12.

**[0052]** Examples of the polyorganosiloxane (B) include a polyorganosiloxane having a straight or branched molecular chain. Particularly, it is preferred that silicon atoms are included in terminals of the molecular chain and/or a side chain of the molecular chain and at least one reactive functional group selected from the group consisting of the (meth)acryloyl group, an vinyl group and the maleimide group is bonded to the silicon atoms of the molecular chain, either directly or through a bivalent linking group. At least one reactive functional group may be included in one molecule thereof.

**[0053]** Further, examples of the bivalent linking group may include an alkylene group, an alkyleneoxy group, an oxy group, an imino group, a carbonyl group and the combinations thereof.

**[0054]** The carbon number of the bivalent linking group is preferably in the range of 1 to 30 and more preferably in the range of 1 to 10.

**[0055]** Further, depending on the necessity, the polyorganosiloxane (B) may be used in combination of two or more kinds thereof.

**[0056]** A modified polyorganosiloxane substituted by the reactive functional group is incorporated into and fixed to a cross-linking structure of a cured body of the active energy ray curable compound (A) when the active energy ray curable compound (A) is allowed to cure by the irradiation of the active energy. This makes it possible to prevent the polyorganosiloxane as a component of the release agent layer 12 from

apply more suitable conductive property to the release agent layer 12, thereby enabling a surface resistance value of the outer surface 121 of the release agent layer 12 to be lowered. For this reason, it is possible to prevent the foreign matters from adhering to the outer surface 121 of the release agent layer 12. As a result, it is possible to prevent the pinhole from generating in the green sheet formed on the release agent layer 12.

**[0066]** In particular, the carbon nanotube in the carbon nanomaterial (C) as described above is formed into a fibrous form, which has a high aspect ratio (short-long degree). Therefore, it is possible to orient the carbon nanotube with ease so that a fiber length in a long axis thereof extends along a surface direction of the release agent layer 12. Therefore, if the carbon nanotube is used, it is possible to obtain the release agent layer 12 having more smoother outer surface 121 with the suitable charging property.

**[0067]** An average diameter (fiber diameter) of the carbon nanomaterial (C) is preferably in the range of 1 to 1000 nm, more preferably in the range of 3 to 500 nm, and even more preferably in the range of 5 to 100 nm.

**[0068]** An average length (fiber length) of the carbon nanomaterial (C) is not limited particularly, but preferably in the range of 10 nm to 200 μm, more preferably in the range of 50 nm to 100 μm, and even more preferably in the range of 100 nm to 50 μm.

**[0069]** An aspect ratio of the carbon nanomaterial (C) is preferably in the range of 10 to 10000, more preferably in the range of 200 to 5000, and even more

source to be used include a light source lamp such as a pressure mercury lamp, a metal halide lamp, an excimer lamp and the like.

**[0100]** Further, in the case where the active energy ray (the ultraviolet ray or the visible light) is irradiated, an accumulated amount of light is preferably in the range of 50 to 400 $mJ/cm^2$ and more preferably in the range of 100 to 300 $mJ/cm^2$ as an irradiance of the active energy ray. 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.

**[0101]** 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 release agent layer 12. As a result, it is possible to improve the productivity of the finally obtained release film 1.

**[0102]** According to the steps as described above, it is possible to easily and reliably produce the release film 1 having the high reliability, the superior smoothness and the superior antistatic property.

**[0103]** 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.

**[0104]** Examples of a method of producing a ceramic capacitor 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

(Example 1)

First, a biaxially-stretched polyethyleneterephthalate film [having a thickness of 31 μm, an arithmetic average roughness $Ra_0$ of a first surface of 29 nm, a maximum projection height $Rp_0$ of the first surface of 257 nm, an arithmetic average roughness $Ra_2$ of a second surface of 29 nm, and a maximum projection height $Rp_2$ of the second surface of 257 nm] was prepared as a base material.

**[0113]** Next, 94.05 mass% of dipentaerythritol hexaacrylate (a solid content of 100 mass%) as an active energy ray curable compound (A), 0.95 mass% of polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under a trade name "BYK-3500", and having a solid content of 100 mass%) as a polyorganosiloxane (B), 0.24 mass parts of a multi-layer carbon nanotube (produced by Filgen, Inc., sold under a trade name "F-M-ML-1/25", and having a fiber diameter of about 10 nm and an aspect ratio in the range of 500 to 1500) as a carbon nanomaterial (C), and 4.76 mass% of an α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under a trade name "IRGACURE907", 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having a solid content of 100 mass%) as a photopolymerization initiator (D) were diluted with a mixed solvent of isopropylalcohol/methylethylketone (mass ratio 3/1) to obtain a material for forming release agent layer having a solid content of 20 mass%.

**[0114]** The material for forming release agent layer thus obtained was coated on a first surface of the base

**[0126]** (Comparative Examples 6 and 7)

Release films were produced in the same manner as in Comparative Example 5 except that the thicknesses of the release agent layers were changed as shown in Table 1.

**[0127]** (Comparative Example 8)

A Release film for forming a green sheet was produced in the same manner as in Example 1 except that the following materials were used as the material for forming release agent layer.

**[0128]** 94.05 mass% of dipentaerythritol hexaacrylate (a solid content of 100 mass%) as an active energy ray curable compound (A), 0.95 mass% of polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under a trade name "BYK-3500", and having a solid content of 100 mass%) as a polyorganosiloxane (B), 0.24 mass parts of acicular antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under a trade name "FS-10P", and having a fiber diameter in the range of 10 to 20 nm and an aspect ratio in the range of 20 to 30), and 4.76 mass% of an α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under a trade name "IRGACURE907", 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having a solid content of 100 mass%) as a photopolymerization initiator (D) were diluted with a mixed solvent of isopropylalcohol/methylethylketone (mass ratio 3/1) to obtain a material for forming release agent layer having a solid content of 20 mass%.

**[0129]** (Comparative Example 9)

A Release film for forming a green sheet was produced in the same manner as in Example 1 except that the following materials were used as the material for forming release agent layer.

**[0130]** 94.05 mass% of dipentaerythritol hexaacrylate (a solid content of 100 mass%) as an active energy ray curable compound (A), 0.95 mass% of polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under a trade name "BYK-3500", and having a solid content of 100 mass%) as a polyorganosiloxane (B), 0.24 mass parts of an acicular electrical conducting material in which acicular rutile type titanium dioxide was coated with antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under a trade name "FT-1000", and having a fiber diameter of about 130 nm and an aspect ratio in the range of 10 to 20), and 4.76 mass% of an α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under a trade name "IRGACURE907", 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having a solid content of 100 mass%) as a photopolymerization initiator (D) were diluted with a mixed solvent of isopropylalcohol/methylethylketone (mass ratio 3/1) to obtain a material for forming release agent layer having a solid content of 20 mass%.

**[0131]** 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.

**[0132]** In Table 1, the dipentaerythritol hexaacrylate (the solid content of 100 mass%) as the active energy ray curable compound (A) was represented

as “A”, the polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under the trade name “BYK-3500”, and having the solid content of 100 mass%) as the polyorganosiloxane (B) was represented as “B”, the multi-layer carbon nanotube (produced by Filgen, Inc., sold under the trade name “F-M-ML-1/25”, and having the fiber diameter of about 10 nm and the aspect ratio in the range of 500 to 1.500) as the carbon nanomaterial (C) was represented as “C”, the α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under the trade name “IRGACURE907”, 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having the solid content of 100 mass%) as the photopolymerization initiator (D) was represented as “D”, the thermosetting silicone (produced by Shin-Etsu Chemical Co., Ltd., sold under the trade name “KS-847H” and having the solid content of 30 mass%) was represented as “X1”, the platinum catalyst (produced by Shin-Etsu Chemical Co., Ltd., sold under the trade name “CAT-PL-50T” and having the solid content of 2 mass%) was represented as “Y1”, the acicular antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under the trade name “FS-10P”, and having the fiber diameter in the range of 10 to 20 nm and the aspect ratio in the range of 20 to 30) was represented as “Z1”, and the acicular electrical conducting material in which the acicular rutile type titanium dioxide was coated with the antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under the trade name “FT-1000”, and having the fiber diameter of about 130 nm and the aspect ratio in the range of 10 to 20) was represented as “Z2”.

**[0133]** The thicknesses of the base materials and the release agent layers of the respective Examples and

Table. 1

| | Base material | | | | | Release agent layer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface roughness of first surface | | Surface roughness of second surface | | Thickness | Material for forming release agent layer | | | | | | Surface roughness of outer surface | | Thickness |
| | Arithmetic average roughness $R_{a0}$ | Maximum projection height $R_{p0}$ | Arithmetic average roughness $R_{a2}$ | Maximum projection height $R_{p2}$ | | Content of A | Content of B | Content of C | Content of D | Other components | | Arithmetic average roughness $R_{a1}$ | Maximum projection height $R_{p1}$ | |
| | | | | | | | | | | Kind | Content | | | |
| | [nm] | [nm] | [nm] | [nm] | [μm] | [mass%] | [mass%] | [mass%] | [mass%] | | [mass%] | [nm] | [nm] | [nm] |
| Example.1 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 17 | 0.97 |
| Example.2 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 5 | 49 | 0.55 |
| Example.3 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 16 | 1.45 |
| Example.4 | 29 | 257 | 29 | 257 | 31 | 94.52 | 0.48 | 0.24 | 4.76 | - | - | 3 | 17 | 0.97 |
| Example.5 | 29 | 257 | 29 | 257 | 31 | 93.81 | 0.95 | 0.48 | 4.76 | - | - | 4 | 19 | 0.97 |
| Example.6 | 29 | 257 | 29 | 257 | 31 | 93.34 | 0.95 | 0.95 | 4.76 | - | - | 5 | 24 | 0.97 |
| Example.7 | 15 | 98 | 15 | 98 | 38 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 11 | 0.97 |
| Example.8 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 48 | 0.40 |
| Example.9 | 7 | 43 | 34 | 250 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 9 | 0.97 |
| Comparative Example. 1 | 29 | 257 | 29 | 257 | 31 | 95.00 | - | 0.24 | 4.76 | - | - | 4 | 21 | 0.97 |
| Comparative Example. 2 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 15 | 156 | 0.10 |
| Comparative Example. 3 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 10 | 69 | 0.25 |
| Comparative Example. 4 | 29 | 257 | 29 | 257 | 31 | 94.29 | 0.95 | - | 4.76 | - | - | 3 | 16 | 0.97 |
| Comparative Example. 5 | 29 | 257 | 29 | 257 | 31 | - | - | 0.24 | - | X1+Y1 | 99.72+0.04 | 29 | 241 | 0.30 |
| Comparative Example. 6 | 29 | 257 | 29 | 257 | 31 | - | - | 0.24 | - | X1+Y1 | 99.72+0.04 | 26 | 219 | 0.60 |
| Comparative Example. 7 | 29 | 257 | 29 | 257 | 31 | - | - | 0.24 | - | X1+Y1 | 99.72+0.04 | 24 | 202 | 1.00 |
| Comparative Example. 8 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | - | 4.76 | Z1 | 0.24 | 6 | 83 | 0.97 |
| Comparative Example. 9 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | - | 4.76 | Z2 | 0.24 | 6 | 83 | 0.97 |

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 as it is. The blocking property thereof was evaluated under the following evaluation criteria.

**[0143]** A: The outward appearance 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 an area less than half of the roll of the release film for producing the green sheet in a width direction thereof, the hue was changed, which resulted from the close contact between the films (Blocking was generated slightly).

C: The hue was changed over a half region of the roll of the release film for producing the green sheet in the width direction, which resulted from the close contact between the films (Blocking was generated).

**[0144]** [2.5] Unwinding Electric Charge Amount

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, an electric charge amount when the release

film was unwound at a speed of 50 m/min was measured using “KSD-0103” made by KASUGA ELECTRIC WORKS LTD. The electric charge amount was measured at a region of 100 mm of the just-unwound release film every an unwinding length of 500 M.

**[0145]** A: The electric charge amount was - 5 kV to + 5 kV.

B: The electric charge amount was - 10 kV to - 5 kV or + 5 kV to + 10 kV.

C: The electric charge amount was - 10 kV or less or + 10 kV or more.

**[0146]** [2.6] Evaluation of Coatability of Slurry

135 mass parts of a mixed solvent of toluene and ethanol (mass ratio of 6:4) were added to 100 mass parts of barium titanate powder ($BaTiO_3$, produced by Sakai Chemical Industrial Co., Ltd. and sold under a trade name “BT-03”), 8 mass parts of polyvinyl butyral (produced by Sekisui Chemical Co., Ltd. and sold under a trade name “S-LEC B·K BM-2”) as a binder, and 4 mass parts of dioctyl phthalate (produced by KANTO CHEMICAL CO., INC. and sold under a trade name “DIOCTYL PHTHALATE Cica GRADE 1”) as a plasticizer. A Ceramic slurry was prepared by mixing and dispersing these substances with a ball mill.

**[0147]** A coated layer was obtained by coating the ceramic slurry, with a die coater, on the 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, the green sheet had a thickness of 1 μm, a width of 250 mm and a length of 10 m. Thereafter, the release film for producing the

green sheet provided with the ceramic green sheet was obtained by drying the coated layer with a drying machine at 80°C for one minute. Then, light of a fluorescent lamp was irradiated to the release film for producing the green sheet provided with the ceramic green sheet from a side of the release film for producing the green sheet. Thus, surfaces of all of the coated ceramic green sheets were visually observed. The coatability of the slurry was evaluated under the following evaluation criteria. The results are shown in Table 1.

**[0148]** A: No pinhole was found in the ceramic green sheet.

B: 1 to 5 pinholes were found in the ceramic green sheet.

C: 6 or more pinholes were found in the ceramic green sheet.

**[0149]** [2.7] Evaluation of Releasability

A ceramic green sheet was formed on the surface of the release agent layer of the release film for producing the green sheet in the same manner as in the above item [2.6]. The ceramic green sheet was cut into a size of 200 mm × 200 mm so that the release film for producing the green sheet was not cut. Next, the cut ceramic green sheet was adsorbed to a vacuum suction stage using a sheet peeling machinery of a green sheet lamination machine and released from the release film for producing the green sheet. At this time, the releasability of the ceramic green sheet was evaluated under the following evaluation criteria.

**[0150]** A: The ceramic green sheet was smoothly released from the release agent layer without being

Table. 2

| | Surface resistivity [Ω/□] | Curability of release agent layer | Curl property | Blocking property | Unwinding electric charge amount | Coatability of sulurry | Releasability of green sheet | Evaluation of defect of release agent layer |
|---|---|---|---|---|---|---|---|---|
| Example.1 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.2 | $1.0\times10^{11}$ | A | A | A | A | A | A | A |
| Example.3 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.4 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.5 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.6 | $1.0\times10^{8}$ | A | A | A | A | A | A | A |
| Example.7 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.8 | $1.0\times10^{11}$ | A | A | A | A | A | A | A |
| Example.9 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Comparative Example. 1 | $1.0\times10^{9}$ | A | A | A | A | A | C | A |
| Comparative Example. 2 | $1.0\times10^{12}$ | A | A | A | A | A | B | C |
| Comparative Example. 3 | $1.0\times10^{9}$ | A | A | A | A | A | B | C |
| Comparative Example. 4 | $1.0\times10^{15}$ | A | A | A | C | A | B | A |
| Comparative Example. 5 | $1.0\times10^{9}$ | A | A | B | A | B | B | C |
| Comparative Example. 6 | $1.0\times10^{9}$ | A | A | C | B | C | C | – |
| Comparative Example. 7 | $1.0\times10^{9}$ | A | A | C | B | C | C | – |
| Comparative Example. 8 | $1.0\times10^{15}$ | A | A | A | C | A | B | C |
| Comparative Example. 9 | $1.0\times10^{15}$ | A | A | A | C | A | B | C |

12.

**[0052]** Examples of the polyorganosiloxane (B) include a polyorganosiloxane having a straight or branched molecular chain. Particularly, it is preferred that silicon atoms are included in terminals of the molecular chain and/or a side chain of the molecular chain and at least one reactive functional group selected from the group consisting of the (meth)acryloyl group, an vinyl group and the maleimide group is bonded to the silicon atoms of the molecular chain, either directly or through a bivalent linking group. At least one reactive functional group may be included in one molecule thereof.

**[0053]** Further, examples of the bivalent linking group may include an alkylene group, an alkyleneoxy group, an oxy group, an imino group, a carbonyl group and the combinations thereof.

**[0054]** The carbon number of the bivalent linking group is preferably in the range of 1 to 30 and more preferably in the range of 1 to 10.

**[0055]** Further, depending on the necessity, the polyorganosiloxane (B) may be used in combination of two or more kinds thereof.

**[0056]** A modified polyorganosiloxane substituted by the reactive functional group is incorporated into and fixed to a cross-linking structure of a cured body of the active energy ray curable compound (A) when the active energy ray curable compound (A) is allowed to cure by the irradiation of the active energy ray. This makes it possible to prevent the polyorganosiloxane as a component of the release agent layer 12 from

apply more suitable conductive property to the release agent layer 12, thereby enabling a surface resistance value of the outer surface 121 of the release agent layer 12 to be lowered. For this reason, it is possible to prevent the foreign matters from adhering to the outer surface 121 of the release agent layer 12. As a result, it is possible to prevent the pinhole from generating in the green sheet formed on the release agent layer 12.

**[0066]** In particular, the carbon nanotube in the carbon nanomaterial (C) as described above is formed into a fibrous form, which has a high aspect ratio (short-long degree). Therefore, it is possible to orient the carbon nanotube with ease so that a fiber length in a long axis thereof extends along a surface direction of the release agent layer 12. Therefore, if the carbon nanotube is used, it is possible to obtain the release agent layer 12 having more smoother outer surface 121 with the suitable conductive property.

**[0067]** An average diameter (fiber diameter) of the carbon nanomaterial (C) is preferably in the range of 1 to 1000 nm, more preferably in the range of 3 to 500 nm, and even more preferably in the range of 5 to 100 nm.

**[0068]** An average length (fiber length) of the carbon nanomaterial (C) is not limited particularly, but preferably in the range of 10 nm to 200 μm, more preferably in the range of 50 nm to 100 μm, and even more preferably in the range of 100 nm to 50 μm.

**[0069]** An aspect ratio of the carbon nanomaterial (C) is preferably in the range of 10 to 10000, more preferably in the range of 200 to 5000, and even more

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.

**[0100]** Further, in the case where the active energy ray (the ultraviolet ray or the visible light) is irradiated, an accumulated amount of light is preferably in the range of 50 to 400 $mJ/cm^2$ and more preferably in the range of 100 to 300 $mJ/cm^2$ as an irradiance of the active energy ray. 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.

**[0101]** 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 release agent layer 12. As a result, it is possible to improve the productivity of the finally obtained release film 1.

**[0102]** According to the steps as described above, it is possible to easily and reliably produce the release film 1 having the high reliability, the superior smoothness and the superior antistatic property.

**[0103]** 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.

**[0104]** Examples of a method of producing a ceramic capacitor 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

(Example 1)

First, a biaxially-stretched polyethyleneterephthalate film [having a thickness of 31 μm, an arithmetic average roughness $Ra_0$ of a first surface of 29 nm, a maximum projection height $Rp_0$ of the first surface of 257 nm, an arithmetic average roughness $Ra_2$ of a second surface of 29 nm, and a maximum projection height $Rp_2$ of the second surface of 257 nm] was prepared as a base material.

**[0113]** Next, 94.05 mass% of dipentaerythritol hexaacrylate (a solid content of 100 mass%) as an active energy ray curable compound (A), 0.95 mass% of polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under a trade name "BYK-3500", and having a solid content of 100 mass%) as a polyorganosiloxane (B), 0.24 mass% of a multi-layer carbon nanotube (produced by Filgen, Inc., sold under a trade name "F-M-ML-1/25", and having a fiber diameter of about 10 nm and an aspect ratio in the range of 500 to 1500) as a carbon nanomaterial (C), and 4.76 mass% of an α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under a trade name "IRGACURE907", 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having a solid content of 100 mass%) as a photopolymerization initiator (D) were diluted with a mixed solvent of isopropylalcohol/methylethylketone (mass ratio 3/1) to obtain a material for forming release agent layer having a solid content of 20 mass%.

**[0114]** The material for forming release agent layer thus obtained was coated on a first surface of the base

**[0126]** (Comparative Examples 6 and 7)

Release films were produced in the same manner as in Comparative Example 5 except that the thicknesses of the release agent layers were changed as shown in Table 1.

**[0127]** (Comparative Example 8)

A Release film for forming a green sheet was produced in the same manner as in Example 1 except that the following materials were used as the material for forming release agent layer.

**[0128]** 94.05 mass% of dipentaerythritol hexaacrylate (a solid content of 100 mass%) as an active energy ray curable compound (A), 0.95 mass% of polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under a trade name "BYK-3500", and having a solid content of 100 mass%) as a polyorganosiloxane (B), 0.24 mass% of acicular antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under a trade name "FS-10P", and having a fiber diameter in the range of 10 to 20 nm and an aspect ratio in the range of 20 to 30), and 4.76 mass% of an α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under a trade name "IRGACURE907", 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having a solid content of 100 mass%) as a photopolymerization initiator (D) were diluted with a mixed solvent of isopropylalcohol/methylethylketone (mass ratio 3/1) to obtain a material for forming release agent layer having a solid content of 20 mass%.

**[0129]** (Comparative Example 9)

A Release film for forming a green sheet was produced in the same manner as in Example 1 except that the following materials were used as the material for forming release agent layer.

**[0130]** 94.05 mass% of dipentaerythritol hexaacrylate (a solid content of 100 mass%) as an active energy ray curable compound (A), 0.95 mass% of polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under a trade name "BYK-3500", and having a solid content of 100 mass%) as a polyorganosiloxane (B), 0.24 mass% of an acicular electrical conducting material in which acicular rutile type titanium dioxide was coated with antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under a trade name "FT-1000", and having a fiber diameter of about 130 nm and an aspect ratio in the range of 10 to 20), and 4.76 mass% of an α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under a trade name "IRGACURE907", 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having a solid content of 100 mass%) as a photopolymerization initiator (D) were diluted with a mixed solvent of isopropylalcohol/methylethylketone (mass ratio 3/1) to obtain a material for forming release agent layer having a solid content of 20 mass%.

**[0131]** 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.

**[0132]** In Table 1, the dipentaerythritol hexaacrylate (the solid content of 100 mass%) as the active energy ray curable compound (A) was represented

as “A”, the polyether modified acryloyl group-containing polydimethylsiloxane (produced by BYK-Chemie GmbH, sold under the trade name “BYK-3500”, and having the solid content of 100 mass%) as the polyorganosiloxane (B) was represented as “B”, the multi-layer carbon nanotube (produced by Filgen, Inc., sold under the trade name “F-M-ML-1/25”, and having the fiber diameter of about 10 nm and the aspect ratio in the range of 500 to 1,500) as the carbon nanomaterial (C) was represented as “C”, the α-aminoalkylphenone-based photopolymerization initiator (produced by BASF Ltd., sold under the trade name “IRGACURE907”, 2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one, and having the solid content of 100 mass%) as the photopolymerization initiator (D) was represented as “D”, the thermosetting silicone (produced by Shin-Etsu Chemical Co., Ltd., sold under the trade name “KS-847H” and having the solid content of 30 mass%) was represented as “X1”, the platinum catalyst (produced by Shin-Etsu Chemical Co., Ltd., sold under the trade name “CAT-PL-50T” and having the solid content of 2 mass%) was represented as “Y1”, the acicular antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under the trade name “FS-10P”, and having the fiber diameter in the range of 10 to 20 nm and the aspect ratio in the range of 20 to 30) was represented as “Z1”, and the acicular electrical conducting material in which the acicular rutile type titanium dioxide was coated with the antimony doped tin oxide (produced by ISHIHARA SANGYO KAISHA, LTD., sold under the trade name “FT-1000”, and having the fiber diameter of about 130 nm and the aspect ratio in the range of 10 to 20) was represented as “Z2”.

**[0133]** The thicknesses of the base materials and the release agent layers of the respective Examples and

Table. 1

| | Base material | | | | | Release agent layer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface roughness of first surface | | Surface roughness of second surface | | Thickness | Material for forming release agent layer | | | | | | Surface roughness of outer surface | | Thickness |
| | Arithmetic average roughness $Ra_0$ | Maximum projection height $Rp_0$ | Arithmetic average roughness $Ra_2$ | Maximum projection height $Rp_2$ | | Content of A | Content of B | Content of C | Content of D | Other components | | Arithmetic average roughness $Ra_1$ | Maximum projection height $Rp_1$ | |
| | | | | | | | | | | Kind | Content | | | |
| | [nm] | [nm] | [nm] | [nm] | [μm] | [mass%] | [mass%] | [mass%] | [mass%] | | [mass%] | [nm] | [nm] | [μm] |
| Example.1 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 17 | 0.97 |
| Example.2 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 5 | 49 | 0.55 |
| Example.3 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 16 | 1.45 |
| Example.4 | 29 | 257 | 29 | 257 | 31 | 94.52 | 0.48 | 0.24 | 4.76 | - | - | 3 | 17 | 0.97 |
| Example.5 | 29 | 257 | 29 | 257 | 31 | 93.81 | 0.95 | 0.48 | 4.76 | - | - | 4 | 19 | 0.97 |
| Example.6 | 29 | 257 | 29 | 257 | 31 | 93.34 | 0.95 | 0.95 | 4.76 | - | - | 5 | 24 | 0.97 |
| Example.7 | 15 | 98 | 15 | 98 | 38 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 11 | 0.97 |
| Example.8 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 48 | 0.40 |
| Example.9 | 7 | 43 | 34 | 250 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 3 | 9 | 0.97 |
| Comparative Example. 1 | 29 | 257 | 29 | 257 | 31 | 95.00 | - | 0.24 | 4.76 | - | - | 4 | 21 | 0.97 |
| Comparative Example. 2 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 15 | 156 | 0.10 |
| Comparative Example. 3 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | 0.24 | 4.76 | - | - | 10 | 69 | 0.25 |
| Comparative Example. 4 | 29 | 257 | 29 | 257 | 31 | 94.29 | 0.95 | - | 4.76 | - | - | 3 | 16 | 0.97 |
| Comparative Example. 5 | 29 | 257 | 29 | 257 | 31 | - | - | 0.24 | - | X1+Y1 | 99.72+0.04 | 29 | 241 | 0.30 |
| Comparative Example. 6 | 29 | 257 | 29 | 257 | 31 | - | - | 0.24 | - | X1+Y1 | 99.72+0.04 | 26 | 219 | 0.60 |
| Comparative Example. 7 | 29 | 257 | 29 | 257 | 31 | - | - | 0.24 | - | X1+Y1 | 99.72+0.04 | 24 | 202 | 1.00 |
| Comparative Example. 8 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | - | 4.76 | Z1 | 0.24 | 6 | 83 | 0.97 |
| Comparative Example. 9 | 29 | 257 | 29 | 257 | 31 | 94.05 | 0.95 | - | 4.76 | Z2 | 0.24 | 6 | 83 | 0.97 |

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 as it is. The blocking property thereof was evaluated under the following evaluation criteria.

**[0143]** 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 an area less than half of the roll of the release film for producing the green sheet in a width direction thereof, the hue was changed, which resulted from the close contact between the films (Blocking was generated slightly).

C: The hue was changed over a half region of the roll of the release film for producing the green sheet in the width direction, which resulted from the close contact between the films (Blocking was generated).

**[0144]** [2.5] Unwinding Electric Charge Amount

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, an electric charge amount when the release

film was unwound at a speed of 50 m/min was measured using "KSD-0103" made by KASUGA ELECTRIC WORKS LTD. The electric charge amount was measured at a region of 100 mm of the just-unwound release film every an unwinding length of 500 m.

**[0145]** A: The electric charge amount was - 5 kV to + 5 kV.

B: The electric charge amount was - 10 kV to - 5 kV or + 5 kV to + 10 kV.

C: The electric charge amount was - 10 kV or less or + 10 kV or more.

**[0146]** [2.6] Evaluation of Coatability of Slurry

135 mass parts of a mixed solvent of toluene and ethanol (mass ratio of 6:4) were added to 100 mass parts of barium titanate powder ($BaTiO_3$, produced by Sakai Chemical Industrial Co., Ltd. and sold under a trade name "BT-03"), 8 mass parts of polyvinyl butyral (produced by Sekisui Chemical Co., Ltd. and sold under a trade name "S-LEC B·K BM-2") as a binder, and 4 mass parts of dioctyl phthalate (produced by KANTO CHEMICAL CO., INC. and sold under a trade name "DIOCTYL PHTHALATE Cica GRADE 1") as a plasticizer. A Ceramic slurry was prepared by mixing and dispersing these substances with a ball mill.

**[0147]** A coated layer was obtained by coating the ceramic slurry, with a die coater, on the 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, the green sheet had a thickness of 1 μm, a width of 250 mm and a length of 10 m. Thereafter, the release film for producing the

green sheet provided with the ceramic green sheet was obtained by drying the coated layer with a drying machine at 80°C for one minute. Then, light of a fluorescent lamp was irradiated to the release film for producing the green sheet provided with the ceramic green sheet from a side of the release film for producing the green sheet. Thus, surfaces of all of the coated ceramic green sheets were visually observed. The coatability of the slurry was evaluated under the following evaluation criteria. The results are shown in Table 2.

**[0148]** A: No pinhole was found in the ceramic green sheet.

B: 1 to 5 pinholes were found in the ceramic green sheet.

C: 6 or more pinholes were found in the ceramic green sheet.

**[0149]** [2.7] Evaluation of Releasability

A ceramic green sheet was formed on the surface of the release agent layer of the release film for producing the green sheet in the same manner as in the above item [2.6]. The ceramic green sheet was cut into a size of 200 mm × 200 mm so that the release film for producing the green sheet was not cut. Next, the cut ceramic green sheet was adsorbed to a vacuum suction stage using a sheet peeling machinery of a green sheet lamination machine and released from the release film for producing the green sheet. At this time, the releasability of the ceramic green sheet was evaluated under the following evaluation criteria.

**[0150]** A: The ceramic green sheet was smoothly released from the release agent layer without being

Table. 2

| | Surface resistivity [Ω/□] | Curability of release agent layer | Curl property | Blocking property | Unwinding electric charge amount | Coatability of sulurry | Releasability of green sheet | Evaluation of defect of release agent layer |
|---|---|---|---|---|---|---|---|---|
| Example.1 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.2 | $1.0\times10^{11}$ | A | A | A | A | A | A | A |
| Example.3 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.4 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.5 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.6 | $1.0\times10^{8}$ | A | A | A | A | A | A | A |
| Example.7 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Example.8 | $1.0\times10^{11}$ | A | A | A | A | A | A | A |
| Example.9 | $1.0\times10^{9}$ | A | A | A | A | A | A | A |
| Comparative Example. 1 | $1.0\times10^{9}$ | A | A | A | A | A | C | – |
| Comparative Example. 2 | $1.0\times10^{12}$ | A | A | A | A | A | B | C |
| Comparative Example. 3 | $1.0\times10^{9}$ | A | A | A | A | A | B | C |
| Comparative Example. 4 | $1.0\times10^{15}$ | A | A | A | C | A | B | A |
| Comparative Example. 5 | $1.0\times10^{9}$ | A | A | B | A | B | B | C |
| Comparative Example. 6 | $1.0\times10^{9}$ | A | A | C | B | C | C | – |
| Comparative Example. 7 | $1.0\times10^{9}$ | A | A | C | B | C | C | – |
| Comparative Example. 8 | $1.0\times10^{15}$ | A | A | A | C | A | B | C |
| Comparative Example. 9 | $1.0\times10^{15}$ | A | A | A | C | A | B | C |