DESCRIPTION

TITLE OF INVENTION: WAFER-PROCESSING TAPE

TECHNICAL FIELD

{0001}

The present invention relates to a wafer-processing tape.

BACKGROUND ART

{0002}

In a process of producing semiconductor devices, the steps to be carried out include: a step of cutting (dicing) a silicon wafer into chip units; a step of picking up the thus-cut semiconductor elements (chips); and a step of die-bonding (mounting) the thus-picked-up chips to lead frames, package substrate boards, or the like. As a wafer-processing tape that is used in the process of producing semiconductor devices, in recent years, a dicing die-bonding sheet is known, in which a removable adhesive layer and an adhesive layer are formed, in this order, on a supporting substrate (see, for example, Patent Literature 1).

As such, in a wafer-processing tape in which a removable adhesive layer and an adhesive layer are formed in this order on a substrate, the time period that the removable adhesive layer and the adhesive layer are brought into contact with each other is necessarily lengthened, between the production and the use thereof. Thus, this causes a problem that those two layers become blended with each other before use, so that, in the step of picking up the thus-chipped and adhesive layer-adhered semiconductor elements, the removable adhesive layer and the adhesive layer may not be sufficiently peeled off from each other.

Thus, a wafer-processing tape that addresses such a problem is known, to make the chipped and adhesive layer-adhered semiconductor elements readily

peel off from the removable adhesive layer, by providing a peeling-off layer between the removable adhesive layer and the adhesive layer (see, for example, Patent Literature 2).

Further, a wafer-processing tape is known, which is advantageous in peeling-off from the removable adhesive layer, and which is also excellent in adhesiveness to an object to adhere, by controlling the surface free energy of the adhesive layer before curing (see Patent Literature 3).

CITATION LIST

PATENT LITERATURES

{0003}

Patent Literature 1: JP-A-60-57642 ("JP-A" means unexamined published Japanese patent application)

Patent Literature 2: JP-A-2005-277383

Patent Literature 3: JP-A-2008-244463

SUMMARY OF INVENTION

TECHNICAL PROBLEM

{0004}

A wafer-processing tape of this kind is used in the steps below:

(1) A step of laminating a supporting substrate, a removable adhesive layer, and an adhesive layer, in this order, to form the wafer-processing tape;

(2) A step of adhering the adhesive layer of the wafer-processing tape to the backing surface of a silicon wafer;

(3) A step of adhering a wafer ring to the removable adhesive layer formed on the supporting substrate of the wafer-processing tape;

(4) A step of dicing, by cutting the silicon wafer into semiconductor elements (chips);

(5) A step of picking up, by peeling off an adhesive layer-adhered semiconductor element from the removable adhesive layer, to take the resultant semiconductor element out; and

(6) A step of die bonding, by adhering the resultant semiconductor element to a wiring-adhered wiring member for external connection, such as a lead frame, or to another semiconductor element.

For this reason, the face of the adhesive layer that is brought into contact with an object to be adhered in the die-bonding step becomes a face that is once adhered to the removable adhesive layer and then peeled off therefrom, to change the surface free energy thereof. Thus, there is a problem that sufficient adhesiveness may not be exhibited, even if the surface free energy of the adhesive layer alone is controlled.

In view of the above, the present invention is contemplated for providing a wafer-processing tape having an adhesive layer which has sufficient adhesiveness, even if the adhesive layer has a face that has been once adhered to a removable adhesive layer and then peeled off from the removable adhesive layer.

SOLUTION TO PROBLEM

{0005}

The problems of the present invention can be solved by the following means.

(1) A wafer-processing tape, having a supporting substrate, a removable adhesive layer, and a single layer of an adhesive layer, which are laminated in this order, in which the adhesive layer is an adhesive layer which is used to crimp (i.e. to adhere by applying a pressure) a semiconductor element to a wiring-adhered wiring member for external connection or another semiconductor element, and in which a difference in surface free energy between the face of the

adhesive layer that has been peeled-off from the removable adhesive layer and the face that is not brought into contact with the removable adhesive layer is 10 mJ/m^2 or less.

(2) The wafer-processing tape as described in the item (1), in which the surface free energy of the face of the adhesive layer that is not in contact with the removable adhesive layer is from 30 mJ/m^2 to 50 mJ/m^2.

(3) The wafer-processing tape as described in the item (1) or (2), in which the adhesive layer contains a polymer compound obtained by suspension polymerization including acrylonitrile.

Herein, according to the present invention, the adhesive refers to a resin composition that is used to fix a semiconductor element (chip) and a wiring member or another semiconductor element in the die-bonding step of the production of semiconductor devices, while the removable adhesive refers to a resin composition that is provided on a supporting substrate, and that is adhered to the backing surface of a silicon wafer, with the adhesive layer interposed therebetween, so as to provisionally fix the adhesive-adhered silicon wafer to a ring frame by the adhesive force of the removable adhesive, in the dicing step of the production of semiconductor devices.

ADVANTAGEOUS EFFECTS OF INVENTION

{0006}

According to the present invention, there is provided a wafer-processing tape having an adhesive layer which has sufficient adhesiveness, even if the adhesive layer has a face that has been once adhered to a removable adhesive layer and then peeled off from the removable adhesive layer.

{0007}

Other and further features and advantages of the invention will appear more fully from the following description, appropriately referring to the

accompanying drawing.

BRIEF DESCRIPTION OF DRAWING

{0008}

{Fig. 1}

Fig. 1 is a cross-sectional view schematically illustrating a wafer-processing tape of the present invention.

MODE FOR CARRYING OUT THE INVENTION

{0009}

The wafer-processing tape of the present invention has a supporting substrate, a removable adhesive layer, and a single layer of an adhesive layer, laminated in this order. Fig. 1 illustrates the wafer-processing tape of the present invention in a schematic cross-sectional view. A wafer-processing tape 10 is composed of a removable adhesive film 12 and an adhesive layer 13. The removable adhesive film 12 is a film in which a removable adhesive layer 12b is laminated on a supporting substrate 12a. On the adhesive layer 13, a releasable PET film 11 is superimposed, but at the time of use, this releasable PET film is peeled off, and a silicon wafer is adhered to the adhesive layer 13.

(Surface free energy)

In the present invention, the surface free energy is defined as the value obtained by measuring the contact angle between water and diiodomethane (liquid droplet volume: water 2 μL, diiodomethane 3 μL; reading time: 30 seconds after dropwise addition), and calculated by the following formulas:

{0010}

$$\gamma_s = \gamma_s^p + \gamma_s^d$$

$$72.8(1 + \cos\theta^H) = 2(21.8\gamma_s^d)^{\frac{1}{2}} + 2(51.0\gamma_s^p)^{\frac{1}{2}}$$

$$50.8(1 + \cos\theta^I) = 2(48.5\gamma_s^d)^{\frac{1}{2}} + 2(2.3\gamma_s^p)^{\frac{1}{2}}$$

γ_s : **Surface free energy**

γ_s^p : **Polar component of surface free energy**

γ_s^d : **Dispersed component of surface free energy**

θ^H : **Contact angle of water against solid surface**

θ^I : **Contact angle of diiodomethane against solid surface**

{0011}

The reason is not clearly known, why a wafer-processing tape having an adhesive layer which has sufficient adhesiveness, even if the adhesive layer is a face that has been once adhered to a removable adhesive layer and then peeled off from the removable adhesive layer, can be obtained, by controlling the difference in the surface free energy. However, it is anticipated that the reason may be as follows.

When the difference in the surface free energy is controlled, it is prevented that the adhesiveness of only one of the faces is conspicuously lowered, and the fracture mode of the adhesive can be maintained to be cohesive fracture. When the fracture mode of the adhesive is cohesive fracture, if the adhesive itself is not fractured, fixing of the semiconductor element is not broken, and even if thermal

stress is generated in a reflow step, the adhesive exhibits resistance. However, if the control is insufficient, and the adhesiveness of only any one face is conspicuously lowered, the fracture mode of the adhesive comes to be interfacial fracture. Even if the strength of the adhesive is sufficient, peeling off caused by thermal stress proceeds, and reliability (resistance to cracking upon reflow) is lowered.

{0012}

In the wafer-processing tape of the present invention, the difference in the surface free energy between the face of the adhesive layer that has been peeled off from the removable adhesive layer and the face that is not brought into contact with the removable adhesive layer is 10 mJ/m^2 or less, and preferably 0.1 to 5.0 mJ/m^2. If the difference in the surface free energy is greater than 10 mJ/m^2, there is a possibility that the transfer of components may occur from the removable adhesive layer to the adhesive layer, or from the adhesive layer to the removable adhesive layer. In the former case, low-molecular weight components volatilize upon the reflow step. In the latter case, the resultant adhered surface is roughened to occur voids due to that the surface unevenness may not be embedded in the bonding step, and thereby to lower the reliability (resistance to cracking upon reflow).

{0013}

The surface free energy of the face of the adhesive layer that is not brought into contact with the removable adhesive layer is preferably from 30 mJ/m^2 to 50 mJ/m^2, and the surface free energy of the face of the adhesive layer that has been peeled off from the removable adhesive layer is preferably from 30 mJ/m^2 to 60 mJ/m^2. The surface free energy of the face of the adhesive layer that is not brought into contact with the removable adhesive layer is more preferably from 30 mJ/m^2 to 40 mJ/m^2, and the surface free energy of the face of the adhesive layer that has been peeled off from the removable adhesive layer is

more preferably from 30 mJ/m^2 to 50 mJ/m^2. If the surface free energy is less than 30 mJ/m^2, since the face does not have sufficient wettability, voids are apt to be introduced, and the reliability (resistance to cracking upon reflow) may be lowered.

{0014}

(Adhesive layer)

The adhesive layer is a layer produced by forming an adhesive into a film in advance, and use can be made, for example, of any of a polyimide resin, a polyamide resin, a polyether imide resin, a polyamideimide resin, a polyester resin, a polyester imide resin, a phenoxy resin, a polysulfone resin, a polyether sulfone resin, a polyphenylene sulfide resin, a polyether ketone resin, a chlorinated polypropylene resin, an acrylic resin, a polyurethane resin, an epoxy resin, a polyacrylamide resin, a melamine resin, or a mixture thereof, which are known to be used in adhesives. From the viewpoints of adhesiveness and reliability of the adhesive layer, it is preferable that the adhesive layer contain an acrylic-based copolymer or an epoxy resin, and that the acrylic-based copolymer has a Tg of from 0°C to 40°C, and a mass average molecular weight of 100,000 to 1,000,000. A more preferred mass average molecular weight is from 600,000 to 900,000.

The mass average molecular weight is defined as a value measured by a gel permeation chromatographic (GPC) method, using a calibration curve produced with polystyrene standard.

(Measurement conditions according to the GPC method)

Instrument to be used: High-performance liquid chromatography LC-20AD [trade name, manufactured by Shimadzu Corp.]

Column: Shodex Column GPC KF-805 [trade name, manufactured by Shimadzu Corp.]

Eluent: chloroform

Measurement temperature: 45°C

Flow rate: 3.0 ml/min

RI detector: RID-10A

{0015}

There are no particular limitations on the method of polymerizing the acrylic-based copolymer, and examples include pearl polymerization, solution polymerization, and suspension polymerization. The copolymer can be obtained by any of these methods. Suspension polymerization is preferred due to excellent heat resistance of the product, and examples of such an acrylic-based copolymer include Paracron W-197C (trade name, manufactured by Negami Chemical Industries Co., Ltd.).

The acrylic-based copolymer preferably contains acrylonitrile. In the acrylic-based copolymer, the content of acrylonitrile is preferably 10 to 50 mass%, and more preferably 20 to 40 mass%. When the content of acrylonitrile is 10 mass% or greater, the Tg of the adhesive layer is raised, and thereby adhesiveness can be enhanced. However, if the content is greater than 50 mass%, the fluidity of the adhesive layer is deteriorated, and adhesiveness may be lowered. An acrylic-based copolymer containing acrylonitrile, which is obtained by suspension polymerization, is particularly preferred.

{0016}

The acrylic-based copolymer may have a functional group, to enhance adhesiveness. There are no particular limitations on the functional group, but examples thereof include an amino group, a urethane group, an imido group, a hydroxyl group, a carboxyl group, and a glycidyl group. Among them, a glycidyl group is preferred. Since a glycidyl group is highly reactive with epoxies, which are thermosetting resins, and is not quite reactive with the removable adhesive layer as compared with a hydroxyl group or the like, thus any change in the surface free energy is not apt to occur.

{0017}

The adhesive layer may contain an inorganic filler, but if the amount of addition of the inorganic filler is too large, fluidity is lowered, and adhesiveness is lowered. Thus, the amount of addition thereof is preferably less than 40 mass%, more preferably less than 20 mass%, and even more preferably less than 15 mass%. Furthermore, if the particle size is too large, the surface to be adhered has surface unevenness, and thus adhesiveness is lowered. Thus, the average particle size is preferably less than 1 μm, more preferably less than 0.5 μm, and even more preferably less than 0.1 μm. There are no particular limitations on the lower limit of the particle size of the inorganic filler, but the lower limit is practically 0.003 μm or greater.

In order to control the surface free energy, a silane coupling agent or a titanium coupling agent, or a fluorine-based graft copolymer may also be added as an additive. It is preferable that these additives contain mercapto groups or glycidyl groups.

The thickness of the adhesive layer is not particularly limited, but generally the thickness is preferably 3 to 100 μm, and more preferably 5 to 20 μm.

{0018}

(Supporting substrate)

Examples of the material for the supporting substrate include a homopolymer or copolymer of α-olefin, such as polyethylene, polypropylene, an ethylene-propylene copolymer, polybutene-1, poly-4-methylpentene-1, an ethylene/vinyl acetate copolymer, an ethylene/ethyl acrylate copolymer, an ethylene/methyl acrylate copolymer, an ethylene/acrylic acid copolymer, and an ionomer, or a mixture thereof; a thermoplastic elastomer, such as polyurethane, a styrene/ethylene/butene copolymer or pentene-based copolymer, and a polyamide/polyol copolymer; and a mixture thereof. Furthermore, use may be made of a mixture of two or more kinds of materials selected from this group of

materials, or a single layer substrate or a multilayer substrate of these materials may also be used. The thickness of the supporting substrate is not particularly limited, and may be appropriately set, and the thickness is preferably 50 to 200 μm.

{0019}

(Removable adhesive layer)

The removable adhesive layer can be classified into a radiation-curable type and a non-radiation-curable type which has no change in the adhesive force even under irradiation with a radiation. Since the former type allows easy control of the adhesive force, while the latter type can be used in devices which do not tolerate irradiation with any radiation, the removable adhesive layer is appropriately selected in accordance with the use. In the case of selecting a radiation-curable type, it is preferable to prepare the removable adhesive layer by appropriately blending with a radiation-polymerizable compound having photopolymerizable carbon-carbon double bonds or a photopolymerization initiator.

When the removable adhesive layer is of the radiation-curable type, it is preferable to use a removable adhesive layer having a peeling force between the removable adhesive layer and the adhesive layer after curing of from 0.01 N/25mm to 0.5 N/25mm. More preferably, the peeling force is from 0.01 N/25mm to 0.1 N/25mm. If the peeling force is less than 0.01 N/25mm, there is a possibility that at the time of conveyance from a dicing apparatus to a pickup apparatus, adhesive layer-adhered semiconductor elements may be peeled off from the removable adhesive layer. If the peeling force is greater than 0.5 N/25mm, the adhesive layer is apt to be affected by the removable adhesive layer, so that the face may be roughened, or transfer of the surface components may occur. Thus, the surface free energy is apt to be changed.

When the removable adhesive layer is of the non-radiation-curable type, it

is preferable to use a removable adhesive layer having a peeling force between the removable adhesive layer and the adhesive layer of from 0.01 N/25mm to 0.5 N/25mm. More preferably, the peeling force is from 0.01 N/25mm to 0.3 N/25mm. If the peeling force is less than 0.01 N/25mm, chip flying-off may occur upon dicing, or there is a possibility that at the time of conveyance from a dicing apparatus to a pickup apparatus, adhesive layer-adhered semiconductor elements may be peeled off from the removable adhesive layer. If the peeling force is greater than 0.5 N/25mm, the adhesive layer is apt to be affected by the removable adhesive layer, so that the face may be roughened, or transfer of the surface components may occur. Thus, the surface free energy is apt to be changed.

There are no particular limitations on the thickness of the removable adhesive layer, but generally the thickness is preferably 5 to 50 μm, and more preferably 7 to 20 μm.

EXAMPLES

{0020}

The present invention will be described in more detail based on examples given below, but the invention is not meant to be limited by these.

{0021}

<Preparation of acrylic polymer>

First, description is made on the production methods of acrylic polymers that were included in the adhesive layers of the wafer-processing tapes according to Examples according to the present invention and Comparative Examples.

(Acrylic polymer (1))

In a four-necked round bottom flask made of glass and equipped with a stirrer, 300 parts by mass of water was placed, and 0.7 parts by mass of polyvinyl alcohol as a dispersion stabilizer was dissolved therein. While the resultant

solution was stirred at 300 rpm with a stirring blade, a monomer mixture including 60 parts by mass of ethyl acrylate, 5 parts by mass of butyl acrylate, 15 parts by mass of glycidyl methacrylate, and 20 parts by mass of acrylonitrile, and 1 part by mass of N,N'-azobisisobutyronitrile as a polymerization initiator were introduced to the flask all at once. Thus, a suspension was prepared.

This suspension was allowed to cause reaction by heating the reaction system to 68°C and maintaining the temperature constant for 4 hours, while the system was continuously stirred. Thereafter, the reaction system was cooled to room temperature (about 25°C). Then, the reaction product was subjected to solid-liquid separation, and the solid product was sufficiently washed with water. The solid product was dried at 70°C for 12 hours using a dryer, and then 2-butanone was added thereto to adjust the solid content to 15%. Thus, an acrylic polymer (1) was obtained. The Tg calculated from the mixing ratio is 3°C. The mass average molecular weight of this polymer as measured by gel permeation chromatography (GPC) was 950,000, and the degree of dispersion was 3.5.

{0022}

(Acrylic polymer (2))

An acrylic polymer (2) was produced by the production method in the same manner as that for the acrylic polymer (1), except that 60 parts by mass of ethyl acrylate, 5 parts by mass of butyl acrylate, 6 parts by mass of glycidyl methacrylate, and 29 parts by mass of acrylonitrile were used. The Tg calculated from the mixing ratio is 7°C. The mass average molecular weight of this polymer as measured by gel permeation chromatography was 600,000, and the degree of dispersion was 3.4.

(Acrylic polymer (3))

An acrylic polymer (3) was produced by the production method in the same manner as that for the acrylic polymer (1), except that 34 parts by mass of ethyl acrylate, 15 parts by mass of butyl acrylate, 2 parts by mass of glycidyl

methacrylate, and 49 parts by mass of acrylonitrile were used. The Tg calculated from the mixing ratio is 21°C. The mass average molecular weight of this polymer as measured by gel permeation chromatography was 120,000, and the degree of dispersion was 2.3.

{0023}

(Acrylic polymer (4))

An acrylic polymer (4) was produced by the production method in the same manner as that for the acrylic polymer (1), except that 43 parts by mass of ethyl acrylate, 15 parts by mass of butyl acrylate, 5 parts by mass of glycidyl methacrylate, and 37 parts by mass of acrylonitrile were used. The Tg calculated from the mixing ratio is 12°C. The mass average molecular weight of this polymer as measured by gel permeation chromatography was 700,000, and the degree of dispersion was 3.6.

(Acrylic polymer (5))

An acrylic polymer (5) was produced by the production method in the same manner as that for the acrylic polymer (1), except that 65 parts by mass of ethyl acrylate, 23 parts by mass of butyl acrylate, 2 parts by mass of glycidyl methacrylate, and 10 parts by mass of acrylonitrile were used. The Tg calculated from the mixing ratio is -22°C. The mass average molecular weight of this polymer as measured by gel permeation chromatography was 400,000, and the degree of dispersion was 3.8.

{0024}

(Acrylic polymer (6))

In a reactor provided with a mixer and a cooler, 60 parts by mass of ethyl acrylate, 5 parts by mass of butyl acrylate, 16 parts by mass of glycidyl methacrylate, and 19 parts by mass of acrylonitrile were placed, and the resultant mixture was heated to 85°C. To this mixture, 2 parts by mass of 2-butanone and 0.05 parts by mass of t-butyl peroxybenzoate were added, and then the mixture

was kept warm for 8 hours. After the mixture was cooled, methanol was added thereto to precipitate a polymer. The supernatant was removed, and methanol remaining in the polymer was dried. Then, 2-butanone was added to the polymer to adjust the solid content to 15%. Thus, an acrylic polymer (6) was produced. The Tg calculated from the mixing ratio is 3°C. The mass average molecular weight of this polymer as measured by gel permeation chromatography was 500,000, and the degree of dispersion was 11.5.

{0025}

The mass average molecular weights of the acrylic polymers (1) to (6) were measured by a gel permeation chromatographic (GPC) method, using a calibration curve produced with polystyrene standard.

{0026}

<Preparation of adhesive layer>

(Adhesive layer (1))

25 parts by mass of a cresol novolac-type epoxy resin (epoxy equivalent 197, molecular weight 1200, softening point 70°C), 60 parts by mass of a xylene novolac resin (hydroxyl group equivalent 104, softening point 80°C), and 20 parts by mass of a silica filler with average particle size 0.045 μm as a filler were added to 100 parts by mass of the acrylic polymer (1), to obtain a thermosetting adhesive composition. This adhesive composition was applied on a PET film that served as a releasable film, followed by heating to dry for 10 minutes at 120°C. Thus, a coating film in the B stage state with thickness after drying 20 μm was formed, to obtain a laminate of PET film/adhesive layer (1)/PET film.

As the PET film, a silicone releasing-treated PET film (Teijin DuPont Films: PUREX S-314 (trade name), thickness 25 μm) was used.

(Adhesive layers (2) to (6))

Adhesive layers (2) to (6) were obtained in the same manner as that for the adhesive layer (1), except that any one of the acrylic polymers (2) to (6) was

used instead of the acrylic polymer (1), respectively.

{0027}

<Preparation of removable adhesive film>

(Removable adhesive layer composition (1))

77 parts by mass of 2-ethylhexyl acrylate and 23 parts by mass of 2-hydroxypropyl acrylate were polymerized to obtain an acrylic copolymer having a mass average molecular weight of 800,000, and 3 parts by mass of polyisocyanate as a curing agent was added and mixed with the copolymer. Thus, a removable adhesive layer composition (1) was obtained.

(Removable adhesive layer composition (2))

65 parts by mass of butyl acrylate, 25 parts by mass of 2-hydroxyethyl acrylate, and 10 parts by mass of acrylic acid were radical polymerized, and 2-isocyanatoethyl methacrylate was added dropwise thereto, to allow reaction with the resultant copolymer. To the thus-produced acrylic copolymer having a mass average molecular weight of 800,000, 3 parts by mass of polyisocyanate as a curing agent, and 1 part by mass of 1-hydroxycyclohexyl phenyl ketone as a photopolymerization initiator were added and mixed, and thus, a removable adhesive layer composition (2) was obtained.

{0028}

(Removable adhesive films (1) and (2))

Any one of the removable adhesive layer compositions thus prepared was applied on a PET film that served as a releasable film, to a dry thickness of 10 μm, followed by drying for 3 minutes at 120°C. This removable adhesive layer composition applied on the PET film was transferred onto a polypropylene elastomer (PP:HSBR = 80:20) resin film with thickness 100 μm as a supporting substrate, to produce removable adhesive films (1) and (2), respectively.

As the polypropylene (PP), NOVATEC FG4 (trade name) manufactured by

Japan Polychem Corp. was used, and as the hydrogenated styrene/butadiene rubber (HSBR), DYNARON 1320P (trade name) manufactured by JSR Corp. was used. Furthermore, as the PET film, a silicone releasing-treated PET film (Teijin DuPont Films: PUREX S-314 (trade name), thickness 25 μm) was used.

{0029}

<Example 1>

From the adhesive layer (1) and the removable adhesive film (1) obtained as above, only one side of the PET films of the adhesive layer was peeled off, and the adhesive layer and the removable adhesive film were adhered such that the adhesive layer would be in contact with the removable adhesive layer, to obtain a releasable film-adhered wafer-processing tape, as shown in Fig. 1, in which the supporting substrate, the removable adhesive layer, the adhesive layer, and the releasable film were laminated in this order. This wafer-processing tape was used as a sample of Example 1.

<Example 2>

A wafer-processing tape of Example 2 was produced in the same manner as in Example 1, by using the adhesive layer (2) and the removable adhesive film (1) obtained as above.

<Example 3>

A wafer-processing tape of Example 3 was produced in the same manner as in Example 1, by using the adhesive layer (3) and the removable adhesive film (1) obtained as above.

<Example 4>

A wafer-processing tape of Example 4 was produced in the same manner as in Example 1, by using the adhesive layer (4) and the removable adhesive film (1) obtained as above.

<Example 5>

A wafer-processing tape of Example 5 was produced in the same manner

as in Example 1, by using the adhesive layer (1) and the removable adhesive film (2) obtained as above.

<Comparative Example 1>

A wafer-processing tape of Comparative Example 1 was produced in the same manner as in Example 1, by using the adhesive layer (5) and the removable adhesive film (1) obtained as above.

<Comparative Example 2>

A wafer-processing tape of Comparative Example 2 was produced in the same manner as in Example 1, by using the adhesive layer (6) and the removable adhesive film (1) obtained as above.

{0030}

The wafer-processing tapes of Examples 1 to 5 and Comparative Examples 1 and 2 were subjected to the following analyses and evaluations. The results are shown in Table 1.

(Surface free energy)

With respect to the adhesive layer of each sample of the Examples and Comparative Examples, the face that was not in contact with the removable adhesive layer was designated as face A, and the face that was peeled off from the removable adhesive layer was designated as face B. At this time, with respect to Example 5, the removable adhesive layer was irradiated with ultraviolet ray at 200 mJ/cm^2 with an air-cooled high-pressure mercury lamp (80 W/cm, irradiation distance 100 mm) before the adhesive layer was peeled off. The contact angles of water and diiodomethane against these face A and face B were measured (liquid droplet volume: water 2 μL, diiodomethane 3 μL; reading time: 30 seconds after dropping), and from the contact angles of water and diiodomethane obtained by the measurement, the surface free energy was calculated by the calculation formulas described above using a geometric mean method.

{0031}

(Peeling force)

The releasable film of the adhesive layer of each sample of the Examples and Comparative Examples was peeled off, and a shape retention tape (manufactured by Sekisui Chemical Co., Ltd., trade name: FORTE) was adhered to the resultant surface of the adhesive layer from which the releasable film had been peeled off, using a 2-kg roller. The resultant samples were cut out into a strip shape with width 25 mm, to give specimens in which the supporting substrate, the removable adhesive layer, the adhesive layer, and the shape retention tape were laminated in this order. The specimens thus produced were each split into two parts, to hold a laminate of "supporting substrate and removable adhesive layer" and a laminate of "adhesive layer and shape retention tape", with STROGRAPH (VE10) manufactured by Toyo Seiki Seisakusho, Ltd. Thus, the peeling force between the removable adhesive layer and the adhesive layer was measured at a line velocity of 300 mm/min. At this time, with respect to Example 5, the removable adhesive layer was irradiated with ultraviolet ray at 200 mJ/cm^2 with an air-cooled high-pressure mercury lamp (80 W/cm, irradiation distance 100 mm) before the adhesive layer was peeled off. Herein, the unit for the peeling force is [N/25mm]. Furthermore, the specimens each were split into a laminate of "supporting substrate and removable adhesive layer" and a laminate of "adhesive layer and shape retention tape", and the laminate of "adhesive layer and shape retention tape" was peeled off from the laminate of "supporting substrate and removable adhesive layer". This is because if only the adhesive layer is held to peel off, the adhesive layer is stretched.

{0032}

(Picking-up property)

The wafer-processing tape of each sample of the Examples and Comparative Examples was heated for 10 seconds at 70°C to adhere to a silicon

wafer with thickness 50 μm, and then the resultant silicon wafer was diced into chips of 10 mm × 10 mm. Then, with respect to Example 5, the removable adhesive layer was irradiated with ultraviolet ray at 200 mJ/cm^2 with an air-cooled high-pressure mercury lamp (80 W/cm, irradiation distance 10 cm). Fifty chips obtained from the central portion of the resultant silicon wafer were subjected to a pickup test with a die-bonder apparatus (manufactured by NEC Machinery Corp., trade name: CPS-100FM), to determine the success ratio of picking-up in terms of the number of chips thus picked-up. At that time, for each of the picked-up elements, when the adhesive layer peeled off from the removable adhesive layer was retained, it was judged that the picking up was successful, and the success ratio of picking-up was calculated. The calculation results are shown in Table 1. In Table 1, the criteria for "◉", "○", "Δ", and "×" (criteria for picking-up property) are as follows.

"◉": The success ratios of picking-up at thrust height 0.7 mm, 0.5 mm, and 0.3 mm, provided by thrust pins, each are 100%.

"○": The success ratios of picking-up at thrust height 0.7 mm and 0.5 mm each are 100%, and the success ratio of picking-up at thrust height 0.3 mm is lower than 100%.

"Δ": The success ratio of picking-up at thrust height 0.7 mm is 100%, and the success ratios of picking-up at thrust height 0.5 mm and 0.3 mm each are lower than 100%.

"×": The success ratios of picking-up at thrust height 0.7 mm, 0.5 mm, and 0.3 mm each are lower than 100%.

{0033}

(Reliability (crack occurrence ratio upon reflow))

The adhesive layer of each wafer-processing tape according to the Examples and Comparative Examples was adhered to the backing surface of a silicon wafer with thickness 200 μm, and then the resultant silicon wafer was

diced into chips of 7.5 mm × 7.5 mm. Then, each chip was mounted on a silver-plated lead frame, under the conditions of temperature 160°C, pressure 0.1 MPa, and time period for 1 second. Further, the chips were molded with a sealant material (KE-1000SV, trade name, manufactured by Kyocera Chemical Corp.), and thus twenty samples were produced for each Example and each Comparative Example.

Each sample after sealing of the Examples and Comparative Examples was subjected to a treatment of: holding the sample for 196 hours in a constant temperature and constant humidity layer at 85°C/60%RH; passing the resultant sample through an IR (infrared) reflow furnace that was set such that the highest temperature of the sample surface would be 260°C in 20 seconds; and cooling the resultant sample by leaving at room temperature, with this treatment being repeated three times. For each Example and Comparative Example, cracks whether occurred or not was observed in twenty samples that had been treated as above, and the proportion of samples in which cracks occurred among the twenty samples was calculated. Thus, the crack occurrence ratio upon reflow is indicated as the reliability in Table 1.

When cracks whether occurred or not was observed, each sample was observed by a transmission method with a scanning acoustic tomograph (SAT), and a sample in which peeling off was observed was judged to have cracks.

{0034}

Table 1

	Content of acrylonitrile	Surface energy			Peeling force	Picking-up property	Reliability (crack occurrence ratio upon reflow)
		Face A	Face B	Difference			
	mass%	mJ/m^2			N/25mm		
Example 1	20	49.8	59.3	9.5	0.2	○	0/20
Example 2	29	39.6	30.2	9.4	0.3	◉	0/20
Example 3	49	32.1	29.0	3.1	0.08	◉	0/20
Example 4	37	50.7	48.9	1.8	0.08	△	0/20
Example 5	29	39.5	38.4	1.1	0.05	◉	0/20
Comparative Example 1	10	41.9	52.1	10.2	0.4	×	0/20
Comparative Example 2	19	40.4	29.7	10.7	0.3	×	1/20

Face A: The face that was not in contact with the removable adhesive
Face B: The face that had been peeled off from the removable adhesive

{0035}

Comparative Examples 1 and 2 had a problem with the picking-up property, and in Comparative Example 2, the reliability was also poor.

On the contrary, Examples 1 to 5 according to the present invention were all satisfactory in terms of the peeling force, the picking-up property, and the reliability. With respect to the wafer-processing tape of the present invention, it can be understood that the adhesive layer has sufficient adhesive force even if the adhesive layer is a face that has been once adhered to the removable adhesive layer.

{0036}

Having described our invention as related to the present embodiments, it is our intention that the invention not be limited by any of the details of the description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

{0037}

This application claims priority on Patent Application No. 2011-141266 filed in Japan on June 24, 2011, which is entirely herein incorporated by reference.

REFERENCE SIGNS LIST

{0038}

10 Wafer-processing tape

11 Releasable PET film

12 Removable adhesive film

12a Supporting substrate

12b Removable adhesive layer

13 Adhesive layer

CLAIMS

{Claim 1}

A wafer-processing tape, having a supporting substrate, a removable adhesive layer, and a single layer of an adhesive layer, which are laminated in this order,

in which the adhesive layer is an adhesive layer which is used to crimp a semiconductor element to a wiring-adhered wiring member for external connection or another semiconductor element, and

in which a difference in surface free energy between the face of the adhesive layer that has been peeled-off from the removable adhesive layer and the face that is not brought into contact with the removable adhesive layer is 10 mJ/m^2 or less.

{Claim 2}

The wafer-processing tape according to claim 1, in which the surface free energy of the face of the adhesive layer that is not in contact with the removable adhesive layer is from 30 mJ/m^2 to 50 mJ/m^2.

{Claim 3}

The wafer-processing tape according to claim 1 or 2, in which the adhesive layer contains a polymer compound obtained by suspension polymerization including acrylonitrile.