

DESCRIPTION

ADHESIVE TAPE FOR TEMPORARY-ATTACHMENT OF GREEN SHEETS
FOR CERAMIC ELECTRONIC DEVICES

5

AND

METHOD FOR PRODUCING CERAMIC ELECTRONIC DEVICES

TECHNICAL FIELD

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The present invention relates to an adhesive tape for temporary attachment, used during the production of ceramic electronic devices, e.g., multilayer ceramic capacitors, multilayer ceramic inductors, resistors, ferrites, sensor elements, thermistors, varistors, or piezoelectric ceramics, and in particular for use in a step of cutting a green (i.e., unprocessed) sheet of ceramic into a number of chips.

20 BACKGROUND ART

For example, a multilayer ceramic capacitor may be produced through the following steps.

A slurry of ceramic powder is thinly spread out

with a doctor blade to make a ceramic green sheet. After a plurality of electrodes are printed on the surface of the green sheet, a number of such green sheets are laminated and integrated so as to form a green sheet laminate. Next, after the laminate is initially heat-pressed, the laminate is cut in longitudinal and transverse directions with a cutting tool such as a dicer or a guillotine blade to obtain a number of ceramic laminate chips. These chips (also referred to as "works") are then sintered, and external electrodes are formed on end faces of the resultant chips.

In the aforementioned step of obtaining an integrated laminate and the step of cutting the laminate into green chips, a green sheet is temporarily fixed on a base for sheet stabilization by using an adhesive tape, and after the cutting, the works need to be peeled off the adhesive tape on the surface of the base. At the time of peeling, it is necessary to reduce the adhesion strength between the works and the adhesive tape. If the adhesion strength cannot be adequately reduced, the following problems may occur.

(1) Since the laminate itself has not been sintered yet,

the adhesion between the respective layers may be insufficient. Therefore, when the chips are peeled off the surface of the adhesive tape, interlayer peeling may occur within the laminate due to an excessively strong
5 adhesion strength of the adhesive tape.

(2) Even if interlayer peeling does not occur, the adhesive layer may be left as a contaminant on the bottom of a chip. As a result, when the chips are sent to a
10 subsequent process, the contaminant may cause blocking. As the residue of the contaminant is also subjected to sintering, voids or cracks may occur due to the sintering of an organic material.

15 Thus, the reliability and the yield of the product are unfavorably affected.

Accordingly, as disclosed in Japanese Publication for Opposition No. 6-79812, for example, an
20 adhesive tape which includes an adhesive layer of a thermal foaming type is conventionally used. A foaming agent is contained in the adhesive layer of this adhesive tape. As a result, by heating the adhesive tape after the cutting of a laminate, the foaming agent acts to reduce

the area of contact between the adhesive tape and the works,
so that the works can be easily peeled off the adhesive
tape surface.

5 However, since the adhesive tape has a high
foaming temperature, there are problems in that a binder
within the laminate may evaporate to contaminate the works
at the time of heating the adhesive tape, or that the
laminate may fail to attain a predetermined hardness due
10 to the evaporation of the binder prior to a preliminary
sintering. Moreover, the adhesion strength may not be
adequately reduced due to non-uniform foaming, so that
the works may not be able to be peeled off the adhesive
tape.

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DISCLOSURE OF THE INVENTION

 An adhesive tape for temporary attachment of green
sheets for a ceramic electronic device according to the
20 present invention comprises a substrate film and an
adhesive layer provided on at least one face of the
substrate film, wherein the adhesive layer comprises an
adhesive composition, the adhesive composition
containing a pressure-sensitive adhesive and about 1 to

about 30 wt.% of a side-chain crystallizable polymer on the basis of the adhesive composition.

In the case where adhesive layers are provided on both faces of the substrate film, the following pressure-sensitive adhesives may be used as the pressure-sensitive adhesive on the second face constituting the adhesive layer, for example:

10 natural rubber adhesives; synthetic rubber adhesives; styrene/butadiene latex-base adhesives; block copolymer type thermoplastic rubbers; butyl rubbers; polyisobutylene; acrylic adhesives; and vinyl ether copolymer adhesive compositions.

15 In one embodiment, the side-chain crystallizable polymer comprises as a main component an acrylic acid alkyl ester and/or a methacrylic acid alkyl ester which has a straight-chain alkyl group including 16 or more
20 carbon atoms as a side chain.

In one embodiment, the adhesive composition is of such a nature that the adhesive composition easily peels off the green sheets for the ceramic electronic device

at about 35°C or above.

In one embodiment, the side-chain crystallizable polymer has a melting point occurring within a temperature
5 range narrower than about 15°C.

In one embodiment, an adhesion strength of the adhesive composition with a stainless steel plate when heated to about 35°C or above is about 10% or less of an
10 adhesion strength with the stainless steel plate at 23°C or about 10 g/25 mm or less.

In one embodiment, the polymer has a weight average molecular weight of about 3,000 to about 25,000.
15

A method for producing a ceramic electronic device according to the present invention comprises the steps of: allowing a green sheet laminate of ceramics to adhere to a base via an adhesive tape; cutting the laminate into
20 chips; and peeling the chips off a surface of the adhesive tape while heating the adhesive tape, wherein the adhesive tape comprises a substrate film and an adhesive layer provided on at least one face of the substrate film, the adhesive layer comprising an adhesive composition, the

adhesive composition containing a pressure-sensitive adhesive and about 1 to about 30 wt.% of a side-chain crystallizable polymer on the basis of the adhesive composition, wherein the side-chain crystallizable
5 polymer comprises as a main component an acrylic acid alkyl ester and/or a methacrylic acid alkyl ester which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain, and wherein an adhesion strength of the adhesive composition with a stainless
10 steel plate when heated to about 35°C or above is about 10% or less of an adhesion strength with the stainless steel plate at 23°C.

A laminate which is obtained by laminating ceramic
15 green sheets with electrodes printed thereon is affixed to a base via an adhesive tape, and thereafter the laminate is cut. Since the adhesive tape provides excellent tackiness, the laminate cannot be peeled at this time. When the works are removed from the adhesive tape after
20 the laminate is cut, the adhesive tape is heated to a predetermined temperature or above so that the works can be easily peeled off the adhesive tape.

Specifically, since an adhesive composition

comprised in the adhesive tape contains a pressure-sensitive adhesive and about 1 to about 30 wt.% of a side-chain crystallizable polymer on the basis of the adhesive composition, the side-chain crystallizable
5 polymer containing as a main component an acrylic acid alkyl ester and/or a methacrylic acid alkyl ester which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain, the polymer becomes crystalline or non-crystalline in a reversible
10 manner by slightly varying the temperature from an arbitrarily selected temperature, resulting in a substantial change in the tackiness with respect to a chip.

15 Thus, when the adhesive layer is heated to a predetermined temperature or above, the adhesion strength of the adhesive layer rapidly decreases. Therefore, after adhering a green sheet for ceramic electronic devices to the adhesive tape and performing a cutting
20 process, the tape may be heated so as to greatly decrease its tackiness with respect to the green sheet for ceramic electronic devices, whereby the chips (ceramic electronic devices) can be easily peeled off the tape.

As used herein, "green sheets for ceramic electronic devices" encompass both green sheets and green sheet laminates composed essentially of ceramics, which are used during the production of ceramic electronic devices, e.g., multilayer ceramic capacitors, multilayer ceramic inductors, resistors, ferrites, sensor elements, thermistors, varistors, or piezoelectric ceramics.

According to the present invention, the tackiness of an adhesive tape for temporary attachment with respect to green sheets for ceramic electronic devices can be controlled simply by changing the temperature of the adhesive tape. Thus, a large adhesion strength can be obtained when temporarily attaching the green sheets for ceramic electronic devices; when a work is to be removed, peeling can easily occur simply by heating. Since the works will not be contaminated, it is possible to enhance the reliability of ceramic electronic devices.

In particular, by employing a side-chain crystallizable polymer having a weight average molecular weight of about 3,000 to about 25,000, it is possible obtain an adhesive tape for temporary attachment which exhibits a significant decrease in tackiness at the time

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of heating and which undergoes little change in tackiness with the lapse of time.

5 BEST MODES FOR CARRYING OUT THE INVENTION

(substrate film)

Examples of substrate films which can be used for the adhesive tape for temporary attachment according to
10 the present invention include sheets composed of a single layer or multiple layers of a synthetic resin film having a thickness of about 5 to about 500 μ m, e.g., polyethylene, polypropylene, polyester, polyamide, polycarbonate, ethylene-vinyl acetate copolymer, ethylene-ethyl
15 acrylate copolymer, ethylene-polypropylene copolymer, polyvinyl chloride.

In order to enhance the adhesion with the adhesive layer, the surface of the substrate film may be subjected
20 to a corona discharge treatment, a plasma treatment, a blast treatment, a chemical etching treatment, a primer treatment, or the like.

On at least one face of such a substrate film, an

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adhesive layer composed of an adhesive composition as described below is laminated.

The adhesive composition may contain a side-chain
5 crystallizable polymer having a melting point which occurs within a temperature range narrower than about 15°C, and a pressure-sensitive adhesive. The adhesive composition is of such a nature that it exhibits tackiness with respect to a green sheet for ceramic electronic
10 devices or other materials to which it is adhered at temperature T1, while exhibiting a significantly reduced tackiness with respect to the green sheet for ceramic electronic devices or other materials at temperature T2 which is higher than temperature T1 by about 15°C or more.

15

(pressure-sensitive adhesive)

Examples of pressure-sensitive adhesives contained in the adhesive composition include the following pressure-sensitive adhesives, for example:

20

natural rubber adhesives; styrene/butadiene latex-base adhesives; ABA block copolymer type thermoplastic rubbers (where A represents a thermoplastic polystyrene end block; and B represents a rubber

intermediate block such as polyisoprene, polybutadiene
or poly(ethylene/butylene)); butyl rubbers;
polyisobutylene; acrylic adhesives such as polyacrylate
and vinyl acetate/acryl ester copolymer; and vinyl ether
5 copolymers such as polyvinylmethylether,
polyvinylethylether, and polyvinylisobutylether.

In particular, the use of acryl type pressure-
sensitive adhesives provides interaction with the polymer
10 such that the polymer will be sufficiently dispersed at
a predetermined temperature so as to exhibit tackiness,
and yet the polymer will exhibit good releasability when
heated to the predetermined temperature or above.
Preferable acryl type pressure-sensitive adhesives are
15 composed essentially of ethylhexyl acrylate,
hydroxyethyl acrylate, or the like. Examples thereof
include a copolymer containing 80 to 95 parts by weight
of 2-ethylhexyl acrylate and 5 to 20 parts by weight of
2-hydroxyethyl acrylate.

20

(side-chain crystallizable polymer)

A side-chain crystallizable polymer to be
contained in the adhesive composition preferably has a
melting point which occurs within a temperature range

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narrower than about 15°C.

As used herein, the term "melting point" means the temperature at which an equilibrium process causes
5 certain portions of a polymer, initially aligned in an ordered array, to become disordered.

In one embodiment, the melting point of the polymer is preferably in the range of about 30°C to about
10 100°C, and more preferably in the range of about 35°C to about 65°C. It is preferable that the melting occur rapidly, i.e., over a relatively narrow temperature range which is less than about 15°C and preferably less than about 10 °C . It is preferable that the polymer
15 crystallizes rapidly. To this end, seeding agents, or crystallization catalysts can be incorporated into the polymer.

After use, the adhesive layer can be easily peeled
20 off the surface of a green sheet for ceramic electronic devices or a chip by heating the adhesive layer to a temperature which is slightly higher than the use temperature. The heating temperature is usually about 40°C to about 100°C, preferably about 40°C to about 70°C,

and more preferably about 50°C to about 70°C.

The side-chain crystallizable polymer contained in the adhesive composition includes as a component
5 thereof an acrylic acid ester and/or methacrylic acid ester which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain.

As an acrylic acid ester and/or a methacrylic acid
10 ester (hereinafter also referred to as "(meth)acrylate") which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain, a (meth)acrylate which has a straight-chain alkyl group including 16 to 22 carbon atoms may be preferably used, e.g.,
15 hexadecyl(meth)acrylate, stearyl (meth)acrylate, or dococyl (meth)acrylate.

Furthermore, a (meth)acrylate which has a straight-chain alkyl group including 16 to 30 carbon atoms,
20 e.g., triaconta(meth)acrylate, may also be used.

Furthermore, the following monomers may be used instead of or in addition to a (meth)acrylate which has a straight-chain alkyl group including 16 or more carbon

atoms as a side chain:

at least one kind of monomer selected from the group consisting of: acrylates, methacrylates, 5 acrylamide derivatives, methacrylamide derivatives, vinyl ether derivatives, vinyl ester derivatives, or alpha olefins or their derivatives having an aliphatic group which includes 16 or more carbon atoms and at least a portion of which is fluorinated; and styrene derivatives 10 having an alkyl group which has 16 or more carbon atoms, etc.

In particular, acrylates, methacrylates, acrylamide derivatives, methacrylamide derivatives, or 15 the like having a straight-chain aliphatic group including 16 or more carbon atoms are preferable. More preferable are acrylates, methacrylates, acrylamide derivatives, methacrylamide derivatives or the like having a straight-chain aliphatic group including 14 to 20 22 carbon atoms. Especially preferable are acrylates and methacrylates having a straight-chain aliphatic group including 14 to 18 carbon atoms.

Furthermore, the following monomers having

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functional groups may be used as a copolymer component. Examples of monomers having such functional groups include at least one kind which is selected from the group consisting of: acrylic acid, methacrylic acid, itaconic
5 acid, mesaconic acid, citraconic acid, fumaric acid, maleic acid, itaconic acid monoalkyl ester, mesaconic acid monoalkyl ester, citraconic acid monoalkyl ester, fumaric acid monoalkyl ester, maleic acid monoalkyl ester, acrylic acid 2-hydroxyethyl, acrylamide, methacrylamide,
10 tertiary-butylaminoethylmethacrylate, and the like. Such monomers, which are to be used while paying attention to the amount of (meth)acrylate which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain used, may be contained in an amount ranging
15 from about 1 to about 30 wt.% in the total amount of all of the monomers serving as raw materials for the base polymer.

Listed below are the melting points of side-chain
20 crystallizable polymers which are obtained from monomers which have a straight-chain alkyl group including 16 to 22 carbon atoms:

monomer used

melting point (°C)

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	C16 acrylate	36
	C16 methacrylate	26
	C18 acrylate	49
5	C18 methacrylate	39
	C20 acrylate	60
	C20 methacrylate	50
	C22 acrylate	71
	C22 methacrylate	62

10

Preferable examples of polymers contained in the adhesive composition include the following:

15 (1) a copolymer of 80 to 98 parts by weight of stearyl acrylate, 2 to 20 parts by weight of acrylic acid, and 2 to 10 parts by weight of dodecylmercaptan;

20 (2) a copolymer of 5 to 90 parts by weight of dococyl acrylate, 5 to 90 parts by weight of stearyl acrylate, 1 to 10 parts by weight of acrylic acid, and 2 to 10 parts by weight of dodecylmercaptan; and

(3) a copolymer of 80 to 98 parts by weight of dococyl acrylate, 2 to 20 parts by weight of acrylic acid, and

2 to 10 parts by weight of dodecylmercaptan.

The amount of the crystallizable polymer in the adhesive composition is in the range of about 1 wt.% to about 30 wt.%, preferably about 5 wt.% to about 20 wt.%, and particularly preferably about 5 wt.% to about 15 wt.%. The aforementioned effects provided by the polymer cannot be exhibited if the polymer is contained in an amount less than 1 wt.% or more than 30 wt.%.
10

The specific molecular weight of the crystallizable polymer to be used is an important factor that determines the manner in which the adhesive composition used in the present invention exhibits temperature-dependent tackiness and/or adhesion binding strength. Specifically, a low molecular weight crystallizable polymer will lose bonding strength when heated. For example, the adhesion strength when heated at 60°C is decreased by 90% or more from the adhesion strength (peeling force) at room temperature (23°C) (the detailed adhesion strength test conditions will be described later).
15
20

Accordingly, the weight average molecular weight

of the polymer is preferably about 3,000 to about 25,000, and more preferably about 4,000 to about 15,000. If the weight average molecular weight of the polymer exceeds about 25,000, there is an insufficient decrease in
5 tackiness responsive to heating. If the weight average molecular weight of the polymer is less than about 3,000, the adhesion strength undergoes a substantial change with the lapse of time, which is not preferable.

10 The adhesive composition according to the present invention may be obtained by admixing a pressure-sensitive adhesive and a crystallizable polymer in a compatible solvent, and adding optional components thereto, e.g., plasticizers, tackifiers, fillers,
15 cross-linking agents and the like. The solid contents are adjusted to a desired viscosity, and the mixture is blended until it is homogeneous. After blending, bubbles are removed from the mixture.

20 Examples of tackifiers include special rosin ester type tackifiers, terpene phenol type tackifiers, petroleum resin type tackifiers, high hydroxyl value rosin ester type tackifiers, hydrogenated rosin ester type tackifiers, and the like.

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Examples of cross-linking agents include:
isocyanate-type compounds such as
tetramethylenediisocyanate, hexamethylenediisocyanate,
5 an adduct obtained by adding three tolylenediisocyanates
to trimethylolpropane, or polyisocyanate; epoxy-type
compounds such as sorbitol polyglycidylether,
polyglycerol polyglycidylether, pentaerythritol
polyglycidylether, diglycerol polyglycidylether,
10 glycerol polyglycidylether, neopentylglycol
diglycidylether, or resorcin diglycidylether;
aziridine-type compounds such as trimethylolpropane-
tri- β -aziridynyl propionate, tetramethylolmethane-
tri- β -aziridynyl propionate, N,N'-hexamethylene-1,6-
15 bis(1-aziridine carboxyamide), N,N'-toluene-2,4-bis(1-
aziridine carboxyamide), N,N'-diphenylmethane-4,4'-
bis(1-aziridine carboxyamide), or trimethylolpropane-
tri- β -(2-methylaziridine)propionate; and melamine-type
compounds such as hexamethoxymethylol melamine. These
20 may be used alone, or two or more kinds of them may be
used in combination. The cross-linking agent is
contained preferably in an amount of 0.1 to 5 parts by
weight, and more preferably 0.1 to 3 parts by weight, with
respect to 100 parts by weight of the base polymer.

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In order to provide a temperature-active adhesive composition on a substrate film, a knife coater, a roll coater, a calender coater, a comma coater, or the like
5 is often used in general. Depending on the thickness of the coating and the viscosity of the material, a gravure coater or a rod coater may be used. The adhesive composition may be applied by being transferred from a release sheet, as in the manner of transfer printing. The
10 composition may be applied neat (i.e., without anything else), or in a suitable solvent, or as an emulsion or latex. Thus, an adhesive layer is formed from the adhesive composition.

15 In terms of prevention of contamination during storage or commercial distribution, it is preferable to adhesion-protect the adhesive layer with a separator until the adhesive layer is adhered to the surface of a green sheet for ceramic electronic devices. The
20 separator can be made of paper, a plastic film such as a polypropylene film or a polyester film, or a thin flexible leaf of metal foil or the like. The separator is subjected to a surface treatment with a release agent as necessary so as to be rendered easy to peel.

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Next, a method for producing a ceramic multilayer capacitor as a ceramic electronic device will be described.

5

First, a slurry of ceramic powder is thinly spread out with a doctor blade to make a ceramic green sheet, and electrodes are printed on the surface of the green sheet. Then, a number of such green sheets are laminated and integrated so as to form a green sheet laminate. Next, the laminate is affixed on a base via the adhesive tape according to the present invention. Since the temperature at this time is relatively low (e.g., about 20°C to about 40°C), the laminate adheres well to the adhesive layer of the adhesive tape.

Next, the laminate is heat-pressed and cut. At this time, the works do not peel off the adhesive layer or be transferred onto any green sheets that are yet to be cut. After a number of ceramic laminate chips are formed in this manner, the resultant works are removed from the adhesive tape. Thereafter, the works are subjected to a preliminary sintering process, and a sintering process. At this time, the adhesive tape is

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heated at a predetermined temperature or above as mentioned above, whereby the work can be easily peeled off the adhesive tape. Thereafter, the works are sintered, and external electrodes are formed on end faces
5 of the works, whereby chip-type multilayer ceramic capacitors are obtained.

As for methods for heating the adhesive tape, the tape or a retention member (base) for the tape may be heated
10 by the following methods, for example:

placing the tape or the retention member on a hot plate, blowing hot air over it (e.g., from an air heater or a drier), placing it in an oven, blowing steam over
15 it, applying radiowaves to it for heating, or using a lamp (infrared or far-infrared).

Specifically, it is preferable to attach a green sheet for ceramic electronic devices to the adhesive tape
20 surface at a temperature which is below the melting point of the polymer used, and to peel the chip off the adhesive tape surface at a temperature which is equal to or greater than the melting point of the polymer after the cutting.

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Moreover, it is preferable to ensure that the peeling force is reduced to about 10% or less at a temperature which is equal to or greater than the melting point of the side-chain crystallizable polymer. It is
5 preferable that the adhesion strength of the adhesive composition with a stainless steel plate when heated to about 35°C or above is about 10% or less of the adhesion strength with a stainless steel plate at about 23°C, or about 10 g/25 mm or less.

10

Although multilayer ceramic capacitors are illustrated above as ceramic electronic devices, the present invention is not limited thereto. The present invention is applicable to, for example, an adhesive tape
15 for temporary attachment which is to be used in a step of cutting green sheets for ceramic electronic devices into a number of chips during the production of fine ceramic devices such as IC circuit boards, ferrites, sensor elements, or varistors.

20

(Examples)

Hereinafter, the present invention will be specifically described by way of illustrative examples. In the following description, any reference to "part(s)"

means "part(s) by weight".

A. Preparation of polymer

5 (Synthesis Example 1)

First, 95 parts of stearyl acrylate, 5 parts of acrylic acid, 5 parts of dodecylmercaptan, and 1 part of Kayaester HP-70 (Kayaku Akzo K.K.) were mixed. The mixture was stirred at 80°C for 5 hours to polymerize these
10 monomers. The resultant polymer had a weight average molecular weight of about 8,000, and a melting point of 50°C.

(Synthesis Example 2)

15 First, 92 parts of 2-ethylhexylacrylate, 8 parts of 2-hydroxyethylacrylate, and 0.3 parts of Trigonox 23-C70 (Kayaku Akzo K.K.) were mixed in 150 parts of ethyl acetate/heptane (70/30). The mixture was stirred at 55°C for 3 hours, and thereafter heated to 80°C, and 0.5 parts
20 of Kayaester HP-70 was added. The mixture was stirred for 2 hours to polymerize these monomers. The resultant polymer had a weight average molecular weight of about 600,000.

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B. Preparation of an adhesive tape for temporary attachment of green sheets for multilayer ceramic capacitors

5 (Example 1)

The polymers obtained according to Synthesis Examples 1 and 2 above were mixed at a ratio of 5 parts to 100 parts. To this polymer solution, Coronate L45 (Nippon Polyurethane Industry Co., Ltd.) was added as a
10 cross-linking agent, so that 0.5 parts of Coronate L45 was present for 100 parts of the polymer of Synthesis Example 2. Then, the polymer solution was applied by using a roll coater on a surface of a polyethylene terephthalate (PET) film (about 100 μm) which had been
15 subjected to a corona treatment. Thus, an adhesive tape for temporary attachment with a release sheet, having an acrylic-type adhesive layer (thickness: about 30 μm) was obtained.

20 The following evaluation tests were performed for the resultant adhesive tape for temporary attachment.

(1) Peeling force

A 180° peeling force of the adhesive tape was

measured with respect to SUS, according to JIS C2107. The measurements were taken at 23°C and 60°C, respectively.

(2) Work peeling state

5 After the adhesive tape was peeled off a SUS surface, the level of contamination on the SUS surface was measured by TDS (Thermal Desorption Spectroscopy) techniques. In addition, the presence/absence of interlayer destruction in the works was determined by
10 visual inspection of the work cross-sections. The results are shown in Table 1. In the table, "○" represents an excellent product; and "×" represents an unacceptable product.

15 (Example 2)

 An adhesive tape for temporary attachment was obtained in a manner similar to Example 1 except that Coronate L45 was added as a cross-linking agent to the polymer solution obtained according to Example 1 so that
20 1.0 parts of Coronate L45 was present for 100 parts of the polymer according to Synthesis Example 2. The peeling force and the work peeling state of the resultant adhesive tape for temporary attachment were evaluated in a manner similar to Example 1. These results are shown

in Table 1.

(Example 3)

An adhesive tape for temporary attachment was
5 obtained in a manner similar to Example 1 except that
Coronate L45 was added as a cross-linking agent to the
polymer solution obtained according to Example 1 so that
3.0 parts of Coronate L45 was present for 100 parts of
the polymer according to Synthesis Example 2. The
10 peeling force and the work peeling state of the resultant
adhesive tape for temporary attachment were evaluated in
a manner similar to Example 1. These results are shown
in Table 1.

15 (Comparative Example 1)

To 100 parts of the polymer obtained according to
Synthesis Example 2 above, 3 parts of Coronate L45
(Nippon Polyurethane Industry Co., Ltd.) was added as a
cross-linking agent. This mixture was applied by using
20 a roll coater on a surface of a PET film (about 100 μ
m) which had been subjected to a corona treatment. Thus,
an adhesive tape for temporary attachment with a release
sheet, having an acrylic-type adhesive layer (thickness:
about 50 μ m) was obtained.

The peeling force and the work peeling state of the resultant adhesive tape for temporary attachment were evaluated in a manner similar to Example 1. These
5 results are shown in Table 1.

(Comparative Example 2)

To 100 parts of the polymer obtained according to Synthesis Example 2 above, 6 parts of Coronate L45
10 (Nippon Polyurethane Industry Co., Ltd.) was added as a cross-linking agent. This mixture was applied by using a roll coater on a surface of a PET film (about 100 μ m) which had been subjected to a corona treatment. Thus, an adhesive tape for temporary attachment with a release
15 sheet, having an acrylic-type adhesive layer (thickness: about 50 μ m) was obtained.

The peeling force and the work peeling state of the resultant adhesive tape for temporary attachment were
20 evaluated in a manner similar to Example 1. These results are shown in Table 1.

(Comparative Example 3)

With respect to a commercially available product

RIBAALPHA 3194MS, manufactured by Nitto Denko Corporation), the adhesion strength and contaminating properties of this adhesive tape for temporary attachment were evaluated in a manner similar to Example 1. These
5 results are shown in Table 1.

Table 1

	Adhesive	Peeling force (g/25 mm)		Work peeling state	
		23°C	60°C	interlayer destruction	residue
Ex.1	temperature sensitive adhesive	100	10 or less	○	○
Ex.2	temperature sensitive adhesive	30	10 or less	○	○
Ex.3	temperature sensitive adhesive	20	10 or less	○	○
Comp Ex.1	pressure sensitive adhesive	300	200	×	×
Comp Ex.2	pressure sensitive adhesive	300	100	×	×
Comp Ex.3	pressure sensitive adhesive	30	10	○	×

○: excellent products

10 ×: unacceptable products

The adhesive tapes according to Comparative

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Examples 1 and 2 had poor releasability from the work surface, resulting in interlayer destruction. Contamination on the work surface was also observed for Comparative Examples 1 to 3. In contrast, Examples 1 to 5 3 were excellent in terms of releasability as well as contaminating properties after heating (60°C), and yet the initial adhesion strength (23°C) was enhanced.

(Example 4)

10 Next, a test was conducted as follows to study the relationship between the molecular weight of the side-chain crystallizable polymer contained in the adhesive layer and the rate of decrease in the peeling force responsive to the heating of the adhesive tape for 15 temporary attachment having such an adhesive layer.

Monomer mixtures obtained by adding different numbers of parts of dodecylmercaptan (polymerization inhibitor) to a mixture of 95 parts of stearyl acrylate and 5 parts of acrylic acid were stirred at 80°C for 5 20 hours to polymerize these monomers. As a result, polymers having weight average molecular weights of about 2,000, 4,000, 8,000, 15,000, and 19,000 were obtained (respectively shown in Table 2 as Polymers 1 to 5).

To 15 parts of each polymer obtained above,
85 parts of the polymer obtained according to Synthesis
Example 2 above was mixed. Coronate L45 (Nippon
5 Polyurethane Industry Co., Ltd.) was added as a
cross-linking agent to these polymer solutions so that
0.5 parts of Coronate L45 was present for 100 parts of
the polymer according to Synthesis Example 2. These
polymer solutions were applied by using a roll coater on
10 a surface of a polyester film (thickness: about 50 μ
m) whose surface had been subjected to a matt treatment.
Thus, adhesive tapes for temporary attachment with a
release sheet, each having an acrylic-type adhesive layer
(dry thickness: about 20 μ m) were obtained.

15

The resultant adhesive tapes for temporary
attachment were cut out in strips having a width of 25 mm
to be used as test pieces.

20

Next, the adhesive layers of the aforementioned
test pieces were pressure-attached onto a SUS plate, whose
surface had been polished with #280, by allowing a rubber
roller (width: 45 mm; load: 2 kg) to reciprocate thereon
four times at 23°C. After the attachment, the test pieces

were left intact for 20 minutes. One end of each test piece was peeled at a rate of 300 mm/minute in a 180° direction, and the resistance value felt during peeling was measured as a peeling force at 23°C.

5

Furthermore, test pieces which had been produced in a similar manner to the above were placed on a hot plate, which had previously been heated to 60°C, and left intact for 20 minutes. One end of each test piece was peeled
10 at a rate of 300 mm/minute in a 180° direction, and the resistance value felt during peeling was measured as a peeling force at 60°C. The results are shown in Table 2.

Table 2

15 <Example 4>

Sample No.	Molecular weight	Peeling force (g/25 mm)		
		23°C	60°C	Rate of decrease from 23°C to 60°C
Polymer 1	2,000	60 g	5 g	92%
Polymer 2	4,000	150 g	10 g	93%
Polymer 3	8,000	180 g	8 g	96%
Polymer 4	15,000	160 g	10 g	94%
Polymer 5	19,000	150 g	30 g	80%

From Table 2, it can be seen that the peeling force at the time of heating does not decrease if the molecular

weight of the side-chain crystallizable polymer is too large, thereby resulting in a low rate of decrease.

(Example 5)

5 Next, a test was conducted as follows to study the relationship between the molecular weight of the side-chain crystallizable polymer contained in the adhesive layer and the change in the peeling force, due to a lapse of time, of the adhesive tape for temporary
10 attachment having such an adhesive layer.

 Adhesive tapes for temporary attachment, obtained in a manner similar to Example 4 above, were cut out in strips having a width of 25 mm to be used as test
15 pieces.

 The peeling forces of these test pieces at 23°C were measured in a manner similar to Example 4.

20 Next, similarly produced test pieces were left in an isothermal/isohumid room at 23°C for 2 months, and the peeling forces of these test pieces at 23°C were measured in a manner similar to Example 4.

These results are shown in Table 3. In Table 3, the rate of change over 2 months is shown as a rate compared against the value taken immediately after manufacture defined as 100.

5

Table 3

<Example 5>

Sample No.	Molecular weight	Peeling force (g/25 mm)		
		Immediately after manufacture	2 months from manufacture	Rate of change over 2 months
Polymer 1	2,000	60 g	40 g	-33%
Polymer 2	4,000	150 g	125 g	-17%
Polymer 3	8,000	180 g	160 g	-11%
Polymer 4	15,000	160 g	165 g	+3%
Polymer 5	19,000	150 g	145 g	-3%

From Table 3, it can be seen that the tackiness of the adhesive tape decreases somewhat during storage if the molecular weight of the side-chain crystallizable polymer is small.

15 INDUSTRIAL APPLICABILITY

There is provided an adhesive tape for temporary attachment of green sheets for ceramic electronic devices, and a method for producing ceramic electronic devices,

such that a sufficient adhesion strength for not causing scattering or dislocation of chips is exhibited until a step of cutting the green sheets is performed and that a reduction in the adhesion strength is realized when
5 peeling off the works so that interlayer destruction does not occur and no residues are left.

CLAIMS

1. (Amended) An adhesive tape for temporary attachment of green sheets for a ceramic electronic device, comprising a substrate film and an adhesive layer provided on at least one face of the substrate film,

wherein the adhesive layer comprises an adhesive composition, the adhesive composition containing a pressure-sensitive adhesive and about 1 to about 30 wt.% of a side-chain crystallizable polymer on the basis of the adhesive composition, and wherein the side-chain crystallizable polymer comprises as a main component an acrylic acid alkyl ester and/or a methacrylic acid alkyl ester which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain, and wherein the adhesion strength of the adhesive composition with a stainless steel plate when heated to about 35°C or above is 10% or less of the adhesion strength with the stainless steel plate at about 23°C.

2. (Canceled)

3. An adhesive tape for temporary attachment according to claim 1, wherein the adhesive composition is of such

a nature that the adhesive composition easily peels off the green sheets for the ceramic electronic device at about 35°C or above.

4. An adhesive tape for temporary attachment according to claim 1, wherein the side-chain crystallizable polymer has a melting point occurring within a temperature range narrower than about 15°C.

5. (Canceled)

6. An adhesive tape for temporary attachment according to claim 1, wherein the polymer has a weight average molecular weight of about 3,000 to about 25,000.

7. (Amended) A method for producing a ceramic electronic device, comprising the steps of:

allowing a green sheet laminate of ceramics to adhere to a base via an adhesive tape;

cutting the laminate into chips; and peeling the chips off a surface of the adhesive tape while heating the adhesive tape,

wherein the adhesive tape comprises a substrate film

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and an adhesive layer provided on at least one face of the substrate film, the adhesive layer comprising an adhesive composition, the adhesive composition containing a pressure-sensitive adhesive and about 1 to
5 about 30 wt.% of a side-chain crystallizable polymer on the basis of the adhesive composition, and wherein an adhesion strength of the adhesive composition with a stainless steel plate when heated to about 35°C or above is about 10% or less of an adhesion strength with the
10 stainless steel plate at 23°C.

8. A method for producing a ceramic electronic device according to claim 7, wherein the side-chain crystallizable polymer comprises as a main component an
15 acrylic acid alkyl ester and/or a methacrylic acid alkyl ester which has a straight-chain alkyl group including 16 or more carbon atoms as a side chain.

9. A method for producing a ceramic electronic device
20 according to claim 7, wherein the polymer has a weight average molecular weight of about 3,000 to about 25,000.

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ABSTRACT

TITLE : "ADHESIVE TAPE FOR TEMPORARY-ATTACHMENT OF GREEN SHEETS FOR
CERAMIC ELECTRONIC DEVICES AND METHOD FOR PRODUCING CERAMIC
ELECTRONIC DEVICE"

An adhesive tape for temporary attachment of green
sheets for a ceramic electronic device includes a
5 substrate film and an adhesive layer provided on at least
one face of the substrate film. The adhesive layer is
composed of an adhesive composition, the adhesive
composition containing a pressure-sensitive adhesive and
about 1 to about 30 wt.% of a side-chain crystallizable
10 polymer on the basis of the adhesive composition, wherein
the side-chain crystallizable polymer contains as a main
component an acrylic acid alkyl ester and/or a methacrylic
acid alkyl ester which has a straight-chain alkyl group
including 16 or more carbon atoms as a side chain. An
15 adhesive tape for temporary attachment of green sheets
for ceramic electronic devices can be provided such that
a large adhesion strength is obtained when temporarily
attaching green sheets for ceramic electronic devices,
and that when a work is to be removed, peeling can easily
20 occur without contaminating the work.