

SPECIFICATION

RELEASE FILM FOR GREEN SHEET MANUFACTURING, AND METHOD FOR
MANUFACTURING RELEASE FILM FOR GREEN SHEET MANUFACTURING

TECHNICAL FIELD

[0001] The present invention relates to a release film for producing a green sheet and a method of producing a release film for producing a green sheet.

RELATED ART

[0002] When manufacturing a ceramic capacitor, a release film for producing a green sheet is used to form the green sheet.

[0003] The release film for producing the green sheet is usually composed of a base material and a release agent layer. The green sheet is manufactured by coating a ceramic slurry, in which ceramic particles and a binder resin are dispersed and dissolved in an organic solvent, onto the release film for producing the green sheet and drying it. The green sheet thus manufactured is released from the release film for producing the green sheet and is used in manufacturing the ceramic capacitor.

[0004] In the manufacture of the green sheet using the conventional release film for producing the green sheet, there is a problem that a pinhole generates on a surface of the green sheet by transfer of an irregularity shape of a surface of the release film for producing the green sheet to the green sheet. As a result, in the ceramic capacitor which is manufactured by laminating such a green sheet, there occurs a problem that a defect is generated by short circuit. In order to solve such a problem, very high smoothness is required for the surface (cast surface) of the release film for producing the green sheet.

[0005] For this reason, as a method of producing the release film for producing the green sheet having a smooth surface, the Patent Document 1 discloses a release film which is formed by coating a thermosetting resin liquid onto one surface of a base sheet having fine irregularity surfaces, heating it and curing to form a thermosetting resin layer, and then coating a release agent onto the thermosetting resin layer to form a release agent layer (see Patent Document 1).

[0006] Further, according to reduction of the size of the ceramic capacitor and requirement of a high-density ceramic capacitor in recent years, a further thinned ceramic capacitor is required. However, if an attempt of trying to produce a thin green sheet is made in the conventional release film for producing the green sheet, the pinhole and the like generate on the surface of the green sheet, so that it is difficult to obtain the green sheet having high reliability.

[0007] The Patent Document 1 is JP-A 2007-069360.

SUMMARY OF THE INVENTION

[0008] It is an object of the present invention to provide a release film for producing a green sheet which is capable of producing the green sheet having high reliability and preventing a pinhole and a partial thickness variation in a surface of the green sheet from generating. Further, it is another object of the present invention to provide a method of producing the release film for producing the green sheet which is capable of preventing the pinhole and the partial thickness variation in the surface of the green sheet from generating.

[0009] The above objects are achieved by the inventions (1) to (8) set forth below.

(1) A release film for producing a green sheet, comprising:

a base material having a first surface and a second surface;

a smoothed layer provided on the first surface of the base material; and

a release agent layer provided at a side of a surface of the smoothed layer opposite to the base material,

wherein the smoothed layer is formed by curing a coated layer via irradiating an active energy ray to a composition for forming smoothed layer, and the composition contains an active energy ray curable compound,

wherein an arithmetic average roughness Ra_1 of an outer surface of the release agent layer is 8 nm or less and a maximum projection height Rp_1 of the outer surface of the release agent layer is 50 nm or less.

[0010] (2) In the release film for producing the green sheet described in the above-mentioned invention (1), an arithmetic average roughness Ra_2 of the first surface is in the range of 10 to 200 nm and a maximum projection height Rp_2 of the first surface is in the range of 80 to 1000 nm.

[0011] (3) In the release film for producing the green sheet described in the above-mentioned invention (1) or (2), the active energy ray curable compound is a compound having a mass average molecular weight of 950 or less.

[0012] (4) In the release film for producing the green sheet described in any one of the above-mentioned inventions (1) to (3), the active energy ray curable compound is an ultraviolet ray curable compound and the active energy ray is an ultraviolet ray.

[0013] (5) In the release film for producing the green

sheet described in any one of the above-mentioned inventions (1) to (4), an average thickness of the smoothed layer is in the range of 0.2 to 10 μm .

[0014] (6) In the release film for producing the green sheet described in any one of the above-mentioned inventions (1) to (5), the smoothed layer has the surface opposite to the base material,

wherein an arithmetic average roughness Ra_4 of the surface of the smoothed layer opposite to the base material is 8 nm or less and a maximum projection height Rp_4 of the surface of the smoothed layer opposite to the base material is 50 nm or less.

[0015] (7) In the release film for producing the green sheet described in any one of the above-mentioned inventions (1) to (6), an arithmetic average roughness Ra_3 of the second surface is in the range of 10 to 200 nm and a maximum projection height Rp_3 of the second surface is in the range of 80 to 1000 nm.

[0016] (8) A method of producing the release film for producing the green sheet described in any one of above-mentioned inventions (1) to (7), comprising:

a base material preparing step for preparing the base material having the first surface and the second surface;

a coated layer forming step for forming a coated layer by coating the composition for forming smoothed layer containing the active energy ray curable compound at the side of the first surface of the base material;

a smoothed layer forming step for forming the smoothed layer by curing the coated layer via irradiating the active energy ray to the coated layer; and

a release agent forming step for forming the release agent layer at the side of the surface of the smoothed layer opposite to the base material;

wherein the arithmetic average roughness Ra_1 of the outer surface of the release agent layer is 8 nm or less and the maximum projection height Rp_1 of the outer surface of the release agent layer is 50 nm or less.

[0017] According to the present invention, it is possible to provide a release film for producing a green sheet which is capable of producing the green sheet having high reliability and preventing a pinhole and a partial thickness variation in a surface of the green sheet from generating. In particular, even if a base material having a relatively large surface roughness is used as the base material constituting the release film for producing the green sheet, it is possible to provide the release film for producing the green sheet having excellent smoothness in an outer surface thereof. The use of such a release film for producing the green sheet makes it possible to prevent the pinhole and the partial thickness variation in the surface of the green sheet from generating. As a result, when a capacitor is produced by laminating the green sheet, it is possible to prevent a defect from being generated by short circuit. Furthermore, according to the present invention, it is possible to easily and reliably produce the release film for producing the green sheet which is capable of producing the green sheet having the excellent smoothness in the surface thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a cross sectional view of a release film for producing a green sheet according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Hereinafter, the present invention will be described in detail based on a preferred embodiment.

<<Release Film for Producing Green Sheet >>

A release film for producing a green sheet according to the present invention is used for producing the green sheet. The produced green sheet is used for producing a ceramic capacitor and the like.

[0020] FIG. 1 is a cross sectional view of a release film for producing a green sheet according to the present invention. In the following description, the upper side in FIG. 1 will be referred to as "upper" and the lower side thereof will be referred to as "lower".

[0021] As shown in Fig. 1, the release film 1 for producing the green sheet includes a base material 11 having a first surface 111 and a second surface 112, a smoothed layer 12 provided on the first surface 111 of the base material 11 and a release agent layer 13 provided at a side of a surface 121 of the smoothed layer 12 opposite to the base material 11. In other words, the release film 1 for producing the green sheet is constituted from a three layer structure in which the base material 11, the smoothed layer 12 and the release agent layer 13 are laminated to bond together in this order as shown in FIG. 1.

[0022] In this specification, in the case where the green sheet is produced by using the release film 1 for producing the green sheet, the green sheet, for example, is formed by coating a dissolved ceramic slurry onto an outer surface 131 of the release agent layer 13.

[0023] In the present invention, the release film 1 for producing the green sheet includes the smoothed layer 12 between the base material 11 and the release agent layer 13. The smoothed layer 12 is formed by curing a coated layer via irradiating an active energy ray to a composition

for forming smoothed layer which contains an active energy ray curable compound. An arithmetic average roughness Ra_1 of the outer surface 131 of the release agent layer 13 is 8 nm or less and a maximum projection height Rp_1 of the outer surface 131 of the release agent layer 13 is 50 nm or less.

[0024] By having such features, it is possible to obtain the release film 1 for producing the green sheet having excellent smoothness in the outer surface 131 of the release agent layer 13 and excellent releasability. If the green sheet is produced by using this release film 1 for producing the green sheet, it is possible to prevent the pinhole and the partial thickness variation in a surface of the green sheet from generating, so that it is possible to produce the green sheet having the high reliability. As a result, when a capacitor is produced by laminating the green sheet, it is possible to prevent a defect from being generated by short circuit.

[0025] Meanwhile, a film used as the base material has various surface roughnesses. If such a film is inexpensive, there is a tendency that the surface roughness is relatively large. Even if the release film for producing the green sheet is formed by using the base material having such relatively large surface roughness, the provision of the smoothed layer having the features described above onto the surface of the base material makes it possible to reliably fill (compensate) the irregularity of the surface of the base material. As a result, it is possible to make the surface of the smoothed layer opposite to the base material smooth. This makes it possible to prevent the irregularity of the surface of the base material from affecting the outer surface of the release agent layer formed on the smoothed layer, so that it is possible to obtain the release film for producing the green sheet in which the outer surface of the release agent layer

has excellent smoothness.

[0026] Hereinafter, detailed description will now be made on the respective layers that constitute the release film 1 for producing the green sheet according to the present embodiment.

[0027] <Base Material 11>

The base material 11 serves to apply physical strength, such as rigidity or flexibility, to the release film 1 for producing the green sheet (hereinafter, simply referred to as "release film 1").

[0028] The base material 11 includes the first surface 111 and the second surface 112 as shown in FIG. 1.

Examples of a material constituting the base material 11 include, but not limited particularly, a film made of a plastic, e.g., a polyester resin such as a polybutylene terephthalate resin, a polyethylene terephthalate resin, and a polyethylene naphthalate resin; a polyolefin resin such as a polypropylene resin and a polymethylpentene resin; polycarbonate; and the like. The base material 11 may be a monolayer film or a multiple layer film including two or more layers of the same kind or different kinds. Among them, the film made of the polyester resin is preferable. The film made of the polyethylene terephthalate resin is particularly preferable. A film made of a biaxially-stretched polyethylene terephthalate resin is more preferable. The film made of the polyester resin seldom generates dust or the like during the processing or use thereof. It is therefore possible to effectively prevent generation of a coating defect of a ceramic slurry by the dust or the like in a case where the green sheet is produced by using the release film 1 which is produced by using the polyester resin. Consequently, it

is possible to produce the green sheet having less pinhole.

[0029] The base material 11 may include a filler in addition to the material as described above. Examples of the filler include silica, titanium oxide, calcium carbonate, kaolin, aluminum oxide and the like. These materials may be used singly or in combination of two or more of them. By including such a filler, it is possible to improve slipping property between a front surface and a rear surface of the base material 11 while giving mechanical strength to the base material 11, thereby enabling to suppress blocking from generating.

[0030] Further, it is preferred that an arithmetic average roughness Ra_2 of the first surface 111 of the base material 11 is in the range of 10 to 200 nm and an maximum projection height Rp_2 thereof is in the range of 80 to 1000 nm.

[0031] In particular, the arithmetic average roughness Ra_2 of the first surface 111 is preferably in the range of 15 to 1000 nm and more preferably in the range of 20 to 50 nm. Further, the maximum projection height Rp_2 of the first surface 111 is preferably in the range of 90 to 800 nm and more preferably in the range of 100 to 600 nm.

[0032] If the arithmetic average roughness Ra_2 and the maximum projection height Rp_2 of the first surface 111 fall within the above range, even if the smoothed layer 12 as described is relatively thin, it is possible to reliably fill the irregularity of the first surface 111 of the base material 11, thereby enabling the surface 121 of the smoothed layer 12 opposite to the base material 11 to smooth more. Consequently, it is possible to reliably prevent the irregularity of the first surface 111 of the base material 11 from affecting the outer surface 131 of

the release agent layer 13 which is formed on the smoothed layer 12.

[0033] The base material 11 that the arithmetic average roughness Ra_2 and the maximum projection height Rp_2 of the first surface 111 fall within the above range is obtained at relatively inexpensive price as well as with ease.

[0034] In contrast, if the arithmetic average roughness Ra_2 of the first surface 111 exceeds the upper limit value noted above, since it is difficult to sufficiently fill the irregularity of the first surface 111, which depends on a constituent material and the like of the composition for forming smoothed layer, there is a case that it is required to relatively thicken the release agent layer 13.

[0035] In this regard, it is to be noted that the arithmetic average roughness Ra_2 and the maximum projection height Rp_2 of the first surface 111 of the base material 11 are values obtained by measuring in accordance with JIS B0601-1994 using a surface roughness meter "SV3000S4" (probe type) made by Mitsutoyo Corporation in this specification. In this specification, the "arithmetic average roughness and maximum projection height" mean the values obtained by measuring as described above, unless otherwise noted.

[0036] Further, it is preferred for the base material 11 that an arithmetic average roughness Ra_3 of the second surface 112 is in the range of 10 to 200 nm and a maximum projection height Rp_3 thereof is in the range of 80 to 1000 nm. In particular, the arithmetic average roughness Ra_3 of the second surface 112 is preferably in the range of 15 to 100 nm and more preferably in the range of 20 to 50 nm.

Further, the maximum projection height Rp_3 of the second surface 112 is preferably in the range of 90 to 800 nm and more preferably in the range of 100 to 600 nm.

[0037] If the arithmetic average roughness Ra_3 and the maximum projection height Rp_3 of the second surface 112 fall within the above range, it is possible to reliably suppress a winding deviation from occurring when the release film 1 is wound in a roll shape. Moreover, when the release film 1 is wound in the roll shape and stored in a wound state, it is possible to prevent generation of blocking. Specifically, the release film 1 is wound around a paper-made, plastic-made or metal-made core member in the roll shape so that the release agent layer 13 faces to the inside of the rolled release film 1 and stored as necessary. At this time, if the arithmetic average roughness Ra_3 and the maximum projection height Rp_3 of the second surface 112 fall within the above range, when the release film 1 is wound in the roll shape, an air is removed well. This makes it possible to effectively suppress the winding deviation. For that reason, there is no need to increase a winding tension when the release film 1 is wound. It becomes therefore possible to suppress deformation of the core member caused by the winding tension. Further, if the arithmetic average roughness Ra_3 and the maximum projection height Rp_3 of the second surface 112 in the rolled release film 1 fall within the above range, it is possible to sufficiently prevent the generation of blocking between the release agent layer 13 and the second surface 112 of the base material 11 due to the contact therebetween. Therefore, it is easy to unwind the release film 1 in the roll shape.

[0038] In contrast, if the arithmetic average roughness Ra_3 of the second surface 112 is smaller than the lower limit value noted above, when the release film 1 is

wound in the roll shape, there is a fear that it becomes easy to generate the blocking between the front surface and the rear surface of the release film 1 (the second surface 112 of the base material 11 and the outer surface 131 of the release agent layer 13). Further, an average thickness of the base material 11 is not limited particularly, but preferably in the range of 10 to 300 μm and more preferably in the range of 15 to 200 μm . In this case, a resistance to tear or breaking can be made particularly superior while keeping proper the flexibility of the release film 1.

[0039] <Smoothed layer 12>

The smoothed layer 12 serves to reduce phenomena that the irregularity of the first surface 111 of the base material 11 affects the outer surface 131 of the release agent layer 13.

[0040] As shown in FIG. 1, the smoothed layer 12 is provided on the first surface 111 of the base material 11. The smoothed layer 12 is formed by coating the composition for forming smoothed layer onto the first surface 111 of the base material 11 to obtain the coated layer, and curing the coated layer via irradiating an active energy ray to the coated layer.

[0041] The composition for forming smoothed layer contains an active energy ray curable compound which is allowed to cure by irradiating the active energy ray.

[0042] In this regard, it is to be noted that the composition for forming smoothed layer before irradiating the active energy ray exists in an uncured state or a semi-cured state at room temperature.

[0043] Further, such a composition for forming

smoothed layer has suitable fluidity at the time of coating it onto the first surface 111 of the base material 11. Therefore, if the composition for forming smoothed layer is used, it is possible to easily fill the irregularity in the first surface 111 of the base material 11, thereby enabling the filled state to be maintained reliably. As a result, it is possible to prevent the irregularity of the base material 11 from affecting the side of the surface 121 (hereinafter referred to as a "third surface 121") of the smoothed layer 12 opposite to the base material 11, thereby enabling the third surface 121 of the smoothed layer 12 to be smoothed. Therefore, it is possible to more smooth the outer surface 131 of the release agent layer 13 which is formed on the third surface 121 of the smoothed layer 12.

[0044] Examples of the active energy ray curable compound include: an ultraviolet ray curable compound which is allowed to cure by irradiating the ultraviolet ray; an infrared ray curable compound which is allowed to cure by irradiating the infrared ray; a X-ray curable compound which is allowed to cure by irradiating the X-ray; an electron ray curable compound which is allowed to cure by irradiating the electron ray; a visible light ray curable compound which is allowed to cure by irradiating the visible light ray; and the like. Among them, the ultraviolet ray curable compound is preferable. The ultraviolet ray curable compound has suitable fluidity. Therefore, if the composition for forming smoothed layer is coated onto the first surface 111 of the base material 11, it is possible to form a smooth surface. Therefore, even if the smoothed layer 12 is formed relatively thinly, it is possible to reliably fill the irregularity in the first surface 111 of the base material 11. As a result, it is possible to more easily and reliably smooth the third surface 121 of the smoothed layer 12.

[0045] A compound having two or more polymerizable unsaturated group in a molecule thereof is used as the active energy ray curable compound which is allowed to cure by irradiating the active energy ray such as the ultraviolet ray, the electron ray and the like. Examples of the compound include: an urethane acrylate based compound; a multifunctional acrylate based compound; a polyester acrylate based compound; an epoxy acrylate based compound; a polyol acrylate based compound; and the like. Among them, the urethane acrylate based compound is preferable.

[0046] The urethane acrylate based compound is obtained by esterizing a polyurethane oligomer, which is obtained by reacting a polyisocyanate with a polyether polyol and a polyester polyol, with (meth)acrylic acid. Specifically, examples of the urethane acrylate based compound include: a phenyl glycidyl ether acrylate hexamethylene diisocyanate urethane pre-polymer; a pentaerythritol triacrylate hexamethylene diisocyanate urethane pre-polymer; a pentaerythritol triacrylate toluene diisocyanate urethane pre-polymer; a pentaerythritol triacrylate isophorone diisocyanate urethane pre-polymer; a dipentaerythritol pentaacrylate hexamethylene diisocyanate urethane pre-polymer; and the like.

[0047] Examples of the multifunctional acrylate based compound include 1,4-buthanediol di(meth)acrylate, 1,6-hexanediol di(meth)acrylate, neopenthylglycol di(meth)acrylate, polyethyleneglycol di(meth)acrylate, neopenthylglycol adipate di(meth)acrylate, dicyclopentanyl di(meth)acrylate, allylcyclohexyl di(meth)acrylate, isocyanurate di(meth)acrylate, trimethylolpropane tri(meth)acrylate, dipentaerythritol tri(meth)acrylate, pentaerythritol tri(meth)acrylate, tris(acryloxy ethyl)isocyanurate, dipentaerythritol hexa(meth)acrylate,

and the like.

[0048] The polyester acrylate based compound is obtained by esterizing hydroxyl groups of a polyester oligomer having the hydroxyl groups at both ends thereof, which is obtained by condensation between a polycarboxylic acid and a polyalcohol, with (meth)acrylic acid, or hydroxyl groups at ends of an oligomer, which is obtained by adding alkylene oxide to the polycarboxylic acid, with (meth)acrylic acid.

[0049] The epoxy acrylate based compound is obtained by reacting and esterizing (meth)acrylic acid with oxirane rings of a bisphenol type epoxy resin or a novolak type epoxy resin having a relatively low molecular weight.

[0050] The polyol acrylate based compound is obtained by esterizing hydroxyl groups of the polyether polyol with (meth)acrylic acid.

[0051] A mass average molecular weight of the active energy ray curable compound is preferably 950 or less and more preferably in the range of 300 to 700. This makes it possible to appropriately adjust a viscosity of the composition for forming smoothed layer from coating it onto the first surface 111 of the base material 11 to irradiating the active energy ray thereto. Therefore, the composition for forming smoothed layer has further suitable fluidity. If the smoothed layer 12 is formed at the side of the first surface 111 of the base material 11 by using the composition for forming smoothed layer, it is possible to reliably fill the irregularity in the first surface 111 of the base material 11. As a result, it is possible to reliably prevent the irregularity of the base material 11 from affecting the third surface 121 of the smoothed layer 12, thereby enabling the third surface 121 of the smoothed

layer 12 to be smoothed. Therefore, it is possible to particularly prevent the irregularity of the base material 11 from affecting the outer surface 131 of the release agent layer 13 which is formed on the smoothed layer 12, thereby enabling the outer surface 131 of the release agent layer 13 to be smoothed.

[0052] Particularly, even if a degree of the irregularity in the first surface 111 of the base material 11 is relatively large, it is possible to reliably fill the irregularity of the first surface 111 due to actions and effects by the composition for forming smoothed layer as described above. Therefore, it is possible to obtain the release film 1 having excellent smoothness in the outer surface 131 of the release agent layer 13.

[0053] In contrast, if the mass average molecular weight of the active energy ray curable compound is smaller than the lower limit value noted above, there is a case that the viscosity of the composition for forming smoothed layer is lowered, so that it takes a relatively long time to be allowed the smoothed layer 12 to cure. On the other hand, if the mass average molecular weight of the active energy ray curable compound exceeds the upper limit value noted above, since the viscosity of the composition for forming smoothed layer becomes relatively high depending on a kind of the active energy ray curable compound and the like, there is a case that it is required to add a viscosity modifier and the like to it.

[0054] Further, the composition for forming smoothed layer may contain a solvent, as necessary, in addition to the active energy ray curable compound. This makes it possible to easily adjust the viscosity of the composition for forming smoothed layer at the time of coating it onto the first surface 111 of the base material 11.

[0055] Examples of the solvent include: an organic solvent such as an aromatic hydrocarbon (such as toluene and xylene), a fatty acid ester (such as ethyl acetate and butyl acetate), a ketone (such as methylethylketone and methylisobuthylketone), and an alcohol (such as methanol, ethanol and isopropylalcohol); and the like. These materials may be used singly or in combination of two or more of them. This makes it possible to appropriately and easily adjust the viscosity of the composition for forming smoothed layer from coating it onto the first surface 111 of the base material 11 to irradiating the active energy ray thereto.

[0056] In this regard, the composition for forming smoothed layer may contain other components in addition to the components as described above. Examples of the other components include: a cross-linking agent; a photopolymerization initiator; a viscosity modifier; a catalyst; a dye; a dispersant; an antistatic agent; a curing agent; and the like. Further, in the case where the other components are contained, an amount of the other components in the composition for forming smoothed layer (solid content conversion) is preferably in the range of 0.1 to 10 mass%.

[0057] Further, an amount of the active energy ray curable compound in the composition for forming smoothed layer containing the solvent is not limited particularly, but preferably in the range of 0.5 to 60 mass% and more preferably in the range of 1 to 45 mass%. In this way, it becomes easy to set the composition for forming smoothed layer to a suitable viscosity.

[0058] Further, an amount of the active energy ray curable compound in the composition for forming smoothed

layer (solid content conversion) is not limited particularly, but preferably 90 mass% or more and more preferably 95 mass% or more. This makes it possible to obtain the composition for forming smoothed layer having excellent curing property.

[0059] Further, it is preferred that an arithmetic average roughness Ra_4 of the third surface 121 of the smoothed layer 12 is 8 nm or less and a maximum projection height Rp_4 thereof is 50 nm or less. In particular, the arithmetic average roughness Ra_4 of the third surface 121 is preferably 6 nm or less. Further, the maximum projection height Rp_4 of third surface 121 is preferably 40 nm or less.

[0060] If the arithmetic average roughness Ra_4 and the maximum projection height Rp_4 of the third surface 121 fall within the above range, it is possible to reliably prevent the irregularity of the first surface 111 of the base material 11 from affecting the outer surface 131 of the release agent layer 13.

[0061] In contrast, if the arithmetic average roughness Ra_4 of the third surface 121 is smaller than the lower limit value noted above, there is a possibility that adhesion between the smoothed layer 12 and the release agent layer 13 is lowered by depending on the constituent material of the smoothed layer 12. On the other hand, if the arithmetic average roughness Ra_4 of the third surface 121 exceeds the upper limit value noted above, there is a case that it is required to provide with a further new smoothed layer between the release agent layer 13 and the smoothed layer 12.

[0062] On the other hand, if the maximum projection height Rp_4 of the third surface 121 is smaller than the

lower limit value noted above, there is a case that it is required to subject the third surface 121 of the smoothed layer 12 to a treatment to improve the adhesion in order to improve the adhesion to the release agent layer 13. On the other hand, if the maximum projection height Rp_4 of the third surface 121 exceeds the upper limit value noted above, there is a case that it is required to provide with a further new smoothed layer between the release agent layer 13 and the smoothed layer 12.

[0063] An average thickness of the smoothed layer 12 is not limited particularly, but preferably in the range of 0.2 to 10 μm and more preferably in the range of 0.3 to 5 μm . This makes it possible to reliably fill the irregularity of the first surface 111 of the base material 11, so that it is possible to more improve the smoothness of the outer surface of the release film 1. In particular, since the composition for forming smoothed layer of the present embodiment is formed by containing the active energy ray curable compound as described above, even if the smoothed layer 12 has a relatively thin thickness, it is possible to further easily and reliably fill the irregularity of the first surface 111 of the base material 11. Further, it is possible to set the smoothed layer 12 to have suitable flexibility.

[0064] In contrast, if the average thickness of the smoothed layer 12 is smaller than the lower limit value noted above, there is a case that it is required to use the base material 11 having the first surface 111 of a relatively low roughness in order to sufficiently fill the irregularity of the first surface 111 of the base material 11, which depends on the components constituting the composition for forming smoothed layer. On the other hand, if the average thickness of the smoothed layer 12 exceeds the upper limit value noted above, there is a case that it

becomes easy to generate curls in the release film 1 due to cure shrinkage of the smoothed layer 12, thereby lowering handling property of the release film 1, which depend on the components constituting the composition for forming smoothed layer.

[0065] <Release Agent Layer 13>

The release agent layer 13 serves to apply the releasability to the release film 1.

[0066] The release agent layer 13 is provided at the side of the third surface 121 of the smoothed layer 12 as shown in FIG. 1.

[0067] The release agent layer 13 is a layer which is formed by coating a composition for forming release agent layer onto the third surface 121 of the smoothed layer 12, drying it and curing.

[0068] Such a composition for forming release agent layer contains a release agent.

Examples of the release agent include: an alkyd based compound; an acryl based compound; a silicone based compound; a long chain alkyl group-containing compound; a fluorine compound; and the like. These compounds may be used singly or in combination of two or more of them. Among them, it is preferable to use the alkyd based compound, the acryl based compound, the silicone based compound, and the long chain alkyl group-containing compound. This makes it possible to obtain the release agent layer 13 having excellent releasability to the green sheet while having suitable curing property.

[0069] Examples of the alkyd based compound include: a modified material such as a long chain alkyl-modified alkyd

compound and a silicone modified alkyd compound; and the like. Further, in the case where the alkyd based compound is used, a cross-linking agent or a catalyst is further added to the composition for forming release agent layer. By a method of curing a coated layer via heating the composition for forming release agent layer, it is possible to obtain the release agent layer 13 having the alkyd based compound with a cross-linked structure. As a result, it is possible to prevent the alkyd based compound having the releasability from transferring to the green sheet at the time of forming the green sheet on the release agent layer 13. Consequently, it is possible to prevent the releasability of the release agent layer 13 from being lowered.

[0070] Examples of the acryl based compound include: a modified material such as a long chain alkyl-modified acryl compound and a silicone modified acryl compound; and the like. Further, in the case where the composition for forming release agent layer contains the acryl based compound, the cross-linking agent or the catalyst is further added to the composition for forming release agent layer. By the method of curing the coated layer via heating the composition for forming release agent layer, it is possible to obtain the release agent layer 13 having the acryl based compound with the cross-linked structure. As a result, it is possible to prevent the acryl based compound having the releasability from transferring to the smoothed layer 12. Consequently, it is possible to prevent the releasability of the release agent layer 13 from being lowered.

[0071] Examples of the silicone based compound include: a silicone based compound having dimethyl polysiloxane as a basic skeleton; and the like. Examples of the silicone based compound include: an addition

reaction type silicone based compound; a condensation reaction type silicone based compound; an ultraviolet curing type silicone based compound; an electron-ray curing type silicone based compound; and the like. The addition reaction type silicone based compound has high reactivity and excellent productivity. The addition reaction type silicone based compound has merits that a change of peel force after its production is smaller than that of the condensation reaction type silicone based compound and there is no curing shrinkage as compared with it. Therefore, it is preferable to use the addition reaction type silicone based compound as the release agent constituting the release agent layer 13.

[0072] Examples of the addition reaction type silicone based compound include: organopolysiloxane in which ends and/or a side chain of the molecule thereof provide with two or more alkenyl groups having a carbon number of 2 to 10, such as a vinyl group, an allyl group, a propenyl group, a hexenyl group and the like. When such an addition reaction type silicone based compound is used, it is preferred that the cross-linking agent is used in conjunction with the catalyst.

[0073] Examples of the cross-linking agent include organopolysiloxane having hydrogen atoms which are bonded with at least two silicon atoms in one molecule. Specifically, examples of the cross-linking agent include: a dimethylhydrogensiloxy group end-capped dimethylsiloxane-methylhydrogensiloxane copolymer; a trimethylsiloxy group end-capped dimethylsiloxane-methylhydrogensiloxane copolymer; trimethylsiloxy group end-capped methylhydrogenpolysiloxane; poly(hydrogensilsesquioxane); and the like.

[0074] Further, examples of the catalyst include: a

platinum based compound such as fine particulate platinum, fine particulate platinum adsorbed on a carbon powder carrier, chloroplatinic acid, alcohol denaturation chloroplatinic acid, an olefin complex of chloroplatinic acid, palladium, rhodium and the like. The use of such a catalyst makes it possible to more efficiently carry out the curing reaction of the composition for forming release agent layer.

[0075] Further, examples of the long chain alkyl group-containing compound include: polyvinylcarbamate which is obtained by reacting a long-chain alkyl isocyanate having a carbon number of 8 to 30 with a polyvinylalcohol based polymer; an alkylurea derivative which is obtained by reacting the long-chain alkyl isocyanate having the carbon number of 8 to 30 with polyethyleneimine; and the like.

[0076] Further, examples of the fluorine compound include: a fluorine silicone compound; a fluorine boron compound; and the like.

[0077] Further, the composition for forming release agent layer may contain a dispersion medium and a solvent other than the release agent described above. By containing at least one of the dispersion medium and the solvent, it is possible to appropriately set the viscosity of the composition for forming release agent layer from coating it onto the third surface 121 of the smoothed layer 12 to drying it.

[0078] Examples of the dispersion medium and the solvent include: an organic solvent such as an aromatic hydrocarbon such as toluene, a fatty acid ester such as ethyl acetate, a ketone such as methylethylketone, and an aliphatic hydrocarbon such as hexane and heptane; and the like. These compounds may be used singly or in combination

of two or more of them.

[0079] In this regard, it is to be noted that the composition for forming release agent layer may contain other components in addition to the components as described above. Examples of the other components include: a catalyst; a dye; a dispersant; an antistatic agent; a curing agent; and the like. Further, in the case where the other components are contained, an amount of the other components in the composition for forming release agent layer is preferably in the range of 0.1 to 10 mass%.

[0080] Further, an amount of the release agent in the composition for forming release agent layer is not limited particularly, but preferably in the range of 0.3 to 10 mass%.

[0081] As described above, the arithmetic average roughness Ra_1 of the outer surface 131 of the release agent layer 13 is 8 nm or less and the maximum projection height Rp_1 thereof is 50 nm or less. In particular, the arithmetic average roughness Ra_1 of the outer surface 131 of the release agent layer 13 is preferably 6 nm or less. Further, the maximum projection height Rp_1 of the outer surface 131 of the release agent layer 13 is preferably 40 nm or less.

[0082] If the arithmetic average roughness Ra_1 and the maximum projection height Rp_1 of the outer surface 131 of the release agent layer 13 fall within the above range, it is possible to reliably prevent the pinhole and the like from generating in the surface of the green sheet due to phenomena that a surface shape of the outer surface 131 having relatively high smoothness is transferred to the green sheet when the green sheet is formed. As a result, it is possible to obtain the green sheet of which surface

is high smoothness.

[0083] An average thickness of the release agent layer 13 is preferably in the range of 0.01 to 3 μm and more preferably in the range of 0.03 to 1 μm . If the thickness of the release agent layer 13 is smaller than 0.01 μm , there is a case that the function as the release agent layer is not exerted sufficiently depending on the material constituting the release agent layer 13. On the other hand, if the thickness of the release agent layer 13 exceeds 3 μm , since the blocking is easily generated when the release film 1 is wound in the roll shape, there is a case that a trouble is generated in winding the release film 1 or an electric charge amount is increased when unwinding the release film 1.

[0084] <<Method of Producing Release Film for Producing Green Sheet>>

Next, description will be made on one preferred embodiment of a method of producing the release film 1 for producing the green sheet as described above.

[0085] The method of producing the release film 1 of the present embodiment includes a base material preparing step for preparing the base material 11, a coated layer forming step for forming the coated layer by coating the composition for forming smoothed layer containing the predetermined active energy ray curable compound onto the first surface 111 of the base material 11 and drying it as necessary, a smoothed layer forming step for forming the smoothed layer 12 by curing the coated layer via irradiating the active energy ray to the coated layer, and a release agent layer forming step for forming the release agent layer 13 at the side of the surface 121 of the smoothed layer 12 opposite to the base material 11.

[0086] The respective steps will now be described in detail.

<Base Material Preparing Step>

First, the base material 11 is prepared.

The base material 11 constituted as described above is used as the base material 11.

[0087] The first surface 111 of the base material 11 can be subjected to a surface treatment using an oxidation method or a primer treatment. This makes it possible to keep the superior adhesion between the base material 11 and the smoothed layer 12 formed at the side of the first surface 111 of the base material 11.

[0088] The surface treatment using the oxidation method can be arbitrary selected depending on a kind of the base material 11. Examples of the surface treatment include: a corona discharge treatment; a plasma discharge treatment; a chromium oxidation treatment (wet-type); a flame treatment; a hot air treatment; an ozone treatment; an ultraviolet irradiation treatment; and the like. Among them, the corona discharge treatment is particularly preferable from the aspect of the excellent adhesion with the smoothed layer 12 and the simple operability for the surface treatment.

[0089] <Coated Layer Forming Step>

First, in this step, prepared is the composition for forming smoothed layer.

[0090] The active energy ray curable compound as described above may be used for the composition for forming

smoothed layer by itself. In addition to that, the solvent and the other components as described above may be contained in the composition for forming smoothed layer as necessary.

[0091] Next, the composition for forming smoothed layer in the form of a liquid is coated onto the first surface 111 of the base material 11. Thus, the coated layer is obtained. As described above, the composition for forming smoothed layer has the suitable fluidity. Therefore, by coating the composition for forming smoothed layer onto the first surface 111 of the base material 11, it is possible to reliably fill the irregularity of the first surface 111 of the base material 11. Consequently, it is possible to prevent the irregularity of the base material 11 from affecting the third surface 121 of the smoothed layer 12, so that it is possible to smooth the third surface 121 of the smoothed layer 12.

[0092] In the case where the composition for forming smoothed layer contains the solvent, the coated layer is obtained by drying the composition for forming smoothed layer after the composition for forming smoothed layer is coated onto the first surface 111 of the base material 11. Thus, the solvent can be removed by drying the composition for forming smoothed layer.

[0093] Examples of the method of coating the composition for forming smoothed layer include: a gravure coating method; a bar coating method; a spray coating method; a spin coating method; an air-knife coating method; a roll coating method; a blade coating method; a gate roll coating method; a die coating method; and the like. Among them, the gravure coating method and the bar coating method are preferable and the bar coating method is more preferable. This makes it possible to easily form the

coated layer having an aimed thickness.

[0094] Further, in the case where the composition for forming smoothed layer contains the solvent and the like, examples of the method of drying a material for forming smoothed layer include, but not limited particularly, a method of drying with a hot air drying furnace and the like.

[0095] In the case where the composition for forming smoothed layer is dried, a drying condition is not limited particularly. A drying temperature is preferably in the range of 50 to 100°C. A drying time is preferably in the range of 5 seconds to 1 minute. This makes it possible to efficiently form the smoothed layer 12 particularly while preventing the smoothed layer 12 from being altered involuntarily. Consequently, it is possible to improve the productivity of the finally obtained release film 1. Further, if the drying temperature falls within the above range, in the case where the composition for forming release agent layer contains the solvent and the like, it is possible to reliably prevent warpage and cracks in conjunction with the evaporation of the solvent at the time of drying from occurring to the smoothed layer 12.

[0096] <Smoothed Layer Forming Step>

Next, the smoothed layer 12 is formed by curing the coated layer via irradiating the active energy ray to the coated layer obtained in the coated layer forming step.

[0097] In this step, the coated layer which fills the irregularity of the first surface 111 of the base material 11 reliably in the coated layer forming step is allowed to cure with keeping the smoothness of the outer surface thereof. As a result, it is possible to obtain the

smoothed layer 12 of which third surface 121 is sufficiently smooth. This makes it possible to prevent the irregularity of the first surface 111 of the base material 11 from affecting the outer surface 131 of the release agent layer 13. Therefore, it is possible to obtain the outer surface 131 of the release agent layer 13 having the excellent smoothness in the release agent layer forming step described later.

[0098] The active energy ray used for curing is appropriately selected, depending on the material contained in the composition for forming smoothed layer to be used. Examples of the active energy ray include: visible light; ultraviolet ray; infrared light; X-ray; α -ray; β -ray; γ -ray; electron ray; and the like. Among them, the ultraviolet ray and the visible light are preferred.

[0099] A wavelength of the active energy ray (the ultraviolet ray or the visible light) is not limited particularly, but preferably in the range of 200 to 600 nm and more preferably in the range of 250 to 450 nm. If the wavelength of the active energy ray falls within the above range, it is possible to be allowed the coated layer to cure uniformly while shortening the time to be allowed the coated layer to cure sufficiently.

[0100] Means of irradiating the active energy ray (the ultraviolet ray or the visible light) are not limited particularly, but may be various kinds of general means. Examples of a light source to be used include a light source lamp such as a high-pressure mercury lamp, a metal halide lamp, an excimer lamp and the like.

[0101] Further, in the case where the active energy ray (the ultraviolet ray or the visible light) is irradiated, an irradiance of the active energy ray is

preferably in the range of 50 to 400 mJ/cm² and more preferably in the range of 100 to 300 mJ/cm². If the irradiance of the active energy ray falls within the above range, it is possible to be allowed the coated layer to cure more uniformly and reliably.

[0102] Further, a time to irradiate the active energy ray is not limited particularly, but preferably in the range of 5 seconds to 1 minute. This makes it possible more efficiently form the smoothed layer 12. As a result, it is possible to improve the productivity of the finally obtained release film 1.

[0103] <Release Agent Layer Forming Step>

Next, the release agent layer 13 is formed at the side of the surface 121 of the smoothed layer 12 opposite to the base material 11.

[0104] A composition in which materials as described above are mixed is prepared as the composition for forming release agent layer constituting the release agent layer 13.

[0105] Next, the composition for forming release agent layer in the form of a liquid is coated onto the surface 121 of the smoothed layer 12 opposite to the base material 11 to dry it and cure. Thus, the release agent layer 13 is obtained.

[0106] Examples of the drying method include, but not limited particularly, a method of drying with the hot air drying furnace and the like.

[0107] A drying condition is not limited particularly. A drying temperature is preferably in the range of 80 to

150°C. A drying time is preferably in the range of 5 seconds to 1 minute. This makes it possible to efficiently form the release agent layer 13 particularly while preventing the release agent layer 13 from being altered involuntarily. Consequently, it is possible to improve the productivity of the finally obtained release film 1.

[0108] According to the steps as described above, it is possible to easily and reliably produce the release film 1 having the high reliability, which is superior in the smoothness and the releasability.

[0109] Further, if the green sheet is produced using such a release film 1, it is possible to prevent the pinhole and the like from generating in the surface of the green sheet.

[0110] Examples of a method of producing a ceramic green sheet using the release film 1 include a method of coating a ceramic powder dispersion slurry onto the surface of the release agent layer of the release film and drying it to form the green sheet, thereafter laminating the green sheet released from the release film to obtain a laminated body, and then forming electrodes on a ceramic sheet obtained by sintering the laminated body. Thus, the ceramic capacitor is obtained. In this way, by forming the ceramic capacitor with the green sheet formed by using the release film 1, it is possible to obtain the ceramic capacitor having high reliability, which prevents a defect from being generated by short circuit.

[0111] While the present invention has been described in detail based on the preferred embodiment, the present invention is not limited to the aforementioned embodiment.

[0112] For example, in the aforementioned embodiment,

the base material has been described as having the single layer structure. However, the present invention is not limited thereto. For instance, the base material may also have a multiple layer structure having two or more layers which may belong to the same kind or the different kinds. Further, the smoothed layer and the release agent layer have been also described as having the single layer structure. However, the present invention is not limited thereto. The smoothed layer and the release agent layer may also have the multiple layer structure having two or more layers which may belong to the same kind or the different kinds as well.

[0113] Further, for example, in the aforementioned embodiment, described has been the release film for producing the green sheet in which the smoothed layer is provided on the first surface of the base material. However, the release film for producing the green sheet is not limited thereto, but may provide with the smoothed layer or the release agent layer at the side of the second surface of the base material.

[0114] Furthermore, for example, in the aforementioned embodiment, the release film for producing the green sheet has been described as having the three layer structure in which the base material, the smoothed layer and the release agent layer are laminated in this order to bond together. However, the present invention is not limited thereto. For instance, an intermediate layer may be provided between the smoothed layer and the release agent layer. Further, an intermediate layer may be provided between the base material and the smoothed layer. Such an intermediate layer may be a layer to improve the adhesion between the smoothed layer and the release agent layer or a layer to suppress electrification from generating when winding the release film for producing the green sheet not yet provided

with the green sheet.

[0115] The method of producing the release film for producing the green sheet according to the present invention is not limited to the aforementioned method. As necessary, an arbitrary step may be added.

Examples

[0116] Next, description will be made on specific examples of the release film for producing the green sheet according to the present invention. However, the present invention is not limited to only these examples.

[0117] [1] Production of Release Film for Producing Green Sheet

(Example 1)

First, a biaxially-stretched polyethyleneterephthalate film [having a thickness of 38 μm , an arithmetic average roughness Ra_2 of a first surface of 42 nm, a maximum projection height Rp_2 of the first surface of 619 nm, an arithmetic average roughness Ra_3 of a second surface of 42 nm, and a maximum projection height Rp_3 of the second surface of 619 nm] was prepared as a base material.

[0118] Next, 100 mass parts of an ultraviolet ray curable compound [produced by ARAKAWA CHEMICAL INDUSTRIES, Ltd., sold under a trade name "BEAMSET 575CB", having a solid content of 100 mass% and a mass average molecular weight of 470, and containing photopolymerization initiator] which includes an urethane acrylate oligomer as the active energy ray curable compound as a main component thereof, toluene and methylethyl ketone were mixed to obtain a composition for forming smoothed layer having a

solid content of 20 mass%.

[0119] The composition for forming smoothed layer thus obtained was coated on the first surface of the base material with a mayer bar #4 and dried at 80°C for 1 minute to obtain a coated layer.

[0120] Next, the ultraviolet ray (wavelength: 365 nm and irradiance: 200 mJ/cm²) was irradiated to the coated layer with an ultraviolet irradiator to form a smoothed layer (a thickness of 1.3 μm).

[0121] Further, 100 mass parts of a mixture [produced by Shin-Etsu Chemical Co., Ltd., sold under a trade name "Silicone KS-847H" and having a solid content of 30 mass%] of an addition reaction type silicone based compound as a release agent and a cross-linking agent was diluted by toluene to obtain a diluted solution. 2 mass parts of a platinum catalyst [produced by Shin-Etsu Chemical Co., Ltd. and sold under a trade name "PL-50T"] was added into the diluted solution. By mixing it, a composition for forming release agent layer having a solid content of 1.5 mass% was obtained. The composition for forming release agent layer was uniformly coated onto a surface of the smoothed layer opposite to the base material so that a thickness of the composition for forming release agent layer after drying was 0.1 μm. Thereafter, the composition for forming release agent layer was dried at 130°C for 1 minute to form a release agent layer. Thus, a release film for producing a green sheet was produced.

[0122] (Example 2)

A release film for producing a green sheet was produced in the same manner as in Example 1 except that the biaxially-stretched polyethyleneterephthalate film of

Example 1 was changed to a biaxially-stretched polyethyleneterephthalate film [having a thickness of 31 μm , an arithmetic average roughness Ra_2 of a first surface of 29 nm, a maximum projection height Rp_2 of the first surface of 257 nm, an arithmetic average roughness Ra_3 of a second surface of 29 nm, and a maximum projection height Rp_3 of the second surface of 257 nm].

[0123] (Example 3)

A release film for producing a green sheet was produced in the same manner as in Example 1 except that the biaxially-stretched polyethyleneterephthalate film of Example 1 was changed to a biaxially-stretched polyethyleneterephthalate film [having a thickness of 31 μm , an arithmetic average roughness Ra_2 of a first surface of 15 nm, a maximum projection height Rp_2 of the first surface of 98 nm, an arithmetic average roughness Ra_3 of a second surface of 15 nm, and a maximum projection height Rp_3 of the second surface of 98 nm] and the thickness of the smoothed layer was changed to 0.4 μm .

[0124] (Example 4)

A release film for producing a green sheet was produced in the same manner as in Example 1 except that the thickness of the smoothed layer of Example 1 was changed to 1.8 μm .

[0125] (Example 5)

A release film for producing a green sheet was produced in the same manner as in Example 1 except that the thickness of the smoothed layer of Example 1 was changed to 2.3 μm .

[0126] (Comparative Example 1)

First, a biaxially-stretched polyethyleneterephthalate film [having a thickness of 38 μm , an arithmetic average roughness Ra_2 of a first surface of 42 nm, a maximum projection height Rp_2 of the first surface of 619 nm, an arithmetic average roughness Ra_3 of a second surface of 42 nm, and a maximum projection height Rp_3 of the second surface of 619 nm] was prepared as a base material.

[0127] Next, 100 mass parts of a mixture [produced by Shin-Etsu Chemical Co., Ltd., sold under a trade name "Silicone KS-847H" and having a solid content of 30 mass%] of an addition reaction type silicone based compound as a release agent and a cross-linking agent was diluted by toluene to obtain a diluted solution. 2 mass parts of a platinum catalyst [produced by Shin-Etsu Chemical Co., Ltd. and sold under a trade name "PL-50T"] was added into the diluted solution. By mixing it, a composition for forming release agent layer having a solid content of 1.5 mass% was obtained. The composition for forming release agent layer was uniformly coated onto the first surface of the base material so that a thickness of the composition for forming release agent layer after drying was 0.1 μm . Thereafter, the composition for forming release agent layer was dried at 130°C for 1 minute to form a release agent layer. Thus, a release film for producing a green sheet was produced.

[0128] (Comparative Example 2)

First, a biaxially-stretched polyethyleneterephthalate film [having a thickness of 38 μm , an arithmetic average roughness Ra_2 of a first surface of 42 nm, a maximum projection height Rp_2 of the first surface of 619 nm, an arithmetic average roughness Ra_3 of a

second surface of 42 nm, and a maximum projection height Rp_3 of the second surface of 619 nm] was prepared as a base material.

[0129] Next, 100 mass parts of a mixture [produced by Hitachi Kasei Polymer Co., Ltd., sold under a trade name "Tesfine 303", and having a solid content of 20 mass% and a mass average molecular weight of 15000] of a stearyl modified alkyd compound and a methylated melamine compound as a thermosetting compound was mixed with 3 mass parts of p-toluenesulfonic acid of an acid catalyst, toluene and methylethylketone to obtain a composition for forming smoothed layer having a solid content of 20 mass%. The obtained composition for forming smoothed layer was coated onto the first surface of the base material with a mayer bar #4 to obtain a coated layer.

[0130] Next, the coated layer was dried and heated at 140°C for 1 minute to form a smoothed layer (a thickness of 1.0 μm).

[0131] Further, 100 mass parts of a mixture [produced by Shin-Etsu Chemical Co., Ltd., sold under a trade name "Silicone KS-847H" and having a solid content of 30 mass%] of an addition reaction type silicone based compound as a release agent and a cross-linking agent was diluted by toluene to obtain a diluted solution. 2 mass parts of a platinum catalyst [produced by Shin-Etsu Chemical Co., Ltd. and sold under a trade name "PL-50T"] was added into the diluted solution. By mixing it, a composition for forming release agent layer having a solid content of 1.5 mass% was obtained. The composition for forming release agent layer was uniformly coated onto a surface of the smoothed layer opposite to the base material so that a thickness of the composition for forming release agent layer after drying was 0.1 μm . Thereafter, the composition for forming

release agent layer was dried at 130°C for 1 minute to form a release agent layer. Thus, a release film for producing a green sheet was produced.

[0132] (Comparative Example 3)

A release film for producing a green sheet was produced in the same manner as in Example 1, except that the composition for forming smoothed layer having the solid content of 20 mass% was obtained by mixing 40 mass parts of a cation polymerizable ultraviolet ray curable compound [produced by ARAKAWA CHEMICAL INDUSTRIES, Ltd., sold under a trade name "UV POLY200", and having a solid content of 100 mass% and a mass average molecular weight of 20000] which includes an epoxy modified silicone compound as the active energy ray curable compound as a main component thereof, 3 mass parts of a boron based cation curable UV catalyst [produced by ARAKAWA CHEMICAL INDUSTRIES, Ltd., sold under a trade name "UV CAT A211", and having a solid content of 20 mass%] as a catalyst, toluene and methylethyl ketone.

[0133] (Comparative Example 4)

First, a biaxially-stretched polyethyleneterephthalate film [having a thickness of 38 μm , an arithmetic average roughness Ra_2 of a first surface of 42 nm, a maximum projection height Rp_2 of the first surface of 619 nm, an arithmetic average roughness Ra_3 of a second surface of 42 nm, and a maximum projection height Rp_3 of the second surface of 619 nm] was prepared as a base material.

[0134] Next, 80 mass parts of a polyester compound [produced by TOYOBO Co., Ltd., sold under a trade name "Byron 20SS", and having a solid content of 30 mass% and a

mass average molecular weight of 3000] as a thermosetting compound, 20 mass parts of methylated melamine as a cross-linking agent, 3 mass parts of p-toluenesulfonic acid of an acid catalyst, toluene and methylethyl ketone were mixed to obtain a composition for forming smoothed layer having a solid content of 20 mass%.

[0135] The obtained composition for forming smoothed layer was coated onto the first surface of the base material with a mayer bar #4 to obtain a coated layer.

[0136] Next, the coated layer was dried and heated at 130°C for 1 minute to form a smoothed layer (a thickness of 1.2 μm).

[0137] Further, 100 mass parts of a mixture [produced by Shin-Etsu Chemical Co., Ltd., sold under a trade name "Silicone KS-847H" and having a solid content of 30 mass%] of an addition reaction type silicone based compound as a release agent and a cross-linking agent was diluted by toluene to obtain a diluted solution. 2 mass parts of a platinum catalyst [produced by Shin-Etsu Chemical Co., Ltd. and sold under a trade name "PL-50T"] was added into the diluted solution. By mixing it, a composition for forming release agent layer having a solid content of 1.5 mass% was obtained. The composition for forming release agent layer was uniformly coated onto a surface of the smoothed layer opposite to the base material so that a thickness of the composition for forming release agent layer after drying was 0.1 μm . Thereafter, the composition for forming release agent layer was dried at 130°C for 1 minute to form a release agent layer. Thus, a release film for producing a green sheet was produced.

[0138] (Comparative Example 5)

A release film for producing a green sheet was produced in the same manner as in Example 1, except that the composition for forming smoothed layer having the solid content of 20 mass% was obtained by diluting an ultraviolet ray curable compound [produced by TAISEI FINE CHEMICAL CO., Ltd., sold under a trade name "8KX-012C", and having a solid content of 40 mass% and a mass average molecular weight of 25000] which includes an acrylate oligomer as the active energy ray curable compound as a main component thereof with toluene.

[0139] The compositions and the like of the release film for producing the green sheet of each of Examples and Comparative Examples were shown in Table 1.

[0140] In Table 1, the ultraviolet ray curable compound [produced by ARAKAWA CHEMICAL INDUSTRIES, Ltd., sold under the trade name "BEAMSET 575CB", and having the solid content of 100 mass% and the mass average molecular weight of 470] which includes the urethane acrylate oligomer as the active energy ray curable compound as the main component thereof was represented as "A1", the mixture [produced by Hitachi Kasei Polymer Co., Ltd., sold under the trade name "Tesfine 303" and having the solid content of 20 mass% and the mass average molecular weight of 15000] of the stearyl modified alkyd compound and the methylated melamine compound as the thermosetting compound was represented as "A2", the cation polymerizable ultraviolet ray curable compound [produced by ARAKAWA CHEMICAL INDUSTRIES, Ltd., sold under the trade name "UV POLY200", and having the solid content of 100 mass% and the mass average molecular weight of 20000] which includes the epoxy modified silicone compound as the active energy ray curable compound as the main component thereof was represented as "A3", the polyester compound [produced by TOYOCO Co., Ltd., sold under the trade name "Byron 20SS" and having the solid

content of 30 mass% and the mass average molecular weight of 3000] as the thermosetting compound was represented as "A4" and the ultraviolet ray curable compound [produced by TAISEI FINE CHEMICAL CO., Ltd., sold under the trade name "8KX-012C", and having the solid content of 40 mass% and the mass average molecular weight of 25000] which includes the acrylate oligomer as the active energy ray curable compound as the main component thereof was represented as "A5".

[0141] The thicknesses of the base materials, the smoothed layers and the release agent layers of the respective Examples and the respective Comparative Examples were measured with a reflection-type film thickness meter "F20" made by Filmetrics Co, Ltd.

[0142] The arithmetic average roughness Ra_2 and the maximum projection height Rp_2 of the first surface of the base material, the arithmetic average roughness Ra_3 and the maximum projection height Rp_3 of the second surface of the base material, the arithmetic average roughness Ra_4 and the maximum projection height Rp_4 of the third surface of the smoothed layer, and the arithmetic average roughness Ra_1 and the maximum projection height Rp_1 of the outer surface of the release agent layer were measured in the following manner. First, a double-side tape was attached to a glass plate. Then, each of the release films for producing the green sheets obtained in the respective Examples and the respective Comparative Examples was fixed to the double-side tape such that the surface opposite to the surface to measure the arithmetic average roughness and the maximum projection height was positioned at a side of the glass plate. Subsequently, the arithmetic average roughnesses Ra_2 , Ra_3 , Ra_4 and Ra_1 and the maximum projection heights Rp_2 , Rp_3 , Rp_4 and Rp_1 were measured in accordance with JIS B0601-1994 using a surface roughness meter "SV3000S4"

(probe type) made by Mitsutoyo Corporation.

[0143] Table 1

Table.1

	Base material						Smoothed layer						Release agent layer					
	Surface roughness of first surface			Surface roughness of second surface			Thickness	Composition for forming smoothed layer			Surface roughness of third surface			Surface roughness of outer surface		Thickness		
	Arithmetic average roughness Ra2	Maximum projection height Rp2	[nm]	Arithmetic average roughness Ra3	Maximum projection height Rp3	[μ m]		Kind	Molecular weight	Arithmetic average roughness Ra4	Maximum projection height Rp4	[nm]	[μ m]	Arithmetic average roughness Ra1	Maximum projection height Rp1		[nm]	[μ m]
Example.1	42	619	42	619	619	38	A1	470	7	38	7	38	1.3	7	36	0.1		
Example.2	29	257	29	257	257	31	A1	470	5	38	5	38	1.3	5	37	0.1		
Example.3	15	98	15	98	98	31	A1	470	5	40	5	40	0.4	5	38	0.1		
Example.4	42	619	42	619	619	38	A1	470	7	38	7	38	1.8	7	38	0.1		
Example.5	42	619	42	619	619	38	A1	470	7	38	7	38	2.3	7	35	0.1		
Comparative Example. 1	42	619	42	619	619	38	—	—	—	—	—	—	—	41	615	0.1		
Comparative Example. 2	42	619	42	619	619	38	A2	15000	29	280	29	280	1	29	278	0.1		
Comparative Example. 3	42	619	42	619	619	38	A3	20000	26	277	26	277	1.3	26	278	0.1		
Comparative Example. 4	42	619	42	619	619	38	A4	3000	36	384	36	384	1.2	36	382	0.1		
Comparative Example. 5	42	619	42	619	619	38	A5	25000	37	590	37	590	1.3	37	588	0.1		

[0144] [2] Evaluation

The following evaluations were conducted with respect to the release films for producing the green sheets thus obtained.

[0145] [2.1] Evaluation of Blocking Property

Each of the release films for producing the green sheets obtained in the respective Examples and the respective Comparative Examples was wound in a roll shape with a width of 400 mm and a length of 5000 m to obtain a release film roll. The release film roll was stored for 30 days under the environments of a temperature of 40°C and humidity of 50% or less. Thereafter, the outward appearance of the release film roll was visually observed. The blocking property thereof was evaluated under the following evaluation criteria.

[0146] A: The outward appearance of the release film roll after storing was not changed as compared with the outward appearance of the release film roll before storing and obtained by winding the release film for producing the green sheet in the roll shape (Blocking was not generated).

B: In the roll of the release film for producing the green sheet, there was a region where the hue was partially different (The release film roll tended to suffer from blocking but was still usable).

C: The hue was different over a wide region of the roll of the release film for producing the green sheet (Blocking was generated).

In case where, like the evaluation criterion C supra,

the blocking is generated due to the close contact of a front surface and a rear surface of the release film for producing the green sheet and the hue is changed over the wide region of the release film roll, it is sometimes impossible to normally unwind the release film for producing the green sheet.

[0147] [2.2] Evaluation of the Number of Depressed Parts

A coating liquid obtained by dissolving a polyvinyl butyral resin in a mixed solvent of toluene and ethanol (having a mass ratio of 6/4) was coated onto the release agent layer (the outer surface of the release agent layer) of each of the release films for producing the green sheets obtained in the respective Examples and the respective Comparative Examples, such that, when dried, a polyvinyl butyral resin layer had a thickness of 3 μm . Thus, a coated layer was obtained. The polyvinyl butyral resin layer was formed by drying the coated layer at 80°C for one minute. Subsequently, a polyester tape was attached to a surface of the polyvinyl butyral resin layer. Then, the release film for producing the green sheet was released from the polyvinyl butyral resin layer, and the polyvinyl butyral resin layer was transferred to the polyester tape. Thereafter, the surface of the polyvinyl butyral resin layer which was previously in contact with the release agent layer of the release film for producing the green sheet was observed using an optical interference type surface profiler [made by Veeco Instruments Inc. and sold under a trade name "WYKO-1100"]. The observation was conducted in a PSI mode and at a magnification of 50. The depressed parts, which exist in a region of 91.2 μm $\times$ 119.8 μm of the surface of the polyvinyl butyral resin layer, were counted. The depressed parts had a depth of 150 nm or greater and the shape of the release agent layer

transferred thereto. The number of the depressed parts was evaluated under the following evaluation criteria. In the case where a capacitor was manufactured using the polyvinyl butyral resin layer (the green sheet) evaluated to be the criterion C infra, there was a tendency that short was easily generated due to decrease in breakdown voltage.

[0148] A: The number of the depressed parts was zero.
 B: The number of the depressed parts was 1 to 5.
 C: The number of the depressed parts was 6 or more.
 These results are shown in Table 2.

[0149] Table 2

Table.2		
	Evaluation of blocking property	Evaluation of the number of depressed parts
Example.1	A	A
Example.2	A	A
Example.3	B	A
Example.4	A	A
Example.5	A	A
Comparative Example. 1	A	C
Comparative Example. 2	A	B
Comparative Example. 3	A	B
Comparative Example. 4	A	C
Comparative Example. 5	A	C

[0150] As is apparent in Table 2, the release film for producing the green sheet according to the present invention was superior in the smoothness of the outer surface thereof. Further, coarse depressed parts hardly were formed in the green sheet produced by using the release film for producing the green sheet according to the present invention. Furthermore, no defect was generated by short circuit in the ceramic capacitor produced by the

green sheet which was formed by using the release film for producing the green sheet according to the present invention. In contrast, satisfactory results were not obtained in the Comparative Examples.

INDUSTRIAL APPLICABILITY

[0151] The release film for producing the green sheet of the present invention includes the base material having the first surface and the second surface, the smoothed layer provided on the first surface of the base material, and the release agent layer provided at the side of the surface of the smoothed layer opposite to the base material. The smoothed layer is formed by curing the coated layer via irradiating the active energy ray to the composition for forming smoothed layer containing the active energy ray curable compound. The arithmetic average roughness Ra_1 of the outer surface of the release agent layer is 8 nm or less and the maximum projection height Rp_1 of the outer surface of the release agent layer is 50 nm or less. According to the present invention, it is possible to provide the release film for producing the green sheet which is capable of producing the green sheet having the high reliability and preventing the pinhole in the surface of the green sheet from generating. Accordingly, the present invention is industrially applicable.

EXPLANATION OF REFERENCE NUMERAL

[0152] 1: release film for producing green sheet
11: base material
111: first surface of base material
112: second surface of base material
12: smoothed layer
121: surface (third surface)
13: release agent layer
131: outer surface of release agent layer

WHAT IS CLAIMED IS:

1. A release film for producing a green sheet, comprising:

a base material having a first surface and a second surface;

a smoothed layer provided on the first surface of the base material; and

a release agent layer provided at a side of a surface of the smoothed layer opposite to the base material,

wherein the smoothed layer is formed by curing a coated layer via irradiating an active energy ray to a composition for forming smoothed layer, and the composition contains an active energy ray curable compound,

wherein an arithmetic average roughness Ra_1 of an outer surface of the release agent layer is 8 nm or less and a maximum projection height Rp_1 of the outer surface of the release agent layer is 50 nm or less.

2. The release film for producing the green sheet as claimed in claim 1, wherein an arithmetic average roughness Ra_2 of the first surface is in the range of 10 to 200 nm and a maximum projection height Rp_2 of the first surface is in the range of 80 to 1000 nm.

3. The release film for producing the green sheet as claimed in claim 1 or 2, wherein the active energy ray curable compound is a compound having a mass average molecular weight of 950 or less.

4. The release film for producing the green sheet as claimed in any one of claims 1 to 3, wherein the active energy ray curable compound is an ultraviolet ray curable compound and the active energy ray is an ultraviolet ray.

5. The release film for producing the green sheet as

claimed in any one of claims 1 to 4, wherein an average thickness of the smoothed layer is in the range of 0.2 to 10 μm .

6. The release film for producing the green sheet as claimed in any one of claims 1 to 5, wherein the smoothed layer has the surface opposite to the base material,

wherein an arithmetic average roughness Ra_4 of the surface of the smoothed layer opposite to the base material is 8 nm or less and a maximum projection height Rp_4 of the surface of the smoothed layer opposite to the base material is 50 nm or less.

7. The release film for producing the green sheet as claimed in any one of claims 1 to 6, wherein an arithmetic average roughness Ra_3 of the second surface is in the range of 10 to 200 nm and a maximum projection height Rp_3 of the second surface is in the range of 80 to 1000 nm.

8. A method of producing the release film for producing the green sheet as claimed in any one of claims 1 to 7, comprising:

a base material preparing step for preparing the base material having the first surface and the second surface;

a coated layer forming step for forming a coated layer by coating the composition for forming smoothed layer containing the active energy ray curable compound at the side of the first surface of the base material;

a smoothed layer forming step for forming the smoothed layer by curing the coated layer via irradiating the active energy ray to the coated layer; and

a release agent forming step for forming the release agent layer at the side of the surface of the smoothed layer opposite to the base material;

wherein the arithmetic average roughness Ra_1 of the outer surface of the release agent layer is 8 nm or less

and the maximum projection height Rp_1 of the outer surface of the release agent layer is 50 nm or less.