic elastomer" refers to one having a structure in which any aliphatic hydrocarbon moieties other than aromatic hydrocarbon moieties in the styrene unit are constituted of saturated bonding groups.

The content of the styrene unit in the saturated thermoplastic elastomer is not especially limited, but it is preferable that the content ratio be 10 to 80% by mass in mass percentage of the styrene unit to the total mass of the saturated thermoplastic elastomer; and being 20 to 70% by mass is more preferable. When the content ratio of the styrene unit is in the above range, the saturated thermoplastic elastomer is likely to be excellent in the film appearance, the heat resistance and the adhesiveness.

Specific examples of the saturated thermoplastic elastomer having the styrene unit in the molecule include styrene-ethylene-butylene copolymers. The styrene-ethylene-butylene copolymers can be obtained, for example, by carrying out hydrogenation on unsaturated double bonds which structural units originated from butadiene of a styrene-butadiene copolymer have.

The content of the thermoplastic resin is not especially limited, but from the viewpoint of making the dielectric characteristics better, it is preferable that the content be 0.1 to 15% by mass to the total mass of the solid content of the resin composition; being 0.3 to 10% by mass is more preferable; and being 0.5 to 5% by mass is still more preferable.

(Flame Retardant)

The resin composition of the present embodiment may further be blended with a flame retardant. The flame retardant is not especially limited, but there are suitably used bromine-based flame retardants, phosphorus-based flame retardants, metal hydroxides, and the like. The bromine-based flame retardants include brominated epoxy resins such as brominated bisphenol A epoxy resins and brominated phenol novolac epoxy resins; bromination addition-type flame retardants such as hexabromobenzene, pentabromotoluene, ethylenebis(pentabromophenyl), ethylenebistetrabromophthalimide, 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane, tetrabromocyclooctane, hexabromocyclododecane, bis(tribromophenoxy)ethane, brominated polyphenylene ethers, brominated polystyrenes and 2,4,6-tris(tribromophenoxy)-1,3,5-triazine; and bromination reaction-type flame retardants containing an unsaturated double bond group such as tribromophenylmaleimide, tribromophenyl acrylate, tribromophenyl methacrylate, tetrabromobisphenol A dimethacrylate, pentabromobenzyl acrylate, and brominated styrene. These flame retardants may be used singly or in combinations of two or more.

The phosphorus-based flame retardants include aromatic phosphate esters such as triphenyl phosphate, tricresyl phosphate, trixylenyl phosphate, cresyl diphenyl phosphate, cresyl di-2,6-xylenyl phosphate and resorcinol bis(diphenylphosphate); phosphonate esters such as divinyl phenylphosphonate, diallyl phenylphosphonate and bis(1-butenyl) phenylphosphonate; phosphinate esters such as phenyl diphenylphosphinate, methyl diphenylphosphinate and 9,10-dihydro-9-oxa-10-phosphaphenanthrene-10-oxide derivatives; phosphazene compounds such as bis(2-allylphenoxy)phosphazene and dicresylphosphazene; and other phosphorus-based flame retardants such as melamine phosphate, melamine pyrophosphate, melamine polyphosphate, melam polyphosphate, ammonium polyphosphate, phosphorus-containing vinylbenzyl compounds and red phosphorus. The metal hydroxide flame retardants include magnesium hydroxide and aluminum hydroxide. These flame retardants may be used singly or in combinations of two or more.

The resin composition of the present embodiment can be obtained by homogeneously dispersing and mixing the above-mentioned respective components; and its preparation means, conditions and the like are not especially limited. Examples of the preparation means include a method in which the respective components in predetermined amounts blended are fully and homogeneously stirred and mixed by a mixer or the like, and thereafter kneaded by using a mixing roll, an extrusion machine, a kneader, a roll, an extruder, or the like; and further, the obtained kneaded material is cooled and crushed. Here, also the kneading form is not especially limited.

The relative dielectric constant of a cured substance of the resin composition of the present embodiment is not especially limited, but from the viewpoint of being suitably used in a high-frequency band, it is preferable that the relative dielectric constant at 10 GHz be 3.6 or lower; being 3.1 or lower is more preferable; and being 3.0 or lower is still more preferable. The lower limit of the relative dielectric constant is not especially limited, but may be, for example, about 1.0. Further from the viewpoint of being suitably used in a high-frequency band, it is preferable that the dielectric loss tangent of a cured substance of the resin composition of the

present embodiment be 0.004 or lower; and being 0.003 or lower is more preferable. The lower limit of the relative dielectric constant is not especially limited, but may be, for example, about 0.0001. The relative dielectric constant and the dielectric loss tangent can be measured by methods shown in the below Examples.

From the viewpoint of suppressing warpage of the laminate, it is preferable that the thermal expansion coefficient of a cured substance of the resin composition of the present embodiment be 10 to 90 ppm/OC; being 10 to 45 ppm/° C. is more preferable; and being 10 to 40 ppm/OC is still more preferable. The thermal expansion coefficient can be measured according to IPC-TM-650 2.4.24.

The resin composition of the present embodiment has excellent dielectric characteristics of being low in both the relative dielectric constant and the dielectric loss tangent in a high-frequency region. Hence, in the case where a metal-clad cured resin film is made by laminating a metal foil (copper foil) on the surface (one surface or both surfaces) of the resin film, dielectric characteristics excellent in the high-frequency region can be attained.

[Resin Film]

In the present embodiment, a resin film can be produced by using the above-mentioned resin composition. Here, the resin film refers to an uncured or semicured filmy resin composition.

A production method of the resin film is not limited, but the resin film can be obtained, for example, by drying a resin layer formed by applying the resin composition on a support base material. Specifically, the resin composition is applied on a support base material by using a kiss coater, a roll coater, a comma coater or the like, and thereafter, may be dried in a heating dryer or the like, for example, at a temperature of 70 to 250° C., preferably 70 to 200° C., for 1 to 30 min, preferably 3 to 15 min. Thereby, there can be obtained the resin film in the state that the resin composition is semicured.

Here, the resin film in the state of being semicured can be heat-cured by being further heated by a heating oven, for example, at a temperature of 170 to 250° C., preferably 185 to 230° C., for 60 to 150 min.

The thickness of the resin film according to the present embodiment is not especially limited, but it is preferable that the thickness be 1 to 200 μm; being 2 to 180 μm is more preferable; and being 3 to 150 μm is still more preferable. When the thickness of the resin film is made to be in the above range, there are easily satisfied simultaneously both the thickness reduction and the good high-frequency characteristics of a printed wiring board obtained by using the resin film according to the present embodiment.

The support base material is not especially limited, but examples thereof include glasses, metal foils and PET films. When the resin film has the support base material, the storage property and the handleability in production use of a printed wiring board are likely to become good. That is, the resin film according to the present embodiment can take a form of a support with a resin layer which has a resin layer containing the resin composition of the present embodiment and the support base material, and the resin layer may be peeled off the support base material when the resin film is used.

In conventional resin films for printed wiring boards, in the case where no glass cloth or the like is blended in their resin compositions, it is likely that the handleability of the resin films becomes worse and the strength cannot also be sufficiently held. By contrast, the resin film of the present embodiment, particularly since being formed from the flexible resin composition having the (A) component, even without glass cloth or the like, there is made a resin film thin and excellent in handleability (tackiness, cracking, powder dropping and the like). Further the resin film of the present embodiment is sufficiently high in the peel strength to a low-profile foil or the like. Hence, a low-profile foil can be used without any problem, and there can further be provided a printed wiring board sufficiently reduced in the transmission loss. Further the resin film of the present embodiment can simultaneously attain excellent appearance and multi-layering moldability, and is excellent also in the heat resistance and the moisture resistance.

[Prepreg]

The prepreg of the present embodiment can be obtained, for example, by coating the resin composition of the present embodiment on a fiber base material being a reinforcing base material and drying the coated resin composition. Further the prepreg of the present embodiment may be obtained by impregnating the fiber base material with the resin composition of the present embodiment, and thereafter drying the impregnated resin composition. Specifically, the prepreg in which the resin composition is semicured is obtained by drying the fiber base material on which the resin composition adheres in a drying oven usually at a temperature of 80 to 200° C. for 1 to 30 min. With respect to the amount of the resin composition adhering on the fiber base material, from the viewpoint of the good moldability, it is preferable that the resin composition be coated or impregnated so that the resin content ratio in the prepreg after the drying becomes 30 to 90% by mass.

The reinforcing base material of the prepreg is not especially limited, but a sheet-form fiber base material is preferable. As the sheet-form fiber base material, there are used, for example, well-known ones being used for various types of laminates for electric insulating materials. Examples of materials therefor include inorganic fibers of E glass, NE glass, S glass, Q glass or the like; and organic fibers of polyimide, polyester, tetrafluoroethylene or the like. As the sheet-form fiber base material, there can be used ones having a shape of woven fabric, nonwoven fabric, chopped strand mat or the like. Further the thickness of the sheet-form fiber base material is not especially limited, and the sheet-form fiber base materials of, for example, 0.02 to 0.5 mm can be used. Further as the sheet-form fiber base material, ones having been subjected to a surface treatment with a coupling agent or the like, or having been subjected to a mechanical fiber opening treatment are preferable from the viewpoint of the impregnatability of the resin composition, and the heat resistance, hygroscopic resistance and processability of a laminate when the fiber base material is made into the laminate.

[Laminate]

According to the present embodiment, there can be provided a laminate having a resin layer containing a cured substance of the above-mentioned resin composition, and a conductor layer. For example, a metal-clad laminate can be produced by using the resin film or the prepreg. The metal-clad laminate obtained by using the resin film or the prepreg, since having a high solder heat resistance capable of withstanding a solder connection step in the mounting, and being excellent also in the hygroscopic resistance, becomes one suitable for outdoor applications.

A production method of the metal-clad laminate is not limited, but a metal-clad laminate having a metal foil on at least one surface of the resin layer or the prepreg to become an insulating layer can be obtained, for example, by disposing the metal foil to become a conductor layer on at least one

surface of one sheet or a plurality of stacked sheets of the resin film or the prepreg according to the present embodiment, and heating and pressing the resultant, for example, at a temperature of 170 to 250° C., preferably 185 to 230° C., and at a pressure of 0.5 to 5.0 MPa for 60 to 150 min. The heating and pressing can be carried out, for example, under the condition of a degree of vacuum of 10 kPa or lower, preferably 5 kPa or lower, and from the viewpoint of enhancing the efficiency, it is preferable that the heating and pressing be carried out in vacuum. It is preferable that the heating and pressing be carried out for 30 min from the starting time to until the molding-finishing time therefrom.

[Multilayer Printed Wiring Board]

According to the present embodiment, there can be provided a multilayer printed wiring board having a resin layer containing a cured substance of the above-mentioned resin composition, and circuit layers. The upper limit value of the number of circuit layers is not especially limited, and may be 3 layers to 20 layers. A multilayer printed wiring board can also be produced, for example, by using the above-mentioned resin film, prepreg or metal-clad laminate.

A production method of a multilayer printed wiring board is not especially limited, but a multilayer printed wiring board can be produced, for example, by first disposing the resin film on one surface or both surfaces of a core substrate having been subjected to a circuit formation processing or disposing the resin film between a plurality of core substrates, subjecting the resultant to pressing and heating lamination molding or pressing and heating press molding to adhere the each layer, and thereafter subjecting the resultant to a circuit formation processing by laser boring processing, drill boring processing, metal plating processing, metal etching processing or the like. In the case where the resin film has a support base material, the support base material can be peeled off in advance before the resin film is disposed on a core substrate or between core substrates, or be peeled off after the resin layer is laminated on the core substrate.

A production method of a multilayer printed wiring board using the resin film according to the present embodiment will be described by way of FIG. **1**. FIG. **1** is a diagram schematically illustrating production steps of the multilayer printed wiring board according to the present embodiment. The production method of the multilayer printed wiring board according to the present embodiment comprises (a) a step (hereinafter, referred to as “step (a)”) of laminating a resin film on an inner layer circuit board to form a resin layer, (b) a step (hereinafter, referred to as “step (b)”) of heating and pressing the resin layer to cure the resin layer, and (c) a step (hereinafter, referred to as “step (c)”) of forming an antenna circuit layer on the cured resin layer.

As illustrated in (a) of FIG. **1**, a resin film **12** according to the present embodiment is laminated on an inner layer circuit board **11** to thereby form a resin layer consisting of the resin film **12** in the step (a).

A lamination method is not especially limited, but examples thereof include a method of laminating by using a multi-daylight press, a vacuum press, an atmospheric laminator or a laminator which performs heating and pressing under vacuum, and preferable is a method using the laminator which performs heating and pressing under vacuum. Thereby, even if the inner layer circuit board **11** has fine wiring circuits on its surface, spaces between the circuits can be embedded in the resin without producing voids. The lamination condition is not especially limited, but it is preferable that the lamination be carried out at a pressure bonding temperature of 70 to 130° C. and a pressure bonding pressure of 1 to 11 kgf/cm^2, and under reduced pressure or under vacuum. The lamination may be carried out in a batch system or a continuous system using rolls.

The inner layer circuit board **11** can use, without being especially limited, a glass epoxy substrate, a metal substrate, a polyester substrate, a polyimide substrate, a BT resin substrate, a thermosetting polyphenylene ether substrate, or the like. The circuit surface on the surface side of the inner layer circuit board **11** on which the resin film is to be laminated may be previously subjected to a roughening treatment.

The number of circuit layers of the inner layer circuit board **11** is not limited. FIG. **1** illustrates an inner layer circuit board having 6 layers, but the number thereof is not limited to this number of layers; for example, in the case of fabricating a printed wiring board for a millimeter-wave radar, the number thereof can optionally be selected from 2 layers to 20 layers or so according to the design concerned. The multilayer printed wiring board of the present embodiment can be applied to fabrication of a millimeter-wave radar. That is, there can be fabricated a printed wiring board for a millimeter-wave radar which has a resin layer containing a cured substance of the resin film according to the present embodiment, and a circuit layer.

In the case where an antenna circuit layer **14** described later is formed on a resin layer **12***a* by etching, a metal foil **13** may further be laminated on the resin film **12** to form a metal layer **13***a*. Examples of the metal foil include copper, aluminum, nickel and zinc, and from the viewpoint of the conductivity, copper is preferable. The metal foil may be an alloy, and examples of copper alloys include high-purity copper alloys in which a small amount of beryllium or cadmium is added. It is preferable that the thickness of the metal foil be 3 to 200 μm; and being 5 to 70 μm is more preferable.

As illustrated in (b) of FIG. **1**, the inner layer circuit board **11** and the resin layer **12***a* laminated in the step (a) are heated and pressed to be heat-cured in the step (b). The condition is not especially limited, but it is preferable that the condition be in the ranges of a temperature of 100° C. to 250° C., a pressure of 0.2 to 10 MPa and a time of 30 to 120 min; and being 150° C. to 220° C. is more preferable.

As illustrated in (c) of FIG. **1**, the antenna circuit layer **14** is formed on the resin layer **12***a* in the step (c). A formation method of the antenna circuit layer **14** is not especially limited, and the antenna circuit layer **14** may be formed, for example, by an etching process such as a subtractive process or a semi-additive process.

The subtractive process is a process of forming a desired circuit by forming an etching resist layer having a shape corresponding to a desired pattern shape on the metal layer **13***a*, and in a developing process thereafter, dissolving and removing the metal layer in portions where the resist is removed by using a chemical. For example, a copper chloride solution or an iron chloride solution can be used as the chemical.

The semi-additive process is a process of forming a desired circuit layer by forming a metal film on the surface of the resin layer **12***a* by an electroless plating method, forming a plating resist layer having a shape corresponding to a desired pattern on the metal film, then forming a metal layer by an electroplating method, and thereafter removing an unnecessary electrolessly plated layer by using a chemical or the like.

Further in the resin layer **12***a*, as required, holes such as a via hole **15** may be formed. A formation method of the hole is not limited, but there can be applied an NC drill, a carbon dioxide laser, a UV laser, a YAG laser, a plasma or the like.

Here, the inner layer circuit board **11** may also be produced by steps (p) to (r) illustrated in FIG. **2**. FIG. **2** is a diagram schematically illustrating production steps of an inner layer circuit board. That is, the production method of the multilayer printed wiring board according to the present embodiment may comprise a step (p), a step (q), a step (r), the step (a), the step (b) and the step (c). Hereinafter, the steps (p) to (r) will be described.

First, as illustrated in (p) of FIG. **2**, core substrates **41** and prepregs **42** are laminated in the step (p). As the core substrate, there can be used, for example, a glass epoxy substrate, a metal substrate, a polyester substrate, a polyimide substrate, a BT resin substrate, or a thermosetting polyphenylene ether substrate. As the prepreg, there can be used, for example, "GWA-900G", "GWA-910G", "GHA-679G", "GHA-679G(S)", "GZA-71G" or "GEA-75G" (all, trade names), manufactured by Hitachi Chemical Co., Ltd.

Next, as illustrated in (q) of FIG. **2**, a laminated body obtained in the step (p) of the core substrates **41** and the prepregs **42** is heated and pressed in the step (q). The heating temperature is not especially limited, but it is preferable to be 120 to 230° C.; and being 150 to 210° C. is more preferable. Further the pressing pressure is not especially limited, but it is preferable to be 1 to 5 MPa; and being 2 to 4 MPa is more preferable. The heating time is not especially limited, but it is preferable to be 30 to 120 min. Thereby, there can be obtained an inner layer circuit board excellent in the dielectric characteristics, and the mechanical and electrical connection reliability in a high-temperature high-humidity.

Further as illustrated in (r) of FIG. **2**, as required, a through hole **43** is formed in the inner layer circuit board in the step (r). A formation method of the through hole **43** is not especially limited, and may be the same as the above-mentioned step of forming the antenna circuit layer, or may use a known method.

By the above steps, there can be produced the multilayer printed wiring board of the present embodiment. The steps (a) to (c) may further be repeated by using the printed wiring board produced in the above steps as an inner layer circuit board.

FIG. **3** is a diagram schematically illustrating production steps, of a multilayer printed wiring board, using the multilayer printed wiring board produced by the steps illustrated in FIG. **1** as an inner layer circuit board. FIG. **3**(*a*), FIG. **3**(*b*) and FIG. **3**(*c*) correspond to FIG. **1**(*a*), FIG. **1**(*b*) and FIG. **1**(*c*), respectively.

Specifically, (a) of FIG. **3** illustrates a step of laminating a resin film **22** on an inner layer circuit board **21** to form a resin layer **22***a*, and as required, laminating a metal foil **23** on the resin film **22** to form a metal layer **23***a*. (b) of FIG. **3** illustrates a step of heating and pressing the resin layer **22***a* to cure the resin layer **22***a*; and (c) of FIG. **3** illustrates a step of forming an antenna circuit layer **24** on the cured resin layer.

In FIG. **1** and FIG. **3**, the number of the resin layers laminated on the inner layer circuit board for the purpose of forming an antenna circuit pattern and the like is made to be one layer or two layers, but the number thereof is not limited thereto; and the number of layers may be made to be 3 or more layers according to the antenna circuit design. By making an antenna circuit layer to be multilayer, it becomes easy to design antennas having wideband characteristics and antennas exhibiting little angular variation (beam tiltless) in antenna radiation patterns in the use frequency band.

The production method of the multilayer printed wiring board according to the present embodiment, since forming the resin layer by using the resin film containing the (A) component and the (B) component, can fabricate the laminated body without providing an adhesive layer except for providing the layer excellent in the high-frequency characteristics. Thereby, the simplification of the steps can be achieved and the effect of further improving the high-frequency characteristics can be attained.

The resin composition, the resin film, the prepreg, the laminate, and the multilayer printed wiring board according to the present embodiment as described above can suitably be used for electronic devices handling high-frequency signals of 1 GHz or higher, particularly electronic devices handling high-frequency signals of 10 GHz or higher.

Hitherto, the preferred embodiments according to the present invention have been described, but are taken as examples to describe the present invention; and there is no tenor of limiting the scope of the present invention to the embodiments. The present invention can be carried out in various modes different from the above embodiments without departing from its gist.

EXAMPLES

Hereinafter, the present invention will be described in more detail based on Examples and Comparative Examples. However, the present invention is not limited to the following Examples.

[Preparation of Resin Compositions]

Various resin compositions were prepared according to the following procedure. The amounts (parts by mass) of each raw material used for the preparation of resin compositions of Examples 1 to 12 and Comparative Examples 1 to 5 are collectively shown in Tables 1 and 2.

Each component indicated in Table 1 or Table 2 was charged in a 300-mL four-necked flask equipped with a thermometer, a reflux cooling tube and a stirring apparatus, stirred at 25° C. for 1 hour, and thereafter filtered with a #200 nylon mesh (opening: 75 μm) to thereby obtain resin compositions.

Here, the abbreviations and the like of each material in Table 1 and Table 2 are as follows.

(1) (A) Component

BMI-3000 [Mw: about 3000, manufactured by Designer Molecules Inc., trade name]

BMI-5000 [Mw: about 5000, manufactured by Designer Molecules Inc., trade name]

(2) (B) Component

Perbutyl P [di(2-t-butylperoxyisopropyl)benzene, one-minute half-life temperature: 175° C., one-hour half-life temperature: 138° C., manufactured by NOF Corp., trade name]

Percumyl D [dicumyl peroxide, one-minute half-life temperature: 175° C., one-hour half-life temperature: 136° C., manufactured by NOF Corp., trade name]

Perhexyne 25B [2,5-dimethyl-2,5-di(t-butylperoxy) hexane-3, one-minute half-life temperature: 180° C., one-hour half-life temperature: 138° C., manufactured by NOF Corp., trade name]

Perbutyl A [t-butyl peroxyacetate, one-minute half-life temperature: 160° C., one-hour half-life temperature: 121° C., manufactured by NOF Corp., trade name]

Perbutyl 1 [t-butyl peroxyisopropylmonocarbonate, one-minute half-life temperature: 159° C., one-hour half-life temperature: 118° C., manufactured by NOF Corp., trade name]

G-8009L [isocyanate-masked imidazole (addition reaction product of a hexamethylene diisocyanate resin and 2-ethyl-4-methylimidazole), manufactured by DKS Co., Ltd., trade name]

TPP-MK [a tetraphenylphosphonium, manufactured by Hokko Sangyo Co., Ltd., trade name]

(3) (B)' component (a catalyst different from the (B) component) Zinc naphthenate [manufactured by Tokyo Chemical Industry Co., Ltd.]

(4) (C) Component

BMI-1000 [bis(4-maleimidophenyl)methane, manufactured by Daiwa Kasei Industrial Co., Ltd., trade name]

BMI-4000 [2,2-bis(4-(4-maleimidophenoxy)phenyl)propane, manufactured by Daiwa Kasei Industrial Co., Ltd., trade name]

(5) Diamine

Bisaniline M [1,3-bis[2-(4-aminophenyl)-2-propyl]benzene, manufactured by Mitsui Fine Chemicals, Inc., trade name]

(6) Inorganic Filler

A silica slurry [a spherical fused silica, surface treatment: a phenylaminosilane coupling agent (10% by mass/total solid content in the slurry), disperse medium: methyl isobutyl ketone (MIBK), solid content concentration: 70% by mass, average particle diameter: 0.5 μm, density: 2.2 g/cm^3, manufactured by Admatex Co., Ltd., trade name: "SC-2050KNK"]

(7) Solvent

Toluene [manufactured by Kanto Chemical Co., Inc.]

TABLE 2

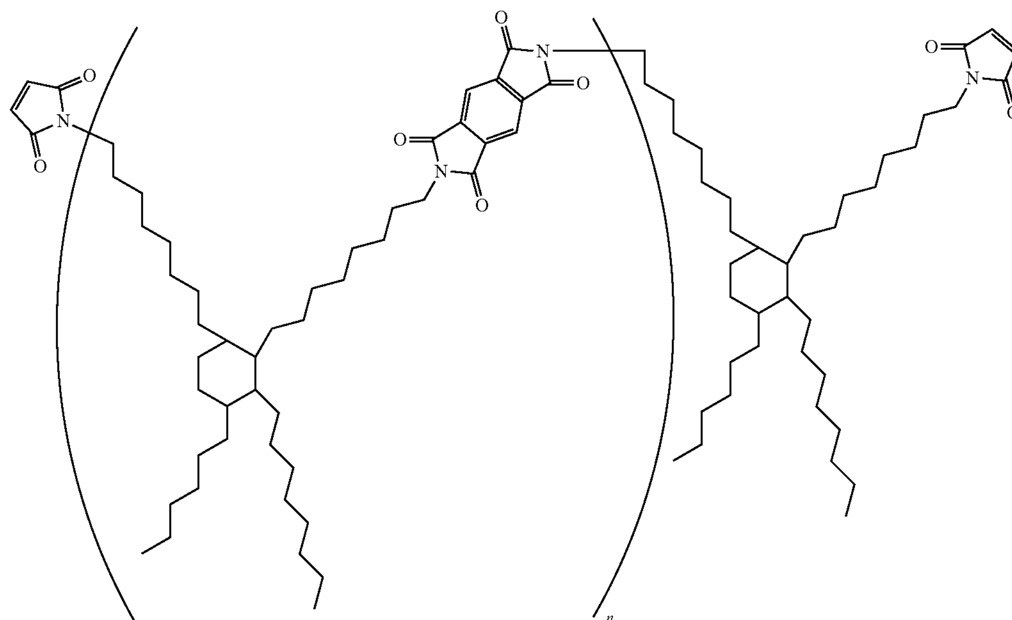
		Comparative Examples				
		1	2	3	4	5
(A) Component	BMI-3000	—	—	—	100	100
	BMI-5000	—	—	—	—	—
(B) Component	Perbutyl P	—	—	2	—	—
	G8009L	2	2	—	—	—
(B)' Component	Zinc Naphthenate	—	—	—	2	—
(C) Component	BMI-1000	100	—	—	—	—
	BMI-4000	—	100	80	—	—
Diamine	Bisaniline M	—	—	20	—	—
Silica Slurry * the number in ( ) indicates the amount of solvent		400 (120)	400 (120)	400 (120)	400 (120)	400 (120)
Solvent	Toluene	43.7	43.7	43.7	43.7	43.7

Here, presumed structures of the compounds (BMI-3000 and BMI-5000) used as the (A) component are as the following formula (XII-3)

TABLE 1

		Examples											
		1	2	3	4	5	6	7	8	9	10	11	12
(A) Component	BMI-3000	100	100	100	100	100	90	—	100	100	100	90	90
	BMI-5000	—	—	—	—	—	—	90	—	—	—	—	—
(B) Component	Perbutyl P	—	—	2	—	—	—	—	—	—	2	2	—
	Percumyl D	—	2	—	—	—	—	2	—	—	—	—	—
	Perhexyne 25B	2	—	—	—	—	2	—	—	—	—	—	—
	Perbutyl A	—	—	—	2	—	—	—	—	—	—	—	—
	Perbutyl I	—	—	—	—	2	—	—	—	—	—	—	—
	G8009L	—	—	—	—	—	—	—	2	—	1	—	—
	TPP-MK	—	—	—	—	—	—	—	—	2	—	—	2
(C) Component	BMI-1000	—	—	—	—	—	—	10	—	—	—	—	—
	BMI-4000	—	—	—	—	—	10	—	—	—	—	8	8
Diamine	Bisaniline M	—	—	—	—	—	—	—	—	—	—	2	2
Silica Slurry * the number in ( ) indicates the amount of solvent		400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)	400 (120)
Solvent	Toluene	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7	43.7

[Chemical Formula 17]



[Fabrication of Resin Films in a Semicured State]

The resin compositions obtained in Examples 1 to 12 and Comparative Examples 1 to 5 were each coated on a PET film (manufactured by Teijin Ltd., trade name: "G2-38") of 38 μm in thickness as a support base material by using a comma coater, and dried at a drying temperature of 130° C. for 10 min to thereby fabricate semicured resin films with a PET film, which had a resin layer in a semicured state. The thickness of the semicured resin films (resin layers) was 50 μm.

[Evaluation of the Resin Films]

There were evaluated the appearance and the handleability of the semicured resin films of the Examples 1 to 12 and the Comparative Examples 1 to 5. The evaluation results are shown in Table 3 and Table 4.

The appearance was visually evaluated according to the following criteria.

○: there were no unevenness, no streaks and the like on the surface of the semicured resin film.

×: there were unevenness, streaks and the like in an impracticable state on the surface of the semicured resin film, and the surface smoothness was poor.

The handleability was evaluated visually and tactually according to the following criteria.

(1) Presence/absence of tackiness on the surface at 25° C.

(2) Presence/absence of resin cracking or powder dropping when being cut by a cutter knife.

○: Both of the above (1) and (2) were absent.

×: At least either one of the above (1) and (2) was present.

[Multilayer Printed Wiring Boards]

Multilayer printed wiring boards were fabricated by the following procedure by using the above-mentioned semicured resin films with a PET film.

A glass fabric base epoxy resin copper-clad laminate having circuit patterns formed therein was used as an inner layer circuit board; one sheet of the semicured resin film obtained by peeling the PET film off was placed on each of both surfaces of the inner layer circuit board; an electrodeposited copper foil (manufactured by Nippon Denkai, Ltd., trade name: "YGP-12") of 12 μm in thickness was disposed on each of the sheets; thereafter, end plates were placed thereon; and the resultant was subjected to heating and pressing molding under the pressing condition of 200° C./3.0 MPa/70 min to thereby fabricate a 4-layered printed wiring board.

Then, the copper foils of the outermost layers of the fabricated 4-layered printed wiring board were etched to evaluate the circuit embeddability (multilayering moldability). The multilayering moldability was visually evaluated according to the following criteria.

○: No voids nor blurs were present on the circuits.

×: More or less voids and blurs were present.

[Double-Sided Metal-Clad Cured Resin Films]

After two sheets of the resin film obtained by peeling the PET film off from the above semicured resin film with the PET film were stacked; a low-profile copper foil (M-surface Rz: 3 μm, manufactured by Furukawa Electric Co., Ltd., trade name: "F3-WS") of 18 μm in thickness was disposed on each of both surfaces of the stacked two sheets so that the roughened surface (M-surface) contacted therewith; an end plate was placed on each of the copper foils; and the resultant was subjected to heating and pressing molding under the pressing condition of 200° C./3.0 MPa/70 min to thereby fabricate a double-sided metal-clad cured resin film (thickness: 0.1 mm).

For the above double-sided metal-clad cured resin film, there were evaluated the handleability (bending resistance), the dielectric characteristics, the copper foil peel strength, the solder heat resistance and the thermal expansion characteristics. The evaluation results are shown in Table 3 and Table 4. Methods for evaluating the characteristics of the double-sided metal-clad cured resin film were as follows.

[Bending Resistance]

The bending resistance was evaluated according to the following criteria by bending, by 180°, the double-sided metal-clad cured resin film whose outer layer copper foils had been etched.

○: No breaking nor cracking were generated on bending.

×: More or less breaking and cracking were generated on bending.

[Dielectric Characteristics]

The relative dielectric constant and the dielectric loss tangent being the dielectric characteristics were measured by a cavity resonator perturbation method, by using a test piece prepared by etching the outer layer copper foils of the double-sided metal-clad cured resin film and cutting the resultant into 60 mm in length, 2 mm in width and about 1 mm in thickness. A measuring device used was a vector network analyzer E8364B, manufactured by Agilent Technologies, Inc.; cavity resonators used were CP129 (10-GHz band resonator) and CP137 (20-GHz band resonator), manufactured by Kanto Electronics Application and Development Inc.; and the measurement program used was CPMA-V2. The condition was set at frequencies of 10 GHz and at a measurement temperature of 25° C.

[Thermal Expansion Coefficient (CTE)]

For the evaluation of the thermal expansion coefficient (in the film thickness direction), a test piece was prepared by etching the copper foils of both sides of the double-sided metal-clad cured resin film and cutting the resultant into 50 mm square; and the thermal expansion coefficient of the test piece was measured by a thermomechanical analyzer TMA (manufactured by TA Instruments Inc., Q400) (temperature range: 30 to 150° C., load: 5 g) according to the IPC standard (IPC-TM-650 2.4.24).

[Copper Foil Peel Strength]

The copper foil peel strength of the double-sided metal-clad cured resin film was measured according to the standard for test methods of copper-clad laminates, JIS-C-6481.

[Solder Heat Resistance]

For the evaluation of the solder heat resistance, test pieces were prepared by etching the copper foil of one side of the double-sided metal-clad cured resin film and cutting the resultant into 50 mm square; the test pieces in the normal condition and test pieces having been treated for predetermined times (1, 3 and 5 hours) in a pressure cooker test (PCT) apparatus (condition: 121° C., 2.2 atm) were made to flow on a molten solder at 288° C. for 20 sec; and the appearance of sheets of the cured resin films different in the treatment time was visually evaluated according to the following criteria. The evaluation was carried out by using three sheets of the cured resin film for the same treatment time; and the number of sheets exhibiting "○" in the following criteria is shown in Table 3 and Table 4. Here, in Table 3 and Table 4, the test piece having been treated for 1 hour is represented as PCT-1h; the test piece having been treated for 3 hours is represented as PCT-3h; and the test piece having been treated for 5 hours is represented as PCT-5h.

○: No generation of blistering or measling in the film interior and between the film and the copper foil was recognized.

×: Generation of blistering or measling in the film interior and between the film and the copper foil was observed.

TABLE 3

		Examples											
		1	2	3	4	5	6	7	8	9	10	11	12
Semicured Resin Film Characteristics	Appearance	○	○	○	○	○	○	○	○	○	○	○	○
	Handleability	○	○	○	○	○	○	○	○	○	○	○	○
	Multilayering Moldability	○	○	○	○	○	○	○	○	○	○	○	○
Bending Resistance		○	○	○	○	○	○	○	○	○	○	○	○
Relative Dielectric Constant	10 GHz	2.98	2.98	2.98	3.00	3.02	3.06	3.00	3.00	3.00	3.06	3.00	3.00
Dielectric Loss Tangent	10 GHz	0.0016	0.0016	0.0016	0.0017	0.0017	0.0016	0.0017	0.0017	0.0017	0.0016	0.0017	0.0017
CTE (ppm/° C.)		85	92	88	98	99	35	41	1.03	1.01	60	41	56
Copper Foil Peel Strength (kN/m)		0.87	0.85	0.85	0.80	0.81	0.85	0.82	0.79	0.82	0.85	0.82	0.82
Solder Heat Resistance	Normal Condition	3	3	3	3	3	3	3	3	3	3	3	3
	PCT-1 h	3	3	3	3	3	3	3	3	3	3	3	3
	PCT-3 h	3	3	3	3	2	3	3	2	1	3	3	3
	PCT-5 h	3	3	3	1	1	3	3	1	0	3	3	1

TABLE 4

		Comparative Examples				
		1	2	3	4	5
Semicured Resin Film Characteristics	Appearance	○	○	○	○	○
	Handleability	X	X	X	○	○
	Multilayering Moldability	○	○	○	○	○

TABLE 4-continued

		Comparative Examples				
		1	2	3	4	5
Bending Resistance		○	○	○	○	○
Relative Dielectric Constant	10 GHz	3.11	3.10	3.16	2.98	2.98
Dielectric Loss Tangent	10 GHz	0.0100	0.0080	0.0120	0.0018	0.0018
CTE (ppm/° C.)		16	18	18	120	160
Copper Foil Peel Strength (kN/m)		0.45	0.55	0.71	0.85	0.85
Solder Heat Resistance	Normal Condition	3	3	3	3	0
	PCT-1 h	3	3	3	0	0
	PCT-3 h	3	3	3	0	0
	PCT-5 h	3	3	3	0	0

As is clear from the results shown in Table 3, it was confirmed that the resin films made by using the resin compositions of Examples 1 to 12 were better in the high-frequency characteristics, the adhesiveness to conductors and the handleability (tackiness, cracking, powder dropping and the like) as well than Comparative Examples 1 to 3, which contained no (A) component, and were better in the solder heat resistance and exhibited a lower thermal expansion property than Comparative Examples 4 and 5, which contained no (B) component. Further it was confirmed that particularly the resin compositions of Examples 1 to 3, which used organic peroxides higher in the one-minute half-life temperature and the one-hour half-life temperature, were better in the heat resistance.

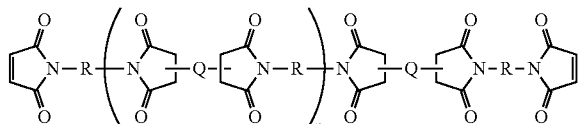
REFERENCE SIGNS LIST

11, **21**: inner layer circuit board, **12**, **22**: resin film, **12***a*, **22***a*: resin layer, **13**, **23**: metal foil, **13***a*, **23***a*: metal layer, **14**, **24**: antenna circuit layer, **15**: via hole, **42**: prepreg, **41**: core substrate, and **43**: through-hole.

The invention claimed is:

1. A resin composition comprising:

a maleimide compound (A) having a maleimide group, a saturated or unsaturated divalent hydrocarbon group and a divalent group having at least two imido bonds and being represented by the following formula



wherein R and each independently represent a divalent organic group and n represents an integer of 1 to 10;

a catalyst (B) comprising at least one selected from the group consisting of an imidazole compound, a phosphorus compound, an azo compound and an organic peroxide, wherein a content of the catalyst is 0.1 to 10 parts by mass with respect to 100 parts by mass of the maleimide compound (A);

a diamine compound or an aromatic maleimide compound (C) different from the maleimide compound (A), wherein, if the aromatic maleimide compound (C) different from the maleimide compound (A) has the above formula, at least one of R and Q is different than R or Q in the maleimide compound (A); and

an inorganic filler.

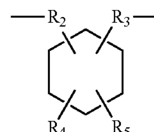
2. The resin composition according to claim **1**, wherein the catalyst comprises an organic peroxide.

3. The resin composition according to claim **1**, wherein a one-hour half-life temperature of the organic peroxide is 110 to 250° C.

4. The resin composition according to claim **1**, wherein the number of carbon atoms of the hydrocarbon group is 8 to 100.

5. The resin composition according to claim **1**, wherein the hydrocarbon group is a group represented by the following formula (II):

[Chemical Formula 1]



(II)

wherein in the formula (II), R_2 and R_3 each independently represent an alkylene group having 4 to 50 carbon atoms: R_4 represents an, alkyl group having 4 to 50 carbon atoms; and R_5 represents an alkyl group having 2 to 50 carbon atoms.

6. A resin film made by using the resin composition according to claim **1**.

7. A laminate comprising:

a resin layer comprising a cured substance of the resin composition according to claim **1**; and

a conductor layer.

8. A multilayer printed wiring board comprising:

a resin layer comprising a cured substance of the resin composition according to claim **1**; and

circuit layers.

9. A method for producing a multilayer printed wiring board, comprising:

a step of laminating the resin film according to claim **6** on an inner layer circuit board to form a resin layer;

a step of heating and pressing the resin layer to cure the resin layer; and

a step of forming a circuit layer on the cured resin layer.

10. The resin composition according to claim **1**, wherein the content of the catalyst is 1 to 5 parts by mass with respect to 100 parts by mass of the maleimide compound.

11. The resin composition according to claim **1**, wherein the content of the catalyst is 1.5 to 5 parts by mass with respect to 100 parts by mass of the maleimide compound.

12. The resin composition according to claim 1, wherein the inorganic filler comprises at least one selected from the group consisting of silica, alumina, titanium oxide, mica, beryllia, barium titanate, potassium titanate, strontium titanate, calcium titanate, aluminum carbonate, magnesium hydroxide, aluminum hydroxide, aluminum silicate, calcium carbonate, calcium silicate, magnesium silicate, silicon nitride, boron nitride, calcined clay, talc, aluminum borate and silicon carbide.

13. The resin composition according to claim 12, wherein the inorganic filler has a particle diameter of 0.01 to 20 μm.

14. The resin composition according to claim 12, wherein the inorganic filler has a particle diameter of 0.1 to 10 μm.

15. The resin composition according to claim 1, wherein a content of the inorganic filler is 3 to 75% by volume with respect to a total volume of a solid content in the resin composition.

16. The resin composition according to claim 1, wherein a content of the inorganic filler is 5 to 70% by volume with respect to a total volume of a solid content in the resin composition.

17. The resin composition according to claim 1, wherein a content of the inorganic filler is 5 to 90% by mass with respect to a total volume of a solid content in the resin composition.

18. The resin composition according to claim 1, wherein a content of the inorganic filler is 10 to 80% by mass with respect to a total volume of a solid content in the resin composition.

19. The resin composition according to claim 1, wherein the catalyst (B) comprises at least one selected from the group consisting of methylimidazole, phenylimidazole, an isocyanate-masked imidazole, an organophosphine, complexes of organophosphines and organoborons, adducts of tertiary phosphine with quinones, 2,2'-azobis-isobutyronitrile, 2,2'-azobis-2-methylbutyronitrile, 1,1'-azobis-1-cyclohexanecarbonitrile, dimethyl-2,2'-azobisisobutyrate, 1,1'-azobis-(1-acetoxy-1-phenylethane), dicumyl peroxide, dibenzoyl peroxide, 2-butanone peroxide, tert-butyl perbenzoate, di-tert-butyl peroxide, 2,5-bis (tert-butylperoxy)-2,5-dimethylhexane, bis(tert-butylperoxyisopropyl)benzene, tert-butyl hydroperoxide, di(4-methylbenzoyl) peroxide, di(3-methylbenzoyl) peroxide, dibenzoyl peroxide, 1,1,3,3-tetramethylbutyl peroxy-2-ethylhexanoate, dilauroyl peroxide, di(3,5,5-trimethylhexanoyl) peroxide and tert-butyl peroxypivalate.

20. The resin composition according to claim 1, wherein the catalyst comprises an organic peroxide having a one-hour half-life temperature of 110 to 250° C.

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