

DESCRIPTION

BASIC CERAMIC-CONTAINING SLURRY COMPOSITION

Technical Field

- 5 [0001] The present invention relates to a basic ceramic-containing slurry composition.

Background Art

- 10 [0002] A slurry composition containing a ceramic fine powder is molded to make a sheet to be used for ceramic electronic parts in the field of electronic equipment. In particular, in production of electro-ceramic parts in the field of high electronic equipment, an unbaked ceramic molded article (green sheet) produced from a basic ceramic-containing slurry composition is used preferably. From the viewpoint of preventing adhesion of foreign matters during the molding, the green sheet is required
- 15 to have an antistatic property.

[0003] Patent document 1 discloses a slurry composition for producing ceramic that includes an organic hydrochloric acid of an amidinium cation as a dispersant having an antistatic property.

20 Prior Art Documents

Patent documents

[0004] Patent document 1: JP 2002-321981 A

Disclosure of Invention

25 Problem to be Solved by the Invention

- [0005] Regarding a monolithic ceramic electronic part, the tendency of decrease in size of the electronic equipment and high performance has continued, and as a result, the particle size of the ceramic material is decreased and also the thickness of the green sheet is decreased. However, the tendency of decrease in the size of the
- 30 ceramic material particles and in the thickness of the green sheet exacerbates the problem in handling ability such as insufficient strength of the green sheet and degradation in releasability in comparison with conventional products. Though

Patent document 1 discloses improvement in the antistatic property of the green sheet, the performance for handling ability such as strength and releasability is insufficient. Furthermore, it fails to propose any recognition regarding production of a green sheet having a thickness of not more than 15 μm or any problems associated therewith.

5 [0006] The present invention provides a basic ceramic-containing slurry composition that can be used for producing a green sheet having an excellent handling ability. Preferably, the present invention provides a basic ceramic-containing slurry composition that can be used for producing a green sheet having a smaller peel static electricity and a smaller peel strength and exhibiting excellent sheet strength, namely
10 toughness.

Means for Solving Problem

[0007] The present invention relates to a slurry composition containing: a cationic compound that contains a nitrogen-containing heteroaromatic quaternary ammonium
15 cationic group, a polymer dispersant, a nonaqueous solvent, a basic ceramic material and a polyvinyl acetal resin.

Effects of the Invention

[0008] According to the present invention, it is possible to provide a basic
20 ceramic-containing slurry composition exhibiting an excellent antistatic property, excellent releasability and excellent toughness of a green sheet. Therefore, in the basic ceramic-containing slurry composition of the present invention, preferably, the handling ability of the green sheet is improved, whereby a monolithic ceramic electronic part with an improved quality can be produced efficiently. If the thickness
25 of the green sheet is decreased further, the strength and the releasability are required to be even higher in comparison with a conventional product. In the present invention, even for a thin green sheet having a thickness of 15 μm or less, the handling ability can be improved, and thus, a monolithic ceramic electronic part with a high quality can be produced.

30

Description of the Invention

[0009] The present invention is based on a finding that a thin monolithic green sheet

having an excellent antistatic property, excellent releasability and excellent toughness can be produced by adding a cationic compound containing a nitrogen-containing heteroaromatic quaternary ammonium cationic group as an antistatic agent to a slurry composition containing a nonaqueous solvent, a basic ceramic material and a polyvinyl acetal resin, and by further adding a polymer dispersant thereto.

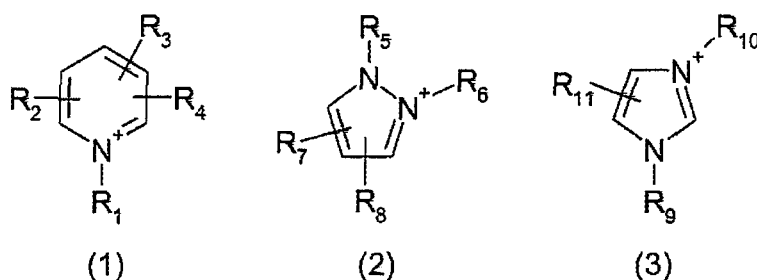
[0010] Although the detail of the mechanism for developing the effect of the present invention has not been clarified, it is assumed as follows. First of all, in a cationic compound including a nitrogen-containing heteroaromatic quaternary ammonium cationic group as an antistatic agent, since the π electron and the cation are delocalized due to its aromaticity, the interaction with the basic ceramic material and the polymer dispersant in the slurry composition is reduced to facilitate bleedout to the green sheet surface so as to develop an excellent antistatic performance and favorable releasability. Further, since the polymer dispersant is adsorbed onto the surface of the ceramic material, adsorption of the cationic compound onto the ceramic material surface is suppressed, and due to its uniform dispersion in the green sheet providing plasticity, the toughness of the green sheet is improved. It should be noted that this is an assumption, and thus the present invention is not limited to these mechanisms.

[0011] That is, the present invention relates to a slurry composition in an aspect, and the slurry composition contains a cationic compound including a nitrogen-containing heteroaromatic quaternary ammonium cationic group, a polymer dispersant, a nonaqueous solvent, a basic ceramic material and a polyvinyl acetal resin (hereinafter, it is referred also to as "a slurry composition of the present invention"). The slurry composition of the present invention can exhibit an effect that the obtained green sheet has an excellent antistatic property, excellent releasability and excellent toughness. Namely, the slurry composition of the present invention first can prevent favorably the electrification of the green sheet formed from the basic ceramic-containing slurry composition and reduce the peel strength. Secondly, the slurry composition of the present invention can improve the toughness of the green sheet formed from the basic ceramic-containing slurry composition. Specifically, it is possible to produce a green sheet that elongates easily and that has a great rupture stress.

[0012] In the present specification, "antistatic" indicates that the level of the peel static electricity of the unbaked green sheet obtained by molding a ceramic material into a sheet shape by using a slurry composition is low. When the absolute value of the peel static electricity of the green sheet is smaller, it indicates that the ceramic material has an excellent "antistatic property". Further, in the present specification, "releasability" indicates that the force (peel strength) required at the time of releasing from a substrate film a green sheet that has been formed by applying and drying on the substrate film is small. When the peel strength is smaller, it indicates that the green sheet has excellent "releasability". In the present specification, "toughness" of a green sheet is one of indices for the strength of the green sheet. It indicated that rupture stress is greater and elongation at rupture (elongation) is greater in a tension test. When the rupture stress is greater and the elongation is greater, it indicates that the green sheet has excellent "toughness".

[0013] [Cationic compound]

The slurry composition of the present invention contains a cationic compound that includes a nitrogen-containing heteroaromatic quaternary ammonium cationic group as an antistatic agent. For the nitrogen-containing heteroaromatic quaternary ammonium cationic group, from the viewpoint of producing a green sheet having an excellent antistatic property, excellent releasability and excellent toughness, a quaternary ammonium cationic group, namely, a cationic group having quaternary ammonium in its aromatic ring that is a nitrogen-containing five-membered ring or six-membered ring heteroaromatic compound, is preferred. Examples of the quaternary ammonium cationic group of a nitrogen-containing five-membered ring or six-membered ring heteroaromatic compound include quaternary ammonium cationic groups having structures of pyridinium, pyrazolium, imidazolium, pyrimidinium, pyrazinium, pyridazinium, pyrrolium and the like. Among them, a quaternary ammonium cationic group having a structure of pyridinium, pyrazolium or imidazolium is preferred, and, a cationic group selected from the group consisting of the cationic groups represented by General formulae (1), (2) and (3) below is preferred further. The slurry composition of the present invention may contain two or more of the cationic compounds.



[In General formula (1), R_1 is a C_1 to C_4 alkyl group; and R_2 , R_3 and R_4 are same or different, each represents a hydrogen atom or a C_1 to C_4 alkyl group which may have a hydroxyl group. In General formula (2), R_5 and R_6 are same or different, each represents a C_1 to C_4 alkyl group; and R_7 and R_8 are same or different, each represents a hydrogen atom or a C_1 to C_4 alkyl group which may have a hydroxyl group. In General formula (3), R_9 and R_{10} are same or different, each represents a C_1 to C_4 alkyl group; and R_{11} represents a hydrogen atom or a C_1 to C_4 alkyl group which may have a hydroxyl group.]

[0014] For the cationic group represented by the above General formula (1), from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, R_1 is a C_1 to C_4 alkyl group, preferably a methyl group or an ethyl group, and more preferably an ethyl group. From the similar viewpoint, R_2 , R_3 and R_4 are same or different, each represents a hydrogen atom or a C_1 to C_4 alkyl group which may be substituted by a hydroxyl group, preferably a hydrogen atom or a C_1 to C_2 alkyl group which may be substituted by a hydroxyl group, and more preferably a hydrogen atom, a methyl group or a hydroxymethyl group. Examples of the cationic group represented by the General formula (1) include cationic groups of 1-methylpyridinium, 1-ethylpyridinium, 1-ethyl-3-hydroxymethylpyridinium, 1-ethyl-3-methylpyridinium, 1-propylpyridinium, 1-butylpyridinium, 1-butyl-3-methylpyridinium, 1-butyl-4-methylpyridinium and the like. Among them, from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, 1-ethyl-3-methylpyridinium and 1-ethyl-3-hydroxymethylpyridinium are preferred.

[0015] For the cationic group represented by the above General formula (2), from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, R_5 and R_6 are same or different, each represents a C_1 to C_4 alkyl group, preferably at least one of R_5 and R_6 is a methyl group or an ethyl group, and more preferably a methyl group. From the similar viewpoint, preferably the total number

of the carbons of R_5 and R_6 is in the range of 2 to 5, more preferably 2 to 3, and further preferably 2. From the similar viewpoint, R_7 and R_8 are same or different, each represents a hydrogen atom or a C_1 to C_4 alkyl group which may be substituted by a hydroxyl group, and preferably a hydrogen atom or a C_1 to C_2 alkyl group which may be substituted by a hydroxyl group, more preferably a hydrogen atom, a methyl group or a hydroxymethyl group, further preferably a hydrogen atom or a methyl group, and even further preferably the total number of the carbons of R_7 and R_8 is 1. Examples of the cationic group represented by the above General formula (2) include a cationic group of 1,2-dimethylpyrazolium, 1-methyl-2-ethylpyrazolium, 1-methyl-2-propylpyrazolium, 1-methyl-2-butylpyrazolium, 1,2-diethylpyrazolium, 1,2-dipropylpyrazolium, 1,2-dibutylpyrazolium, 1,2,4-trimethylpyrazolium, 1,2,3,5-tetramethylpyrazolium, 1-ethyl-2,3,5-trimethylpyrazolium, 1-ethyl-3-methoxy-2,5-dimethylpyrazolium, 1-propyl-2,3,5-trimethylpyrazolium, 1-butyl-2,3,5-trimethylpyrazolium or the like. Among them, from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, 1,2,4-trimethylpyrazolium is preferred.

[0016] For the cationic group represented by the above General formula (3), from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, R_9 and R_{10} are same or different, each represents a C_1 to C_4 alkyl group, preferably at least one of R_9 and R_{10} is a methyl group or an ethyl group, and more preferably a methyl group. From the similar viewpoint, preferably the total number of the carbons of R_9 and R_{10} is in the range of 2 to 5, and more preferably 3 to 5. From the similar viewpoint, R_{11} represents a hydrogen atom or a C_1 to C_4 alkyl group which may be substituted by a hydroxyl group, preferably a hydrogen atom or a C_1 to C_2 alkyl group which may be substituted by a hydroxyl group, more preferably a hydrogen atom, a methyl group or a hydroxymethyl group, and further preferably a hydrogen atom. Examples of the cationic group represented by the above General formula (3) include a cationic group of 1,3-dimethylimidazolium, 1,2,3-trimethylimidazolium, 1-ethyl-3-methylimidazolium, 1,3-diethylimidazolium, 1-ethyl-2,3-dimethylimidazolium, 1,2,3-triethylimidazolium, 1-propyl-3-methylimidazolium, 1-propyl-2,3-dimethylimidazolium, 1-butyl-3-methylimidazolium, 1-butyl-2,3-dimethylimidazolium,

2-hydroxyethyl-1,3-dimethylimidazolium, or the like. Among them, from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, 1-ethyl-3-methylimidazolium, 1-ethyl-2,3-dimethylimidazolium and 1-butyl-3-methylimidazolium are preferred, and, 1-ethyl-3-methylimidazolium and 1-butyl-3-methylimidazolium are more preferred.

[0017] For the cationic group in the present invention, from the viewpoint of improving antistatic property of the green sheet, the cationic groups represented by the General formulae (1) and (3) are preferred, and the cationic group represented by the General formula (3) is more preferred. From the viewpoint of improving the releasability of the green sheet, the cationic group represented by the General formula (3) is preferred. From the viewpoint of improving toughness of the green sheet, the cationic groups represented by the General formulae (2) and (3) are preferred, and the cationic group represented by the General formula (3) is more preferred. And from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, the cationic group represented by the General formula (3) is further preferred for the cationic group in the present invention.

[0018] From the viewpoint of improving antistatic property, releasability and toughness of the green sheet, the molecular weight of the cationic group is preferably 300 or less, and more preferably 200 or less, further preferably 150 or less, and even further preferably 120 or less. From the similar viewpoint, the molecular weight of the cationic group is preferably 90 or more, more preferably 95 or more, and further preferably 100 or more. And, from the similar viewpoint, the molecular weight of the cationic group is preferably in the range of 90 to 300, more preferably 95 to 300, further preferably 95 to 200, even further preferably 100 to 150, and even further preferably 100 to 120.

[0019] The cationic compound may be a salt of the above-mentioned cationic group and an anionic group, or it may be a solution of a nonaqueous solvent. For the anionic group, an organic anionic group is preferred from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, and since it does not include a halogen compound that can cause degradation in the electric characteristics and rust.

[0020] Examples of the organic anionic group include anionic groups of: saturated

and unsaturated aliphatic carboxylic acids such as formic acid, acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, caprylic acid, capric acid, undecanoic acid, tridecanoic acid, myristic acid, pentadecanoic acid, palmitic acid, heptadecanoic acid, isobutyric acid, isovaleric acid, isocaproic acid, ethylbutyric acid, methylvaleric acid, isocaprylic acid, propylvaleric acid, ethylcaproic acid, acrylic acid, crotonic acid, methacrylic acid, isocrotonic acid, 3-butenic acid, pentenoic acid, hexenoic acid, heptynoic acid, octenoic acid, nonenoic acid, decenoic acid, undecenoic acid, dodecenoic acid, oleic acid, and 3-methylcrotonic acid; aromatic carboxylic acids such as toluic acid, ethylbenzoic acid, propylbenzoic acid, isopropylbenzoic acid, butylbenzoic acid, isobutylbenzoic acid, sec-butylbenzoic acid, tert-butylbenzoic acid, resorcinbenzoic acid, hydroxybenzoic acid, and phenylacetic acid; alkyloxalic acids such as methyloxalic acid and ethyloxalic acid; sulfonic acids such as methylsulfonic acid, ethylsulfonic acid, methanesulfonic acid, ethanesulfonic acid, 1,2-ethanedisulfonic acid, vinylsulfonic acid, (meth)allylsulfonic acid, p-toluenesulfonic acid, benzenesulfonic acid, xylenesulfonic acid, alkyl (C_8 to C_{24}) benzenesulfonic acid, anthraquinonesulfonic acid, naphthalenesulfonic acid, naphtholsulfonic acid, and styrenesulfonic acid; and alkyl sulfuric acids and hydroxyalkyl sulfuric acids such as methylsulfuric acid, ethylsulfuric acid, and hydroxyethylsulfuric acid. Among them, from the viewpoint of improving antistatic property, releasability and toughness of the green sheet, anionic groups of alkyloxalic acid, alkylsulfuric acid and aliphatic carboxylic acid are more preferred; anionic groups of alkyl sulfuric acids and alkyloxalic acids are further preferred; and anionic groups of methylsulfuric acid, ethylsulfuric acid and acetic acid are further preferred. And from the viewpoint of improving antistatic property and toughness, an anionic group of ethylsulfuric acid is even further preferred.

[0021] From the viewpoint of improving antistatic property, releasability and toughness of the green sheet, the content of the cationic compound in the slurry composition of the present invention is preferably 0.05 weight parts or more, more preferably 0.1 weight parts or more, further preferably 0.2 weight parts or more, and even further preferably 0.3 weight parts or more with respect to 100 weight parts of the basic ceramic material. From the viewpoint of suppressing the increase in the plasticity of the polyvinyl acetal resin and maintaining the strength of the ceramic molded article, the content of the cationic compound in the slurry composition of the

present invention is preferably 2.0 weight parts or less, more preferably 1.8 weight parts or less, further preferably 1.5 weight parts or less, and even further preferably 1.2 weight parts or less with respect to 100 weight parts of the basic ceramic material.

[0022] Furthermore, from the viewpoint of improving antistatic property,

5 releasability and toughness of the green sheet, the content of the cationic compound in the slurry composition of the present invention is preferably 0.01 weight parts or more, more preferably 0.015 weight parts or more, further preferably 0.02 weight parts or more, and even further preferably 0.03 weight parts or more with respect to 1.0 weight part of the polyvinyl acetal resin. From the viewpoint of suppressing the increase in
10 the plasticity of the polyvinyl acetal resin and maintaining the strength of the ceramic molded article, the content of the cationic compound in the slurry composition of the present invention is preferably 0.2 weight parts or less, more preferably 0.18 weight parts or less, further preferably 0.15 weight parts or less, and even further preferably 0.12 weight parts or less with respect to 1.0 weight part of the polyvinyl acetal resin.

15 [0023] For the antistatic agent, the slurry composition of the present invention may contain an antistatic agent other than the cationic compound. From the viewpoint of improving antistatic property, releasability and toughness, the content of the cationic compound in the antistatic agent is preferably 80 wt% or more, more preferably 90 wt% or more, further preferably 95 wt% or more, and even further preferably
20 substantially 100 wt% with respect to the antistatic agent.

[0024] [Polymer dispersant]

The slurry composition of the present invention contains a polymer dispersant. Examples of the polymer dispersant include a cationic polymer, a nonionic polymer and an anionic polymer.

25 [0025] One aspect of the polymer dispersant is a vinyl copolymer that is soluble in a nonaqueous solvent, and an example of the vinyl copolymer is a vinyl copolymer of a radical unsaturated monomer based on one or more (meth)acrylic acid ester, allylether, olefin and the like. Specific examples of the (meth)acrylic acid ester include: (meth)acrylic acid ester that has a C₁ to C₂₂ alkyl group, such as methyl(meth)acrylate, ethyl(meth)acrylate, n-propyl(meth)acrylate, iso-propyl(meth)acrylate,
30 n-butyl(meth)acrylate, t-butyl(meth)acrylate, iso-butyl(meth)acrylate, 2-ethylhexyl(meth)acrylate, lauryl(meth)acrylate, tridecyl(meth)acrylate, stearyl

(meth)acrylate, hexyl (meth)acrylate, cyclohexyl (meth)acrylate, octyl (meth)acrylate, and isobornyl (meth)acrylate; and polyoxyalkylene (meth)acrylate having a polyoxyalkylene group, such as methoxy polyethylene glycol (meth)acrylate, methoxy polypropylene glycol (meth)acrylate, and methoxy polybutylene glycol (meth)acrylate.

5 Examples of the allylether include (alkoxy-)polyoxyalkylene-allylether, such as (methoxy-)polyethylene glycol-allylether, and (butoxy-)

polyethyleneglycol-polypropyleneglycol-allylether. Examples of the olefins include α -olefin such as hexadecane and eicosen.

[0026] By copolymerizing the one or more (meth)acrylic acid ester, allylether or olefin
10 with an acidic monomer such as (meth)acrylic acid, crotonic acid, maleic anhydride, and itaconic acid, an anionic polymer dispersant is obtained. Examples of commercially available products include "Marialim AKM-0531", "Marialim AWS-0851", "Marialim AAB-0851" and "Marialim AFB-1521" manufactured by NOF Corporation.

15 [0027] And a cationic polymer dispersant is obtained by copolymerizing a basic monomer, such as dimethylaminoethyl(meth)acrylate, diethylaminoethyl(meth)acrylate, butylaminoethyl(meth)acrylate, 2-vinylpyridine, 4-vinylpyridine, 2-methyl-5-vinylpyridine, 2-ethyl-5-vinylpyridine, N-vinylimidazole, and 2-methyl-N-vinylimidazole. Examples of commercially available products
20 include "Efca 4310" and "Efca 4320" and the like manufactured by BASF. A nonionic polymer dispersant is obtained by copolymerizing a monomer having a neutral functional group, such as (meth)acrylamide, vinylpyrrolidone, 2-hydroxyethyl(meth)acrylate, 2-hydroxypropyl(meth)acrylate, and 3-hydroxypropyl(meth)acrylate. Examples of commercially available products
25 include "Antaron V-216 (vinylpyrrolidone/hexadecene copolymer)", "Antaron V-220 (vinylpyrrolidone/eicosen copolymer)" and the like manufactured by ISP Japan Ltd.

[0028] The polymer dispersant is not limited to the vinyl copolymers but polymer dispersants based on modified polyamide, modified polyurethane, modified polyester, polyvinylpyrrolidone and the like also can be used. For example, the dispersant is
30 composed of an amide or a salt formed by allowing reaction of polyalkylene imine like polyethylene imine or polyallylamine with polyester having a free carboxylic acid group such as a polymer of hydroxystearic acid or a polymer of cyclic ester, wherein

two or more polyester chains are bound to either the polyalkylene imine principal chain or the polyallylamine principal chain thereof. Examples of commercially available products include "Solsperse 26000", "Solsperse 28000", "Solsperse 32000", "Solsperse 33000", "Solsperse 36000", "Solsperse 39000" manufactured by Lubrizol Corporation; "Ajisper PB-711", "Ajisper PB-821", "Ajisper PB-822", "Ajisper PB-814", "Ajisper PB-824" manufactured by Ajinomoto Fine-Techno Co., Ltd., and the like. An alternative example of dispersant is obtained by subjecting, respectively with respect to an isocyanate group of a polyisocyanate compound, polyester having free carboxylic acid or a compound having a functional group selected from the group consisting of a hydroxyl group, an amino group, a triazol group, a pyrimidine group, an imidazole group, a pyridine group, a morpholine group, a pyrrolidine group, a piperazine group, a benzimidazoline group, a benzothiazole group and a triazyl group. Examples of commercially available products include "DISPERBYK-161", "DISPERBYK-162", "DISPERBYK-167" manufactured by BYK Japan; "Solspers 76500" manufactured by Lubrizol Corporation; and the like. Another example of dispersant is obtained by subjecting a product that has been obtained through an addition reaction of polyisocyanate with styrene or the derivative, (meth)acrylic acid, or the ester or a copolymer of (meth)acrylic ester having a hydroxyl group to a further addition reaction with a compound having an amino group or an imidazole group. Examples of commercially available products include "Efca 4046", "Efca 4047" and the like manufactured by BASF. And a further example is a dispersant based on polyvinyl pyrrolidone, and examples of commercially available products include "PVP K-15", "PVP K-30", "PVP K-60", "PVP K-90" and the like manufactured by ISP Japan Ltd.

[0029] From the viewpoint of improving antistatic property, releasability and toughness and from the viewpoint of improving dispersibility of the basic ceramic material, the polymer dispersant used for the slurry composition of the present invention is preferably a copolymer, and more preferably a copolymer having a constitutional unit (adsorption unit) having a high affinity for the basic ceramic material and a constitutional unit (dispersion unit) having a high affinity for the nonaqueous solvent. It is considered that the copolymer having the adsorption unit is adsorbed efficiently onto the ceramic material surface, so that the ceramic material is easily coated in the slurry composition. It is considered that the dispersion unit

expands three-dimensionally in the nonaqueous solvent, so that the interaction between the basic ceramic material in the slurry composition and the cationic compound of the present invention is further decreased, as a result, a further preferable antistatic performance and favorable releasability are developed, and the toughness of the green sheet is improved further.

[0030] Examples of the adsorption unit of the copolymer include cationic, nonionic and anionic constitutional units. For the cationic constitutional unit, from the viewpoint of improving antistatic property, releasability and toughness, constitutional units derived from alkylene imine and allylamine are preferred. For the nonionic constitutional unit, from the similar viewpoint, constitutional units derived from (meth)acrylamide and vinylpyrrolidone are preferred. And for the anionic constitutional unit, from the similar viewpoint, constitutional units derived from (meth)acrylic acid and maleic anhydride are preferred. From the viewpoint of improving antistatic property, a constitutional unit derived from (meth)acrylic acid is more preferred.

[0031] Examples of dispersion unit of the copolymer include constitutional units and the like having a polyoxyalkylene group, a polyester group, a poly(hydroxyl)alkyl(meth)acrylate group, an alkyl group or an alkylene group. Among them, from the viewpoint of improving antistatic property, releasability and toughness, a constitutional unit having a group selected from the group consisting of a polyoxyalkylene group, a polyester group, a polyhydroxyethylmethacrylate group, a polymethylmethacrylate group, an alkyl group and an alkylene group is preferred. A constitutional unit having a group selected from the group consisting of a polyoxyalkylene group, a polycaprolactone group and an alkyl group is more preferred; a constitutional unit having a polyoxyalkylene group is further preferred; and a constitutional unit having a polyoxyethylene group is even further preferred. From the similar viewpoint, a constitutional unit derived from (alkoxy-)polyoxyalkylene(meth)acrylate, (alkoxy-)polyoxyalkylene-allylether, polyester having a carboxyl group and α -olefin is preferred; and a constitutional unit derived from (alkoxy-)polyoxyalkylene(meth)acrylate is more preferred.

[0032] From the viewpoint of improving antistatic property, preferably the polymer dispersant used in the slurry composition of the present invention is cationic and

anionic, and from the viewpoint of improving releasability, it is preferably nonionic and anionic. And for the polymer dispersant, from the viewpoint of improving antistatic property and releasability, an anionic polymer dispersant is more preferred. For the cationic polymer dispersant, from the viewpoint of improving antistatic property, releasability and toughness, a copolymer, which is composed of an amide or a salt formed by a reaction between polyethylene imine and polyester of hydroxystearic acid in which two or more polyester chains are bound to each of the polyethylene imine principal chains, is preferred. For the nonionic polymer dispersant, from the viewpoint of antistatic property releasability and toughness, a copolymer of monomers selected from the group consisting of (meth) acrylic acid ester, (alkoxy) polyoxyalkylene (meth)acrylate and (meth) acrylamide, and a copolymer of vinylpyrrolidone and α -olefin are preferred. From the viewpoint of antistatic property and toughness, a copolymer of monomers selected from the group consisting of (meth) acrylic acid ester, (alkoxy) polyoxyalkylene (meth)acrylate and (meth) acrylamide is more preferred.

Furthermore, for the anionic polymer dispersant, from the viewpoint of antistatic property, releasability and toughness, a copolymer of monomers selected from (meth)acrylic acid and maleic anhydride together with monomers selected from (alkoxy)polyoxyalkylene(meth)acrylate and (alkoxy)polyoxyalkylene allylether is preferred. From the viewpoint of antistatic property, a copolymer of (meth)acrylic acid monomer and (alkoxy)polyoxyalkylene(meth)acrylate monomer is more preferred.

[0033] From the viewpoint of antistatic property of the green sheet and dispersibility of the basic ceramic material, the weight average molecular weight of the polymer dispersant is preferably 2000 or more, more preferably 4000 or more, further preferably 6000 or more, and even further preferably 8000 or more. And from the viewpoint of releasability of the green sheet and dispersibility of the basic ceramic material, the weight average molecular weight is preferably 200000 or less, more preferably 120000 or less, further preferably 60000 or less and even further preferably 36000 or less.

[0034] Typically, the content of the polymer dispersant in the slurry composition of the present invention is adjusted on the basis of the specific surface area of the basic ceramic material. As a standard content, for weight parts with respect to 100 weight

parts of the basic ceramic material, a value obtained by dividing the BET specific surface area [unit: m^2/g] by 5 can be used as an index. For example, in a case where barium titanate is used as the basic ceramic material, the content of the polymer dispersant with respect to 100 weight parts of barium titanate may be 1 weight part if the particle diameter is 200 nm (specific surface area: $5 \text{ m}^2/\text{g}$); it is 2 weight parts if the particle diameter is 100 nm (specific surface area: $10 \text{ m}^2/\text{g}$); and, 4 weight parts if the particle diameter is 50 nm (specific surface area: $20 \text{ m}^2/\text{g}$).

[0035] As the weight part with respect to 100 weight parts of the basic ceramic material, from the viewpoint of dispersibility of the basic ceramic material, the content of the polymer dispersant is preferably 0.3 times or higher, and more preferably 0.4 times or higher the value obtained by dividing the BET specific surface area [unit: m^2/g] of the basic ceramic material by 5. Further, from the viewpoint of releasability of the green sheet, the content is preferably 1.5 times or lower, and more preferably 1.2 times or lower the value obtained by dividing the BET specific surface area [unit: m^2/g] of the basic ceramic material by 5.

[0036] In a case where the BET specific surface area of the basic ceramic material is $5 \text{ m}^2/\text{g}$, from the viewpoint of dispersibility of the basic ceramic, the content of the polymer dispersant is preferably 0.3 weight parts or more, and more preferably 0.4 weight parts or more with respect to 100 weight parts of the basic ceramic material. From the viewpoint of releasability of the green sheet, the content is preferably 1.5 weight parts or less, and more preferably 1.2 weight parts or less with respect to 100 weight parts of the basic ceramic material.

[0037] In a case where the BET specific surface area of the basic ceramic material is $10 \text{ m}^2/\text{g}$, from the viewpoint of dispersibility of the basic ceramic material, the content of the polymer dispersant is preferably 0.6 weight parts or more, and more preferably 0.8 weight parts or more with respect to 100 weight parts of the basic ceramic material. From the viewpoint of releasability of the green sheet, the content is preferably 3.0 weight parts or less, and more preferably 2.4 weight parts or less with respect to 100 weight parts of the basic ceramic material.

[0038] In a case where the BET specific surface area of the basic ceramic material is $20 \text{ m}^2/\text{g}$, from the viewpoint of dispersibility of the basic ceramic material, the content of the polymer dispersant is preferably 1.2 weight parts or more, and more preferably

1.6 weight parts or more with respect to 100 weight parts of the basic ceramic material. From the viewpoint of releasability of the green sheet, the content is preferably 6.0 weight parts or less, and more preferably 4.8 weight parts or less with respect to 100 weight parts of the basic ceramic material. In a case where the BET specific surface
5 area of the basic ceramic material takes any other value, a preferable content of the polymer dispersant can be determined through a similar calculation.

[0039] [Nonaqueous solvent]

The slurry composition of the present invention contains a nonaqueous solvent. The nonaqueous solvent is not limited in particular as long as it is
10 nonaqueous (organic solvent). Examples of the nonaqueous solvent include: alcohols such as methanol, ethanol, n-propanol, iso-propanol (IPA), n-butanol, sec-butanol, n-octanol, diacetone alcohol, terpineol, and butylcarbitol; cellosolves such as methyl cellosolve, ethyl cellosolve, and butyl cellosolve; ketones such as acetone, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and diisobutyl ketone (DIBK); amides
15 such as N,N-dimethylacetamide, N,N-dimethyl formamide, and N-methyl-2-pyrrolidone; esters such as methyl acetate, ethyl acetate, isopropyl acetate, and n-butyl acetate; ethers such as ethyl ether, dioxane, and tetrahydrofuran; hydrocarbons such as naphtha, n-hexane, and cyclohexane; and aromatics such as toluene, xylene, and pyridine.

20 [0040] For the nonaqueous solvent, from the viewpoint of solubility of the polyvinyl acetal resin contained in the slurry composition of the present invention, alcohols and cellosolves are preferred; alcohols are more preferred; methanol, ethanol, and iso-propanol are further preferred; and ethanol is even further preferred. Further, from the viewpoint of removing calmly the nonaqueous solvent from the slurry
25 composition and forming a uniform green sheet, a mixture of two or more kinds of organic solvents different from each other in the boiling point is preferred; and a mixture of the alcohol and the cellosolve with another organic solvent that rarely causes azeotropy with the alcohol and the cellosolve is more preferred. For the other organic solvent that rarely causes azeotropy with the alcohol and the cellosolve,
30 hydrocarbons and aromatics are preferred; aromatics are more preferred; and toluene is further preferred. From the viewpoint of solubility of the polyvinyl acetal resin and formation of a uniform green sheet, the nonaqueous solvent is preferably a mixture of

an aromatic and an alcohol, and more preferably, a mixture of toluene and ethanol. The volume ratio of toluene to ethanol in the nonaqueous solvent (toluene/ethanol) is, from the similar viewpoint, preferably 10/90 to 75/25, more preferably 25/75 to 65/35, and further preferably 40/60 to 55/45.

5 [0041] [Basic ceramic material]

The slurry composition of the present invention contains a basic ceramic material. In the present specification, "basic ceramic material" indicates an inorganic compound where basicity has a greater value than that of acidity, and the examples include metallic oxides, metal carbonates, complex oxides and the like. Specific
10 examples thereof include: metallic oxides such as titanium oxide, magnesium oxide, barium oxide, and aluminum oxide; metal carbonates such as magnesium carbonate, and barium carbonate; and complex oxides such as barium zirconate, calcium zirconate, calcium titanate, barium titanate, and strontium titanate. Among them, from the viewpoint of improving performance of the monolithic ceramic electronic
15 parts, a complex oxide of zirconic acid and a complex oxide of titanic acid are preferred; a complex oxide of titanic acid is more preferred; and barium titanate is further preferred.

[0042] In general, surfaces of a ceramic material have both of an acid site and a base site. The amount of the acid sites (acidity) and the amount of the base sites (basicity)
20 can be determined respectively by reverse titration, whereby it can be determined whether the ceramic material is acidic or basic. Reverse titration is a method of mixing a basic reagent (or an acidic reagent) whose concentration is known preliminarily with a ceramic material at a predetermined ratio, sufficiently
neutralizing the mixture, subjecting the same to solid-liquid separation by centrifuge
25 or the like, titrating the obtained supernatant solution, and determining an acidity (or a basicity) according to the decrease in the basic reagent (or the decrease in the acidic reagent). The basicity and acidity are determined as follows in the present specification.

[0043] 1) Determination of Basicity

30 2 g of a ceramic material is weighed (sample amount), then, it is put into 30 mL of 1/100 N acetic acid-toluene/ethanol (volume ratio: 48/52) solution, and is dispersed with an ultrasonic cleaner (manufactured by Branson, model: 1510J-MT)

for one hour. After left to stand for 24 hours, a part of the ceramic material dispersed solution is subjected to solid-liquid separation with a centrifuge (manufactured by Hitachi, Ltd., model: CP-56G) at 25,000 rpm for 60 minutes. 10 mL of a liquid portion thus separated is added to 20 mL of a toluene/ethanol (volume ratio: 2:1) solution to which phenolphthalein indicator has been added, and thereafter, neutralized by titration with a 1/100 N potassium hydroxide-ethanol solution. An amount used for this titration is assumed to be X mL, an amount used for neutralization of 10 mL of a 1/100 N acetic acid-toluene/ethanol (volume ratio: 48/52) solution is assumed to be B mL, and a sample amount is assumed to be S g. Then, the basicity is determined by the following formula:

$$\text{Basicity } (\mu\text{mol/g}) = 30 \times (B - X)/S$$

[0044] 2) Determination of Acidity

2 g of a ceramic material is weighed (sample amount), then, it is put into 30 mL of 1/100 N n-butylamine-toluene/ethanol (volume ratio: 48/52) solution, and is dispersed with an ultrasonic cleaner (manufactured by Branson, model: 1510J-MT) for one hour. After left to stand for 24 hours, a part of the ceramic material dispersion solution is subjected to solid-liquid separation by a centrifuge (manufactured by Hitachi, Ltd., model: CP-56G) at 25,000 rpm for 60 minutes. 10 mL of a liquid portion thus separated is added to 20 mL of a toluene/ethanol (volume ratio: 2/1) solution to which Bromocresol Green indicator has been added, and thereafter, neutralized by titration with a 1/100 N hydrochloric acid-ethanol solution. An amount used for this titration is assumed to be X mL, an amount used for neutralization of 10 mL of a 1/100 N n-butylamine-toluene/ethanol (volume ratio: 48/52) solution is assumed to be B mL, and a sample amount is assumed to be S g. Then, the acidity is determined by the following formula:

$$\text{Acidity } (\mu\text{mol/g}) = 30 \times (B - X)/S$$

[0045] From the viewpoint of suitability for sheet formation, the content (content of solid) of the basic ceramic material in the slurry composition of the present invention is preferably in the range of 10 to 50 wt%, more preferably 15 to 45 wt%, and further preferably 20 to 40 wt% with respect to the slurry composition.

[0046] The average particle diameter of the basic ceramic material based on the BET specific surface area in the present invention is preferably 500 nm or less, more

preferably 200 nm or less, and further preferably 120 nm or less from the viewpoint of decreasing thickness of the green sheet. From the viewpoint of handling ability of the slurry composition and also from the viewpoint of satisfying both the fine dispersion of the basic ceramic material and the antistatic property of the green sheet, the average particle diameter is preferably 5 nm or more, more preferably 10 nm or more, and further preferably 20 nm or more.

[0047] In the present specification, the average particle diameter (average particle diameter based on BET specific surface area) of the basic ceramic material indicates preferably an average particle diameter of a powdery basic ceramic material, and it can be determined by assuming that the material is composed of spheres having a particle diameter R (m) and using a BET specific surface area S (m^2/g) determined by the nitrogen adsorption method and a specific gravity ρ (g/cm^3) of the basic ceramic material. In other words, since the BET specific surface area is a surface area per unit weight, when the surface area is assumed to be A (m^2) and the weight of the particles is assumed to be W (g), the following relational expression is obtained:

$$\begin{aligned} S \text{ (m}^2/\text{g)} &= A \text{ (m}^2) / W \text{ (g)} \\ &= [4 \times \pi \times (R/2)^2] / [4/3 \times \pi \times (R/2)^3 \times \rho \times 10^6] \\ &= 6 / (R \times \rho \times 10^6) \end{aligned}$$

When the unit of the particle diameter is converted, an expression of

$R(\text{nm}) = 6000 / (S \times \rho)$ is obtained, and an average particle diameter (average particle diameter based on BET specific surface area) can be determined. For example, if the BET specific surface area of barium titanate (specific gravity: 6.0) is $5.0 \text{ (m}^2/\text{g)}$, its average particle diameter (particle diameter based on BET specific surface area) is determined to be 200 nm.

[0048] [Polyvinyl acetal resin]

The slurry composition of the present invention contains a polyvinyl acetal resin. The polyvinyl acetal resin is obtained through acetalization of polyvinyl alcohol. The method for the acetalization is not limited in particular, and in an example, the polyvinyl alcohol is dissolved in warm water, and the aqueous solution of polyvinyl alcohol is held at a predetermined temperature. Aldehyde and an acid catalyst are added thereto, and the acetalization reaction is allowed to proceed while agitating the solution. Subsequently, the reaction temperature is raised for aging so

as to complete the reaction, and then steps of neutralization, washing and drying are carried out.

[0049] The aldehyde to be used for the acetalization reaction is not limited in particular, and the examples include: aliphatic aldehydes such as formaldehyde, acetaldehyde, propionaldehyde, n-butyraldehyde, isobutyl aldehyde, n-valeraldehyde, 5 n-hexylaldehyde, 2-ethylbutyl aldehyde, 2-ethylhexyl aldehyde, n-heptyl aldehyde, n-octyl aldehyde, n-nonyl aldehyde, n-decyl aldehyde, and amyl aldehyde; and aromatic aldehydes such as benzaldehyde, cinnamaldehyde, 2-methylbenzaldehyde, 3-methylbenzaldehyde, 4-methylbenzaldehyde, p-hydroxybenzaldehyde, m-hydroxybenzaldehyde, phenylacetaldehyde, and 8-phenyl propionaldehyde. These 10 aldehydes may be used alone or in combination of two or more. For the aldehyde, in particular, butyraldehyde and acetaldehyde are preferred since they exhibit excellent acetalization reaction and have capability of providing excellent properties such as pressure-sensitive adhesiveness during lamination of the green sheet. From the 15 viewpoint of flexibility of the green sheet, butyraldehyde is more preferred.

[0050] It is preferable that the polyvinyl acetal resin has an acetalization degree of 55 to 80 mol%, and more preferably 65 to 75 mol%. When the acetalization degree is 55 mol% or more, the solubility in a nonpolar solvent is improved and thus the flexibility of the green sheet is improved. In the meantime, when the acetalization 20 degree is 80 mol% or less, the sheet strength of the obtained green sheet is improved. Here, the acetalization degree indicates the rate of acetalized hydroxyl groups among the hydroxyl groups of the polyvinyl alcohol. For example, in a case of a polyvinyl butyral resin, it can be measured in accordance with JIS K6728.

[0051] Further, it is preferable for the polyvinyl acetal resin that the residual 25 hydroxyl group content is 10 to 45 mol%, and more preferably 15 to 40 mol%. When the residual hydroxyl group content is 10 mol% or more, the toughness of the polyvinyl acetal resin is improved and the dispersibility of the basic ceramic material is improved. In the meantime, when the residual hydroxyl group content is 45 mol% or less, the solubility in an organic solvent is increased. The residual hydroxyl group 30 content of the polyvinyl acetal resin, for example, polyvinyl butyral resin, can be measured in accordance with JIS K6728.

[0052] The polyvinyl acetal resin may be produced suitably, or it may be a

commercially available product. For the polyvinyl acetal resin, from the viewpoint of flexibility of the green sheet and the pressure-sensitive adhesiveness during lamination of the green sheet, a polyvinyl butyral resin is preferred. Examples of commercially available products of the polyvinyl butyral resin include: S-LEC B series of "BL-1", "BL-2", "BL-5", "BM-1", "BM-2", "BM-5", "BH-3", "BX-1", "BX-3" and "BX-5" manufactured by Sekisui Chemical Co., Ltd.; Denka Butyral series of "#3000-1", "#3000-2", "#3000-4" and "#3000-K" manufactured by Denki Kagaku Kogyo Kabushiki Kaisha; Mowital series of "B30T", "B30H", "B45M", "B45H", "B60T" and "B60H" manufactured by Kuraray Co., Ltd., and the like.

[0053] From the viewpoint of improving the antistatic property, releasability and toughness of the green sheet and also from the viewpoint of exhibiting the binder function, the content of the polyvinyl acetal resin in the slurry composition of the present invention is preferably 2 weight parts or more, more preferably 4 weight parts or more, and further preferably 6 weight parts or more with respect to 100 weight parts of the basic ceramic material. From the viewpoint of improving antistatic property, releasability and toughness of the green sheet and from the viewpoint of lowering the viscosity of the slurry composition so as to facilitate sheet formation, the content is preferably 20 weight parts or less, more preferably 18 weight parts or less, and further preferably 16 weight parts or less with respect to 100 weight parts of the basic ceramic material. And, the content of the polyvinyl acetal resin in the slurry composition of the present invention is preferably 2 to 20 weight parts, more preferably 4 to 18 weight parts, and further preferably 6 to 16 weight parts with respect to 100 weight parts of the basic ceramic material.

[0054] [Other components]

The slurry composition of the present invention may contain any conventionally known additives such as a binder resin like an acrylic resin, a cellulosic resin or the like and a low-molecular weight compound like a plasticizer, a lubricant, a dispersion auxiliary or the like, in a range not sacrificing the effect of the present invention. Though the plasticizer is not limited in particular, the examples include: diester phthalate such as dioctyl phthalate (DOP), and dibutyl phthalate (DBP); diester adipate such as dioctyl adipate; and alkylene glycol diester such as triethylene glycol 2-ethylhexyl. Among them, DOP is suitable because it has low

volatility and thus flexibility of the sheet can be maintained easily. From the viewpoint of flexibility of the green sheet, the content of the plasticizer in the slurry composition of the present invention is preferably 5 weight parts or more, more preferably 10 weight parts or more, and further preferably 15 weight parts or more with respect to 100 weight parts of the polyvinyl acetal resin. From the viewpoint of releasability of the green sheet, the content is preferably 40 weight parts or less, more preferably 30 weight parts or less, and further preferably 25 weight parts or less with respect to 100 weight parts of the polyvinyl acetal resin.

[0055] [Slurry composition]

10 The slurry composition of the present invention can be produced for example by a process including a step of mixing the polymer dispersant, the basic ceramic material and the nonaqueous solvent. The mixing step includes for example mixing the polymer dispersant, the basic ceramic material and the nonaqueous solvent with zirconia beads or the like. Then, the other components including the cationic
15 compound and the polyvinyl acetal resin are added to obtain the slurry composition of the present invention. The contents of the respective components can be determined with reference the above description.

[0056] The slurry composition of the present invention can be used for a ceramic molded article used in the field of electronic equipment. For example, in a case of
20 forming a thin green sheet from a slurry composition containing a basic ceramic by a molding technique such as casting, pressing, extrusion, ejection or the like, the slurry composition of the present invention can improve the antistatic property and the releasability of the molded article and furthermore improve the toughness (rupture stress and elongation) of the sheet. In the specification, "thin monolithic green sheet" or "thin green sheet" indicates a green sheet preferably having a thickness of less than
25 15 μm , more preferably not more than 10 μm , and further preferably not more than 8 μm . Though there is no particular lower limit for the thickness, the thickness is more than 0 μm , and for example, 0.02 μm or more.

[0057] The disclosure relates further to one or more embodiments described below.

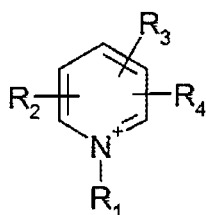
30 [0058] <1> A slurry composition containing a cationic compound that includes a nitrogen-containing heteroaromatic quaternary ammonium cationic group, a polymer dispersant, a nonaqueous solvent, a basic ceramic material, and a polyvinyl acetal

resin.

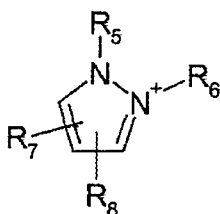
[0059] <2> The slurry composition according to <1>, wherein the cationic group is a cationic group having quaternary ammonium in its aromatic ring.

<3> The slurry composition according to <1> or <2>, wherein the cationic group is a cationic group having at least one structure selected from the group consisting of structures of pyridinium, pyrazolium, imidazolium, pyrimidinium, pyrazinium, pyridazinium, and pyrrolium.

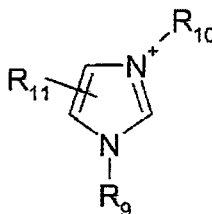
<4> The slurry composition according to any one of <1> to <3>, wherein the cationic group is a cationic group selected from the group consisting of the cationic groups represented by General formulae (1), (2), and (3) below:



(1)



(2)



(3)

[In General formula (1), R₁ is a C₁ to C₄ alkyl group; and R₂, R₃ and R₄ are same or different, each represents a hydrogen atom or a C₁ to C₄ alkyl group which may have a hydroxyl group. In General formula (2), R₅ and R₆ are same or different, each represents a C₁ to C₄ alkyl group; and R₇ and R₈ are same or different, each represents a hydrogen atom or a alkyl group which may have a hydroxyl group. In General formula (3), R₉ and R₁₀ are same or different, each represents a C₁ to C₄ alkyl group; and R₁₁ represents a hydrogen atom or a C₁ to C₄ alkyl group which may have a hydroxyl group.]

<5> The slurry composition according to any one of <1> to <4>, wherein the cationic group is a cationic group represented by the General formula (3).

<6> The slurry composition according to any one of <1> to <5>, wherein the cationic group is a cationic group represented by the General formula (3), and the total number of the carbons of R₉ and R₁₀ in the General formula (3) is in the range of 2 to 5.

<7> The slurry composition according to any one of <1> to <6>, wherein the molecular weight of the cationic group is: 300 or less, preferably 200 or less, more preferably 150 or less, and further preferably 120 or less; 90 or more, preferably 95 or

more, and further preferably 100 or more; or in the range of 90 to 300, preferably 95 to 300, more preferably 95 to 200, further preferably 100 to 150, and even further preferably 100 to 120.

<8> The slurry composition according to any one of <1> to <7>, wherein the
5 cationic compound is a salt of the cationic group and an anionic group, and the anionic group is an organic anionic group.

<9> The slurry composition according to any one of <1> to <8>, wherein the anionic group is an anionic group of at least one acid selected from the group consisting of alkylsulfuric acid and aliphatic carboxylic acid.

10 <10> The slurry composition according to any one of <1> to <9>, wherein the content of the cationic group is: 0.05 weight parts or more, preferably 0.1 weight parts or more, more preferably 0.2 weight parts or more, and further preferably 0.3 weight parts or more with respect to 100 weight parts of the basic ceramic material; 2.0 weight parts or less, preferably 1.8 weight parts or less, more preferably 1.5 weight
15 parts or less, and further preferably 1.2 weight parts or less with respect to 100 weight parts of the basic ceramic material; or in the range of 0.05 to 2.0 weight parts, preferably 0.1 to 1.8 weight parts, more preferably 0.2 to 1.5 weight parts, and further preferably 0.3 to 1.2 weight parts with respect to 100 weight parts of the basic ceramic material.

20 <11> The slurry composition according to any one of <1> to <10>, wherein the content of the cationic compound in the slurry composition is: 0.01 weight parts or more, preferably 0.015 weight parts or more, more preferably 0.02 weight parts or more, and further preferably 0.03 weight parts or more with respect to 1.0 weight part of the polyvinyl acetal resin; 0.2 weight parts or less, preferably 0.18 weight parts or
25 less, more preferably 0.15 weight parts or less, and further preferably 0.12 weight parts or less with respect to 1.0 weight part of the polyvinyl acetal resin; or in the range of 0.01 to 0.2 weight parts, preferably 0.015 to 0.18 weight parts, more preferably 0.02 to 0.15 weight parts, and further preferably 0.03 to 0.12 weight parts with respect to 1.0 weight part of the polyvinyl acetal resin.

30 <12> The slurry composition according to any one of <1> to <11>, wherein the weight average molecular weight of the polymer dispersant is: 2000 or more, preferably 4000 or more, more preferably 6000 or more, and further preferably 8000 or

more; 200000 or less, preferably 120000 or less, more preferably 60000 or less, and further preferably 36000 or less; or in the range of 2000 to 200000, preferably 4000 to 120000, more preferably 6000 to 60000, and further preferably 8000 to 36000.

<13> The slurry composition according to any one of <1> to <12>, wherein
 5 the content of the polymer dispersant in the slurry composition as the weight part with respect to 100 weight parts of the basic ceramic material is: 0.3 times or more, preferably 0.4 times or more of a value obtained by dividing the BET specific surface area [unit: m^2/g] of the basic ceramic material by 5; 1.5 times or less, preferably 1.2 times or less of a value obtained by dividing the BET specific surface area [unit: m^2/g]
 10 of the basic ceramic material by 5; or in the range of 0.3 to 1.5 times, preferably 0.4 to 1.2 times of a value obtained by dividing the BET specific surface area [unit: m^2/g] of the basic ceramic material by 5.

<14> The slurry composition according to any one of <1> to <13>, wherein the polymer dispersant is an anionic polymer dispersant.

15 <15> The slurry composition according to any one of <1> to <14>, wherein the slurry composition includes further a plasticizer selected from the group consisting of diester phthalate, diester adipate, and alkylene glycol diester; preferably it includes diester phthalate, and more preferably it includes dioctyl phthalate.

<16> The slurry composition according to <15>, wherein the content of the
 20 plasticizer is: 5 weight parts or more, preferably 10 weight parts or more, and more preferably 15 weight parts or more with respect to 100 weight parts of the polyvinyl acetal resin; 40 weight parts or less, preferably 30 weight parts or less, and more preferably 25 weight parts or less with respect to 100 weight parts of the polyvinyl acetal resin; or in the range of 5 to 40 weight parts, preferably 10 to 30 weight parts,
 25 and more preferably 15 to 25 weight parts with respect to 100 weight parts of the polyvinyl acetal resin.

<17> The slurry composition according to any one of <1> to <16>, wherein the basic ceramic material is at least one selected from the group consisting of a complex oxide of zirconic acid and a complex oxide of titanic acid, preferably a complex
 30 oxide of titanic acid, and more preferably barium titanate.

<18> The slurry composition according to any one of <1> to <17>, wherein the average particle diameter based on the BET specific surface area of the basic

ceramic material is: 500 nm or less, preferably 200 nm or less, and more preferably 120 nm or less; 5 nm or more, preferably 10 nm or more, and more preferably 20 nm or more; or in the range of 5 to 500 nm, preferably 10 to 200 nm, and more preferably 20 to 120 nm.

5 <19> The slurry composition according to any one of <1> to <18>, wherein the polyvinyl acetal resin is a polyvinyl butyral resin.

 <20> The slurry composition according to any one of <1> to <19>, wherein the polymer dispersant is a copolymer, preferably a copolymer having a constitutional unit having a high affinity for the basic ceramic material and a constitutional unit
10 having a high affinity for the nonaqueous solvent, more preferably a copolymer having a constitutional unit derived from (meth)acrylic acid and a constitutional unit having a polyoxyethylene group.

 <21> The slurry composition according to any one of <1> to <20>, wherein the nonaqueous solvent has a nonaqueous solvent selected from alcohols and
15 cellosolves, preferably it has an alcohol, and more preferably it has ethanol.

 <22> The slurry composition according to any one of <1> to <21>, wherein the nonaqueous solvent has a nonaqueous solvent selected from hydrocarbons and aromatics, preferably it has aromatics, and more preferably it has toluene.

 <23> A method for producing a green sheet, including formation of a green
20 sheet by using the slurry composition according to any one of <1> to <22>.

Examples

[0060] The disclosure will be described below more specifically by referring to the following Examples.

25 [0061] 1. Preparation of slurry composition (Examples 1-17, Comparative Examples 1-9)

 The slurry compositions for Examples 1-17 and Comparative examples 1-9 were prepared by using the cationic compounds A1-A13 illustrated in Table 1 below, the polymer dispersants B1-B7 illustrated in Table 2 below, a basic ceramic material
30 and a polyvinyl acetal resin.

[0062] [Cationic compound]

 In the slurry compositions for Examples 1-17 and Comparative example 7,

the cationic compounds A1-A8 below were used. In Comparative examples 2-6 and Comparative Example 9, the cationic compounds A9-A13 were used in place of the cationic compounds A1-A8. The cationic compounds A1-A13 used are listed in Table 1 below with the molecular weights of the cationic parts.

5 [0063] A1: 1-ethyl-3-methylimidazolium ethyl sulfate (manufactured by Sigma-Aldrich Co. LLC.)

A2: 1-ethyl-3-methylimidazolium acetate (manufactured by Sigma-Aldrich Co. LLC.)

A3: 1-ethyl-2,3-dimethylimidazolium ethyl sulfate (manufactured by
10 Sigma-Aldrich Co. LLC.)

A4: 1-butyl-3-methylimidazolium ethyl sulfate (manufactured by Sigma-Aldrich Co. LLC.)

A5: 1-butyl-3-methylimidazolium acetate (manufactured by Sigma-Aldrich Co. LLC.)

15 A6: 1,2,4-trimethylpyrazolium methyl sulfate (manufactured by Sigma-Aldrich Co. LLC.)

A7: 1-ethyl-3-methylpyridinium ethyl sulfate (manufactured by Tokyo Chemical Industry Co., Ltd.)

A8: 1-ethyl-3-hydroxymethylpyridinium ethyl sulfate (manufactured by
20 Tokyo Chemical Industry Co., Ltd.)

A9: 1-methylimidazolium hydrogen sulfate (manufactured by Sigma-Aldrich Co. LLC.)

A10: tris(2-hydroxyethyl) methylammonium methyl sulfate (manufactured by Sigma-Aldrich Co. LLC.)

25 A11: tributyl methylammonium methyl sulfate (manufactured by Sigma-Aldrich Co. LLC.)

A12: octyl-2-hydroxyethyl imidazolinium ethyl sulfate (manufactured by Sigma-Aldrich Co. LLC.)

A13: lauryl ethyl bis(2-hydroxyethyl)ammonium ethyl sulfate (a quaternary
30 ammonium salt synthesized by allowing ethylene oxide 2-mole adduct of laurylamine to react with diethyl sulfate)

[0064] [Table 1]

(Table 1)

	Cationic compound	Molecular weight of cationic group
A1	1-ethyl-3-methylimidazolium ethyl sulfate Cationic group: Formula(3) R9=CH3-CH2-, R10=CH3-, R11=H-	111
A2	1-ethyl-3-methylimidazolium acetate Cationic group: Formula(3) R9=CH3-CH2-, R10=CH3-, R11=H-	111
A3	1-ethyl-2,3-dimethylimidazolium ethyl sulfate Cationic group: Formula(3) R9=CH3-CH2-, R10=R11=CH3-	125
A4	1-butyl-3-methylimidazolium ethyl sulfate Cationic group: Formula(3) R9=CH3-(CH2)3-, R10=CH3-, R11=H-	139
A5	1-butyl-3-methylimidazolium acetate Cationic group: Formula(3) R9=CH3-(CH2)3-, R10=CH3-, R11=H-	139
A6	1,2,4-trimethylpyrazolium methyl sulfate Cationic group: Formula(2) R5=R6=R7=CH3-, R8=H-	111
A7	1-ethyl-3-methylpyridinium ethyl sulfate Cationic group: Formula(1) R1=CH3-CH2-, R2=CH3-, R3=R4=H-	122
A8	1-ethyl-3-hydroxymethylpyridinium ethyl sulfate Cationic group: Formula(1) R1=CH3-CH2-, R2=HO-CH2-, R3=R4=H-	138
A9	1-methylimidazolium hydrogen sulfate Cationic group: Formula(3) R9=CH3-, R10=R11=H-	83
A10	tris(2-hydroxyethyl) methylammonium methyl sulfate	164
A11	tributyl methylammonium methyl sulfate	200
A12	octyl-2-hydroxyethyl imidazolinium ethyl sulfate	227
A13	lauryl ethyl bis(2-hydroxyethyl)ammonium ethyl sulfate	303

[0065] [Polymer dispersant]

For the slurry compositions in Examples 1-17 and Comparative examples 1-6, 8 and 9, the polymer dispersants B1-B7 in Table 2 below were used. The polymer dispersants B3, B5 and B6 were synthesized under the below-mentioned conditions. Measurement of the nonvolatile contents in the respective polymer dispersants and measurement of the weight average molecular weight were carried out under the below-mentioned conditions.

10 [0066] [Table 2]

(Table 2)

	Polymer dispersant	Weight average molecular weight
B1	Cationic polymer dispersant Trade name: Solsperse 33000 by Lubrizol Corporation	34900
B2	Cationic polymer dispersant Trade name: Ajisper PB-821 by Ajinomoto Fine-Techno Co., Ltd.	48600
B3	Nonionic polymer dispersant Methyl methacrylate-PEGMA23-methacrylamide copolymer	32900
B4	Nonionic polymer dispersant Trade name: Antaron V-216 by ISP Japan Ltd	4800
B5	Anionic polymer dispersant PEGMA23-methacrylic acid copolymer	17400
B6	Anionic polymer dispersant Methyl methacrylate-PEGMA23-methacrylic acid copolymer	8300
B7	Anionic polymer dispersant Trade name: Marialim AKM-0531 by NOF Corporation	33300

[0067] [Production example 1 of polymer dispersant]

In a separable flask attached with a reflux tube, an agitator, a thermometer
 5 and a nitrogen-introducing tube, 1.5 g of methyl methacrylate (manufactured by Waco
 Pure Chemical Industries Ltd.), 5.5 g of methoxy polyethylene glycol (23)
 methacrylate (PEGMA23: NK-ester M-230G manufactured by Shin-Nakamura
 Chemical Co., Ltd., the average addition mole number of ethylene oxide: 23), 3.0 g of
 methacrylamide (manufactured by Waco Pure Chemical Industries Ltd.) and 12.25 g
 10 of ethanol (manufactured by Waco Pure Chemical Industries Ltd.) were introduced,
 subjected to a nitrogen-substitution, and heated to 65°C. After the temperature
 inside the tank reached 65°C, a mixture of 0.3 g of
 2,2'-azobis(2,4-dimethylvaleronitrile) (V-65 manufactured by Waco Pure Chemical
 Industries Ltd.) and 2.5 g of ethanol was added. Then, the mixed liquid of 13.5 g of
 15 methyl methacrylate, 49.5 g of PEGMA 23, 27.0 g of methacrylamide, 110.25 g of
 ethanol and 2.7 g of V-65 was dripped for 3 hours. After allowed to age for 3 hours at
 65°C, the liquid was cooled to room temperature. Ethanol was added for adjusting
 the concentration, thereby obtaining an ethanol solution of the polymer dispersant B3.
 The nonvolatile content of the polymer dispersant B3 solution was 33.6 wt%, and the
 20 weight average molecular weight of the polymer dispersant B3 was 32900.

[0068] [Production example 2 of polymer dispersant]

In a separable flask attached with a reflux tube, an agitator, a thermometer and a nitrogen-introducing tube, 8.5 g of methoxy polyethylene glycol (23) methacrylate (PEGMA23: NK-ester M-230G manufactured by Shin-Nakamura Chemical Co., Ltd., the average addition mole number of ethylene oxide: 23), 1.5 g of methacrylic acid (manufactured by Waco Pure Chemical Industries Ltd.), 10 g of ethanol (manufactured by Waco Pure Chemical Industries Ltd.), and 0.1 g of 3-mercapto-1,2-propanediol (manufactured by Waco Pure Chemical Industries Ltd.) were introduced, subjected to a nitrogen-substitution, and heated to 65°C. After the temperature inside the tank reached 65°C, a mixture of 0.3 g of 2,2'-azobis(2,4-dimethylvaleronitrile) (V-65 manufactured by Waco Pure Chemical Industries Ltd.) and 2.5 g of ethanol was added. Then, the mixed liquid of 76.5 g of PEGMA 23, 13.5 g of methacrylic acid, 90 g of ethanol, 2.7 g of V-65 and 0.9 g of 3-mercapto-1,2-propanediol was dripped for 3 hours. After allowed to age for 3 hours at 65°C, the liquid was cooled to room temperature. Ethanol was added for adjusting the concentration, thereby obtaining an ethanol solution of the polymer dispersant B5. The nonvolatile content of the polymer dispersant B5 solution was 53.2 wt%, and the weight average molecular weight of the polymer dispersant B5 was 17400.

[0069] [Production example 3 of polymer dispersant]

In a separable flask attached with a reflux tube, an agitator, a thermometer and a nitrogen-introducing tube, 1.5 g of methyl methacrylate (manufactured by Waco Pure Chemical Industries Ltd.), 7.0 g of methoxy polyethylene glycol (23) methacrylate (PEGMA23: NK-ester M-230G manufactured by Shin-Nakamura Chemical Co., Ltd., the average addition mole number of ethylene oxide: 23), 1.5 g of methacrylic acid (manufactured by Waco Pure Chemical Industries Ltd.), 15 g of ethanol (manufactured by Waco Pure Chemical Industries Ltd.), and 0.3 g of 3-mercapto-1,2-propanediol (manufactured by Waco Pure Chemical Industries Ltd.) were introduced, subjected to a nitrogen-substitution, and heated to 65°C. After the temperature inside the tank reached 65°C, a mixture of 0.3 g of 2,2'-azobis(2,4-dimethylvaleronitrile) (V-65 manufactured by Waco Pure Chemical Industries Ltd.) and 2.5 g of ethanol was added. Then, the mixed liquid of 13.5 g of methyl methacrylate, 63.0 g of PEGMA 23, 13.5 g of methacrylic acid, 135 g of ethanol, 2.7 g of V-65 and 2.7 g of 3-mercapto-1,2-propanediol was dripped for 3 hours. After

allowed to age for 3 hours at 65°C, the liquid was cooled to room temperature.

Ethanol was added for adjusting the concentration, thereby obtaining an ethanol solution of the polymer dispersant B6. The nonvolatile content of the polymer dispersant B6 solution was 52.0 wt%, and the weight average molecular weight of the polymer dispersant B6 was 8300.

[0070] [Measurement of nonvolatile content]

The nonvolatile content of the polymer dispersant solution was determined in the following manner. A glass rod and dried anhydrous sodium sulfate, 10 g of which was weight out, were placed in a petri dish, and 2 g of the polymer solution was put therein. The contents were mixed with use of the glass rod, and were dried for 2 hours in a low-pressure dryer (pressure: 8 kPa) at 105°C. The contents thus dried were weighed, and the value determined by the following expression was considered to be the nonvolatile content.

Nonvolatile content

$$= \{[\text{weight of sample} - (\text{weight after drying} - (\text{weight of petri dish} + \text{weight of glass rod} + \text{weight of anhydrous sodium sulfate}))] / \text{weight of sample}\} \times 100$$

[0071] [Measurement of weight average molecular weight]

The weight average molecular weight of the polymer dispersant was determined in the following manner. Namely, eluant was flown at a rate of 1 mL per minute, and a column was stabilized in a high-temperature vessel at 40°C. 100 μ L of a sample solution was poured therein, and measurement was carried out. The molecular weight of the sample was calculated based on preliminarily created calibration curves. To create the calibration curves, the following monodisperse polystyrene was used as the standard sample.

Measurement device: HLC-8120GPC (manufactured by Tosoh Corporation)

Measurement conditions:

Sample solution: 0.5 wt% N,N-dimethyl formamide solution

Eluant: N,N-dimethyl formamide solution including H₃PO₄:60 mmol/L and LiBr:50 mmol/L

Column: α -M + α -M (manufactured by Tosoh Corporation)

Detector: differential refractive index

Calibration curve: 5.26×10^2 , 1.02×10^5 , 8.42×10^6 ; polystyrene manufactured by

Tosoh Corporation; 4.0×10^3 , 3.0×10^4 , 9.0×10^5 polystyrene manufactured by Nishio Kogyo Co., Ltd. (numerical figures represent respective molecular weights)

[0072] [Preparation of slurry composition]

[Preparation of slurry composition for Example 1]

5 The slurry composition for Example 1 was prepared in the following manner. That is, 20 g of barium titanate (BET specific surface area: $20 \text{ m}^2/\text{g}$, average particle diameter calculated based on BET specific surface area: 50 nm, basicity: $90 \text{ } \mu\text{mol/g}$, acidity: $10 \text{ } \mu\text{mol/g}$) and 0.8 g of polymer dispersant B6 (effective content (nonvolatile content)) were charged in a 100 mL container; together with 50 g of zirconia beads
10 having a diameter of 1 mm, and a mixture solvent of toluene/ethanol = 48/52 (volume ratio) was added thereto so that the concentration of solid content of barium titanate was 50 wt%, and a dispersion was conducted with a tabletop ball mill for 96 hours. Subsequently, 2.8 g of polyvinyl butyral resin (acetalization degree: 68 mol%, residual hydroxyl group content: 31 mol%), 0.56 g of dioctyl phthalate, 0.2 g of cationic
15 compound A1, and a mixed solvent of toluene/ethanol = 48/52 (volume ratio) was added thereto so that the concentration of solid content of the barium titanate was 35 wt% with respect to the slurry composition, and after mixing for two hours with a tabletop ball mill, the zirconia beads were filtrated and removed, thereby the slurry composition for Example 1 was obtained (Table 3 below).

20 [0073] [Preparation of slurry compositions for Examples 2-8 and Comparative examples 1-6]

 Slurry compositions for Examples 2-8 and Comparative examples 2-6 were prepared in the same manner as Example 1 except that the cationic compounds in Table 3 below were used in place of the cationic compound A1. In Comparative
25 example 1, a slurry composition was prepared in the same manner as in Example 1 except that the cationic compound A1 was not used.

[0074] [Preparation of slurry composition for Example 9]

 The slurry composition for Example 9 was prepared in the following manner. That is, 20 g of barium titanate (BET specific surface area: $20 \text{ m}^2/\text{g}$, average particle
30 diameter calculated based on BET specific surface area: 50 nm, basicity: $90 \text{ } \mu\text{mol/g}$, acidity: $10 \text{ } \mu\text{mol/g}$) and 0.8 g of polymer dispersant B1 (effective content (nonvolatile content)) were charged in a 100 mL container; together with 50 g of zirconia beads

having a diameter of 1 mm, and a mixture solvent of toluene/ethanol = 48/52 (volume ratio) was added thereto so that the concentration of the solid content of barium titanate was 50 wt%, and a dispersion was conducted with a tabletop ball mill for 96 hours. Subsequently, 1.6 g of polyvinyl butyral resin (acetalization degree: 68 mol%, residual hydroxyl group content: 31 mol%), 0.32 g of dioctyl phthalate, 0.16 g of cationic compound A1, and a mixed solvent of toluene/ethanol = 48/52 (volume ratio) was added thereto so that the concentration of solid content of the barium titanate was 35 wt% with respect to the slurry composition, and after mixing for two hours with a tabletop ball mill, the zirconia beads were filtrated and removed, thereby the slurry composition for Example 9 was obtained (Table 3 below).

[0075] [Preparation of slurry compositions for Examples 10-15 and Comparative example 7]

The slurry compositions for Examples 10-15 were prepared in the same manner as Example 9 except that the polymer dispersants in Table 3 below were used in place of the polymer dispersant B1. In Comparative example 7, a slurry composition was prepared in the same manner as Example 9 except that the polymer dispersant B1 was not used.

[0076] [Preparation of slurry composition for Example 16]

The slurry composition for Example 16 was prepared in the following manner. That is, 20 g of barium titanate (BET specific surface area: 10 m²/g, average particle diameter calculated based on BET specific surface area: 100 nm, basicity: 90 μmol/g, acidity: 10 μmol/g) and 0.32 g of polymer dispersant B5 (effective content (nonvolatile content)) were charged in a 100 mL container, together with 50 g of zirconia beads having a diameter of 1 mm, and a mixture solvent of toluene/ethanol = 48/52 (volume ratio) was added thereto so that the concentration of solid content of barium titanate was 50 wt%, and a dispersion was conducted with a tabletop ball mill for 96 hours. Subsequently, 2.8 g of polyvinyl butyral resin (acetalization degree: 68 mol%, residual hydroxyl group content: 31 mol%), 0.56 g of dioctyl phthalate, 0.1 g of cationic compound A1, and a mixed solvent of toluene/ethanol = 48/52 (volume ratio) was added thereto so that the concentration of solid content of barium titanate was 35 wt% with respect to the slurry composition, and after mixing for two hours with a tabletop ball mill, the zirconia beads were filtrated and removed, thereby the slurry

composition for Example 16 was obtained (Table 3 below).

[0077] [Preparation of slurry compositions for Example 17 and Comparative examples 8-9]

Slurry compositions for Example 17 and Comparative example 9 were prepared in the same manner as Example 16 except that the cationic compounds in Table 3 below were used in place of the cationic compound A1. In Comparative example 8, a slurry composition was prepared in the same manner as Example 16 except that the cationic compound A1 was not used.

[0078] 2. Formation and assessment of green sheet

Green sheets were formed from the slurry compositions of Examples 1-17 and Comparative examples 1-9, and the green sheets were subjected to measurement on the peel static electricity, peel strength, rupture strength and elongation.

[0079] [Formation of green sheet]

The slurry compositions of Examples 1-17 and Comparative examples 1-9 were applied on silicone-coated substrate films (Purex manufactured by Teijin DuPont Films) by use of a film applicator (gap: 50 μm), which were dried at 60°C for 16 hours so as to form green sheets. The dried green sheets had thickness in a range of 5 to 8 μm .

[0080] [Measurement of peel static electricity]

The thus formed green sheets were used to measure the peel static electricity in the following manner. Namely, together with the substrate film, each of the green sheets was cut into specimens each having a dimension of 4 cm (short side) $\times$ 10 cm (long side). The specimen was fixed by use of a double-sided tape onto a base, with its surface opposite to the coated surface (i.e., film-side) facing downward, of a table-top type precision tester (Autograph AGS-X manufactured by Shimadzu Corporation) equipped with a jig for a 90° release test. Next, one end at the short side of the green sheet specimen was released off by 1 cm from the substrate film, and then pinched with a clip. Thereafter, the clip was fixed to a load cell. Then, the load cell was lifted at a rate of 1 cm/second to carry out a 90° release, and the maximal value of the static electricity (peel static electricity) at the release surface side of the green sheet was measured with an electrostatic sensor (SK-200 manufactured by Keyence Corporation) placed with a distance of 3 cm from the release surface. The results are

shown in Table 3 below. A smaller absolute value of this peel static electricity indicates a favorable antistatic property.

[0081] [Measurement of peel strength]

In the measurement of the peel static electricity, the load applied to the load
5 cell at the time of releasing the green sheet by 90° at a rate of 1 cm/second was measured. Specifically, the average value of load applied to the load cell from the time the load cell is lifted by 3 cm to 6 cm was set as the peel strength. The results are shown in Table 3 below. A smaller peel strength indicates a favorable releasability.

10 [0082] [Measurement of rupture stress and elongation]

The green sheet was cut into the Dumbbell-shape Type 1 as defined in JIS K6251. Before releasing the green sheet from the substrate film, the thickness was measured in order to calculate the thickness of the green sheet on the basis of the difference from the thickness of the substrate film itself. Next, the released green
15 sheet was attached to a load cell mounted on the table-top type precision tester (Autograph EZ-TEST manufactured by Shimadzu Corporation), stretched at a test rate of 6 cm/minute so as to measure the stress on the specimen at the rupture, and elongation at rupture (elongation). The results are shown in Table 3 below. Greater rupture stress and greater elongation indicate favorable toughness.

20 [0083]

B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (4.9)	7.92	42.4	15.2	1.2
B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (4.9)	-2.68	27.4	21.3	2.5
B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (4.9)	0.10	30.0	6.3	0.4
B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (4.9)	0.14	32.1	22.3	4.9
B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (4.9)	1.74	33.2	12.0	1.9
B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (4.9)	1.77	33.9	12.9	1.8
B1 (1.4)	Cation	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	0.06	40.0	15.2	7.2
B2 (1.4)	Cation	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	0.19	45.8	18.6	5.6
B3 (1.4)	Nonion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	-0.26	33.4	15.8	4.7
B4 (1.4)	Nonion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	-2.21	32.6	13.2	2.8
B5 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	0.05	32.1	13.8	3.6
B6 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	0.04	33.7	13.0	2.6
B7 (1.4)	Anion	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	0.12	29.5	14.3	3.2
—	—	BaTiO ₃ (35)	50nm	Polyvinyl butyral resin (2.8)	-8.38	53.8	12.8	2.5
B5 (0.56)	Anion	BaTiO ₃ (35)	100nm	Polyvinyl butyral resin (4.9)	0.07	22.1	25.0	7.0
B5 (0.56)	Anion	BaTiO ₃ (35)	100nm	Polyvinyl butyral resin (4.9)	0.11	23.3	24.6	6.8
B5 (0.56)	Anion	BaTiO ₃ (35)	100nm	Polyvinyl butyral resin (4.9)	3.27	31.8	20.6	2.9
B5 (0.56)	Anion	BaTiO ₃ (35)	100nm	Polyvinyl butyral resin (4.9)	2.22	29.0	21.0	3.2

example. *1: particle diameter

contents or nonvolatile contents in slurry compositions.

[0084] As shown in Table 3 above, in the green sheets formed from the slurry compositions of Examples 1-8, in comparison with the green sheets of Comparative examples 1-6, the peel static electricity was decreased and the antistatic property was improved, the peel strength was small and the releasability was excellent. Furthermore, measurement values for the rupture stress and elongation were great, i.e., the toughness also was improved. Similarly in the green sheets formed from the slurry compositions of Examples 16-17, in comparison with the green sheets of Comparative examples 8-9, the antistatic property, the peel strength and the toughness were improved. It has been clarified that, the slurry compositions containing the cationic compounds having the cationic groups represented by the above Chemical formulae (1) and (3) are preferred from the viewpoint of improving the antistatic property; the slurry composition containing the cationic compound having the cationic group represented by the above Chemical formula (3) is preferred from the viewpoint of improving releasability; and the slurry compositions containing the cationic compounds having the cationic groups represented by the above Chemical formulae (2) and (3) are preferred from the viewpoint of toughness. Furthermore, it has been clarified that, as the cationic group in the present invention, the cationic group represented by the Formula (3) above is further preferred from the viewpoint of improving antistatic property, peel strength and toughness.

[0085] It has been clarified further that, as shown in Table 3 above, in Examples 9-15, all of the cationic, nonionic and anionic polymer dispersants serve to decrease the peel static electricity and peel strength and improve the rupture stress and elongation, and to exhibit an excellent antistatic property, excellent releasability and excellent toughness in comparison with a case not using a polymer dispersant (Comparative example 7). It has been clarified also that, from the viewpoint of improving antistatic property, the polymer dispersant used for the slurry composition of the present invention is preferably cationic and anionic, and from the viewpoint of improving releasability, it is preferably nonionic and anionic. And it has been clarified that, from the viewpoint of improving both antistatic property and releasability,

an anionic polymer dispersant is more preferred.

Industrial Applicability

[0086] The present invention can be applied favorably to the field of ceramic
5 molding, for example, a field relating to production of ceramic electronic parts.

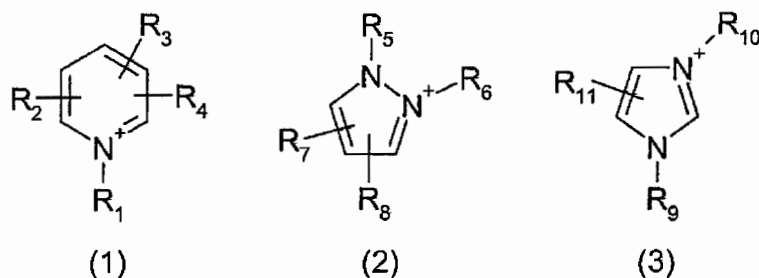
CLAIMS

[1] A slurry composition containing a cationic compound that comprises a nitrogen-containing five-membered ring or six-membered ring heteroaromatic quaternary ammonium cationic group, a polymer dispersant having a weight average molecular weight of not less than 6000 and not more than 200000, a nonaqueous solvent, a basic ceramic material, and a polyvinyl acetal resin.

[2] The slurry composition according to claim 1, wherein the cationic group is a cationic group having quaternary ammonium in its aromatic ring.

[3] The slurry composition according to claim 1 or 2, wherein the cationic group is a cationic group having at least one structure selected from the group consisting of structures of pyridinium, pyrazolium, imidazolium, pyrimidinium, pyrazinium, pyridazinium and pyrrolium.

[4] The slurry composition according to any one of claims 1 to 3, wherein the cationic group is a cationic group selected from the group consisting of the cationic groups represented by General formulae (1), (2), and (3) below:



[In General formula (1), R₁ is a C₁ to C₄ alkyl group; and R₂, R₃ and R₄ are same or different, each represents a hydrogen atom or a C₁ to C₄ alkyl group which may have a hydroxyl group. In General formula (2), R₅ and R₆ are same or different, each represents a C₁ to C₄ alkyl group; and R₇ and R₈ are same or different, each represents a hydrogen atom or a C₁ to C₄ alkyl group which may have a hydroxyl group. In General formula (3), R₉ and R₁₀ are same or different, each represents a C₁ to C₄ alkyl group; and R₁₁ represents a hydrogen atom or a C₁ to C₄ alkyl group which may have a hydroxyl group.]

[5] The slurry composition according to any one of claims 1 to 4, wherein the cationic group is a cationic group represented by the General formula (3).

- [6] The slurry composition according to any one of claims 1 to 5, wherein the cationic group is a cationic group represented by the General formula (3), and the total number of the carbons of R₉ and R₁₀ in the General formula (3) is in the range of 2 to 5.
- 5 [7] The slurry composition according to any one of claims 1 to 6, wherein the cationic group has a molecular weight in the range of 90 to 300.
- [8] The slurry composition according to any one of claims 1 to 7, wherein the cationic compound is a salt of the cationic group and an anionic group, and the anionic group is an organic anionic group.
- 10 [9] The slurry composition according to any one of claims 1 to 8, wherein the anionic group is an anionic group of at least one acid selected from the group consisting of alkylsulfuric acid and aliphatic carboxylic acid.
- [10] The slurry composition according to any one of claims 1 to 9, wherein the content of the cationic compound is not less than 0.05 weight parts and not
- 15 more than 2.0 weight parts with respect to 100 weight parts of the basic ceramic material.
- [11] The slurry composition according to any one of claims 1 to 10, wherein the polymer dispersant is an anionic polymer dispersant.
- [12] The slurry composition according to any one of claims 1 to 11, wherein
- 20 the basic ceramic material is barium titanate.
- [13] The slurry composition according to any one of claims 1 to 12, wherein the polyvinyl acetal resin is a polyvinyl butyral resin.
- [14] The slurry composition according to any one of 1 to 13, wherein the content of the polymer dispersant in the slurry composition as the weight part
- 25 with respect to 100 weight parts of the basic ceramic material is: 0.3 times or more and 1.5 times or less of a value obtained by dividing the BET specific surface area [unit: m²/g] of the basic ceramic material by 5.