

DICING TAPE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a dicing tape, and more specifically, to a dicing tape to be suitably used when stealth dicing is performed through the dicing tape.

2. Description of the Related Art

A workpiece (e.g., a semiconductor wafer) serving as an assembly of electronic parts is produced in a large-diameter state, and a pattern is formed on its front surface. After that, its back surface is typically ground so that the thickness of the workpiece may be from about 100 μm to about 600 μm . Subsequently, the ground workpiece is cut and separated into small element pieces (dicing), and is further subjected to a mounting step. In the dicing step, the workpiece is cut into small pieces. In order to fix the workpiece after the dicing, the dicing is typically performed after a pressure-sensitive adhesive tape (dicing tape) has been bonded to the workpiece (e.g., Japanese Patent Application Laid-open No. 2003-007646). A method involving dicing the workpiece with laser light has been known as one method for the dicing. A method involving converging the laser light on the front surface of the workpiece to form a groove in the front surface of the workpiece,

and then cutting the workpiece has been frequently used as such dicing method. Meanwhile, in recent years, stealth dicing involving converging the laser light in the workpiece to modify the workpiece at the converged site, and then cutting the workpiece has also been proposed.

When the laser light is applied from a dicing tape side in the dicing based on the laser light as described above, the dicing tape is required to have such a characteristic that a position to be irradiated with the laser light may be satisfactorily detected with a camera. In particular, when a semiconductor wafer is diced in the stealth dicing, the recognition of a pattern on the surface of the semiconductor wafer for the determination of a position to be irradiated with the laser light and the detection of a position in the height direction of the semiconductor wafer for the adjustment of the focus of the laser light are required to be performed with high accuracy, and a modified layer is required to be satisfactorily formed. Accordingly, the dicing tape is required to have such a characteristic as not to inhibit the achievement of those requirements.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a dicing tape that may be used in stealth dicing, the dicing tape being free from inhibiting the detection of a position to be irradiated with laser

light with a camera and the formation of a satisfactory modified layer at the time of the dicing.

According to one embodiment of the present invention, there is provided a dicing tape, including: a base material; and a pressure-sensitive adhesive layer arranged on one side of the base material, wherein when an image having brightness of 256 gray scale image levels, which is obtained through observation from a base material side of the dicing tape with a laser microscope, is binarized into a white color portion and a black color portion through use of 55% of maximum brightness as a threshold, a ratio of an area of the white color portion to an area of the image is 80% or more.

In one embodiment, one surface of the base material has a wettability of 40 mN/m or less.

In one embodiment, the base material is arranged so that the surface having a wettability of 40 mN/m or less includes a surface opposite to the pressure-sensitive adhesive layer.

In one embodiment, the base material contains a polyethylene-based resin.

In one embodiment, at least one surface of the base material

includes a corona-treated surface.

In one embodiment, the pressure-sensitive adhesive layer has a tensile modulus of elasticity at 22°C of from 0.05 MPa to 1 MPa.

In one embodiment, the pressure-sensitive adhesive layer is of a two-layer construction, and the dicing tape includes the base material, a first pressure-sensitive adhesive layer, and a second pressure-sensitive adhesive layer in the stated order.

In one embodiment, the first pressure-sensitive adhesive layer has a tensile modulus of elasticity at 22°C of from 0.05 MPa to 1 MPa.

In one embodiment, the second pressure-sensitive adhesive layer has a tensile modulus of elasticity at 22°C of from 0.1 MPa to 2 MPa.

In one embodiment, the first pressure-sensitive adhesive layer has a thickness of from 5 μm to 468 μm .

According to the present invention, the dicing tape that may be used in stealth dicing, the dicing tape being free from inhibiting the detection of a position to be irradiated with laser light with a camera and the formation of a satisfactory modified layer, can

be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view of a dicing tape according to one embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

A. Outline of Dicing Tape

FIG. **1** is a schematic sectional view of a dicing tape according to one embodiment of the present invention. A dicing tape **100** according to this embodiment includes a base material **10** and a pressure-sensitive adhesive layer **20** arranged on one side of the base material **10**. In the dicing tape of the present invention, a release liner may be arranged outside the pressure-sensitive adhesive layer for the purpose of protecting a pressure-sensitive adhesive surface until the tape is subjected to use, though the liner is not shown. In addition, the dicing tape may further include any appropriate other layer as long as the effects of the present invention are obtained. It is preferred that the pressure-sensitive adhesive layer be directly arranged on the base material.

In another embodiment, the pressure-sensitive adhesive layer is of a two-layer construction, and the dicing tape includes the base material, a first pressure-sensitive adhesive layer, and a

second pressure-sensitive adhesive layer in the stated order.

When an image having brightness of 256 gray scale levels, which is obtained through observation from the base material side of the dicing tape with a laser microscope, is binarized into a white color portion (high-brightness portion) and a black color portion (low-brightness portion) through the use of 55% of the maximum brightness as a threshold, the ratio of the area of the white color portion to the area of the image is 80% or more. Here, the binarization through the use of 55% of the maximum brightness as a threshold is processing in which a 140-th gray scale level from the low-brightness side of the 256 gray scale levels of the brightness is used as a boundary to divide the gray scale levels, and an image portion having gray scale levels on the low-brightness side is defined as the black color portion, while an image portion having gray scale levels on the high-brightness side is defined as the white color portion. The binarization processing can be performed with, for example, image analysis software "ImageJ" (manufactured by Wayne Rasband). When the dicing tape of the present invention constructed as described above is used, in a stealth dicing step, camera detection through the dicing tape, that is, the recognition of a pattern on the surface of a semiconductor wafer, the detection of a position in the height direction of the semiconductor wafer, or the like with a camera (e.g., an IR camera or a SD camera) can be performed with high accuracy. In addition,

when the dicing tape of the present invention constructed as described above is used, even in the case where the semiconductor wafer is irradiated with laser light through the dicing tape in the stealth dicing step, the laser light can be satisfactorily converged, and as a result, a modified layer can be satisfactorily formed in the semiconductor wafer. More specifically, the formation of a defective portion, such as disappearance or a meandering, in the modified layer may be prevented.

The ratio of the area of the white color portion to the area of the image is preferably 83% or more, more preferably 85% or more, still more preferably 90% or more. When the ratio falls within such range, the above-mentioned effects become more significant. Although the area of the white color portion is preferably as wide as possible, the upper limit of the ratio is, for example, 99.5% (preferably 99.8%, more preferably 100%).

An initial pressure-sensitive adhesive strength at 23°C when the dicing tape of the present invention is bonded to a stainless plate is preferably from 0.2 N/20 mm to 8 N/20 mm, more preferably from 0.5 N/20 mm to 5 N/20 mm. The pressure-sensitive adhesive strength is measured in conformity with JIS Z 0237:2000. Specifically, the measurement is performed by: reciprocating a 2-kilogram roller once to bond the dicing tape to the stainless plate (arithmetic average surface roughness Ra: 50±25 nm); leaving

the resultant to stand under 23°C for 30 minutes; and then peeling the dicing tape under the conditions of a peel angle of 180° and a peel rate (tensile rate) of 300 mm/min. Although the pressure-sensitive adhesive strength of the pressure-sensitive adhesive layer may be changed by active energy ray irradiation as described later, the term "initial pressure-sensitive adhesive strength" as used herein means a pressure-sensitive adhesive strength before the active energy ray irradiation.

In one embodiment, a pressure-sensitive adhesive strength at 23°C after the dicing tape has been bonded to a mirror wafer made of silicon, and the resultant has been irradiated with UV light having an integrated light quantity of 460 mJ/cm² is preferably from 0.01 N/20 mm to 0.3 N/20 mm, more preferably from 0.02 N/20 mm to 0.2 N/20 mm. When the pressure-sensitive adhesive strength falls within such range, a dicing tape having the following feature can be obtained: its pressure-sensitive adhesive strength is reduced by UV irradiation after dicing, and hence the pick-up of a workpiece (e.g., a semiconductor chip) diced into small pieces is facilitated. The UV irradiation is performed by, for example, irradiating the pressure-sensitive adhesive layer with UV light from a high-pressure mercury lamp (characteristic wavelength: 365 nm, integrated light quantity: 460 mJ/cm², irradiation energy: 70 W/cm², irradiation time: 6.6 seconds) through the use of a UV irradiation apparatus (manufactured by Nitto Seiki Co., Ltd., product name:

"UM-810").

The thickness of the dicing tape is preferably from 35 μm to 500 μm , more preferably from 60 μm to 300 μm , still more preferably from 80 μm to 200 μm .

The total light transmittance of the dicing tape is preferably 70% or more, more preferably 80% or more, still more preferably 90% or more, particularly preferably 95% or more. When the total light transmittance falls within such range, a dicing tape having the following features can be obtained: camera detection through the dicing tape may be satisfactorily performed; and the transmission and convergence of laser light are hardly inhibited. The upper limit of the total light transmittance of the dicing tape is, for example, 98% (preferably 99%).

The transmittance of the dicing tape for light having a wavelength of 1,064 nm is preferably 70% or more, more preferably 80% or more, still more preferably 90% or more, particularly preferably 95% or more. When the transmittance falls within such range, a dicing tape that hardly inhibits the transmission and convergence of laser light can be obtained. The upper limit of the transmittance of the dicing tape for light having a wavelength of 1,064 nm is, for example, 98% (preferably 99%).

The haze value of the dicing tape is preferably 20% or less, more preferably 10% or less, still more preferably 5% or less. When the haze value falls within such range, a dicing tape having the following features can be obtained: camera detection through the dicing tape may be satisfactorily performed; and the transmission and convergence of laser light are hardly inhibited. The lower limit of the haze value of the dicing tape is, for example, 1%.

B. Base Material

The base material may be formed of any appropriate resin. Examples of the resin include: polyolefin-based resins, such as a polyethylene-based resin, a polypropylene-based resin, a polybutene-based resin, and a polymethylpentene-based resin; a polyurethane-based resin; a polyester-based resin; a polyimide-based resin; a polyetherketone-based resin; a polystyrene-based resin; a polyvinyl chloride-based resin; a polyvinylidene chloride-based resin; a fluorine-based resin; a silicon-based resin; a cellulose-based resin; and an ionomer resin. Of those, a polyolefin-based resin is preferred.

In one embodiment, the base material contains a polyethylene-based resin. The use of the base material containing the polyethylene-based resin can provide such a dicing tape that the white color area of the binarized image is large. Examples of the polyethylene-based resin include low-density polyethylene,

linear polyethylene, medium-density polyethylene, high-density polyethylene, and ultralow-density polyethylene.

The content of a constituent unit derived from ethylene in the polyethylene-based resin is preferably 80 mol% or more, more preferably 90 mol% or more, still more preferably 95 mol% or more. A constituent unit except the constituent unit derived from ethylene is, for example, a constituent unit derived from a monomer copolymerizable with ethylene, and examples thereof include propylene, 1-butene, isobutene, 1-pentene, 2-methyl-1-butene, 3-methyl-1-butene, 1-hexene, 3-methyl-1-pentene, 4-methyl-1-pentene, 1-heptene, 1-octene, 1-decene, 1-dodecene, 1-tetradecene, 1-hexadecene, 1-octadecene, and 1-icosene.

The content of the polyethylene-based resin is preferably 80 parts by weight or more, more preferably from 85 parts by weight to 100 parts by weight, still more preferably from 95 parts by weight to 100 parts by weight with respect to 100 parts by weight of the base material.

The base material may further contain any appropriate additive. Examples of the additive include a lubricant, an antioxidant, a UV absorber, a processing aid, a filler, an antistatic agent, a stabilizer, an antibacterial agent, a flame retardant, and a colorant.

In one embodiment, the base material contains a lubricant. The incorporation of the lubricant can prevent blocking when the dicing tape is turned into a roll shape. As a result, such a dicing tape that the white color area of the binarized image is large can be obtained. Examples of the lubricant include a fatty acid amide-based lubricant, a silicone-based lubricant, a fluorine-based lubricant, and a long-chain alkyl-based lubricant. Of those, a fatty acid amide-based lubricant is preferred because its risk of the inclusion of impurities is small and its effect as a lubricant is high. The content of the lubricant is preferably from 0.1 part by weight to 30 parts by weight, more preferably from 0.5 part by weight to 15 parts by weight, still more preferably from 0.8 part by weight to 10 parts by weight, particularly preferably from 1 part by weight to 5 parts by weight with respect to 100 parts by weight of the base material.

In one embodiment, the wettability of one surface of the base material is 40 mN/m or less. In one embodiment, the base material is arranged so that the surface having a wettability of 40 mN/m or less may be a surface opposite to the pressure-sensitive adhesive layer. When the base material is arranged so that the surface having the wettability may be the surface opposite to the pressure-sensitive adhesive layer, the blocking when the dicing tape is turned into a roll shape can be prevented. As a result,

such a dicing tape that the white color area of the binarized image is large can be obtained. The wettability of one surface of the base material is preferably 39 mN/m or less, more preferably 38 mN/m or less, still more preferably from 30 mN/m to 38 mN/m. The wettability of the base material can be adjusted by: the kind of a material for the base material; the presence or absence of an additive to be added to the base material, and the kind and addition amount thereof; the presence or absence of a surface treatment for the surface whose wettability is to be adjusted, the kind thereof, and a condition therefor; and the like. In one embodiment, when a polyolefin-based resin (preferably a polyethylene-based resin) is used as a material for the base material, and a surface treatment, such as a corona treatment, is not performed, a base material having a wettability in the range can be obtained. The wettability may be measured in conformity with JIS K6768.

In one embodiment, at least one surface of the base material is subjected to a corona treatment. It is preferred that only one surface of the base material be subjected to the corona treatment, and the corona-treated surface be a surface on a pressure-sensitive adhesive layer side. When the surface on the pressure-sensitive adhesive layer side is subjected to the corona treatment, adhesiveness between the pressure-sensitive adhesive layer and the base material can be improved. In another embodiment, both surfaces of the base material are free from being subjected to the

corona treatment. When the surface of the base material opposite to the pressure-sensitive adhesive layer is a corona-untreated surface, the blocking when the dicing tape is turned into a roll shape can be prevented. As a result, when the roll-shaped dicing tape is unwound, the dicing tape is hardly damaged, and hence such a dicing tape that the white color area of the binarized image is large can be obtained. The corona treatment may be performed under the conditions of, for example, a speed of 20 m/min, a discharge power of 0.7 kW, and a discharge electrode length of 1,550 mm.

In one embodiment, one surface of the base material is subjected to an embossing treatment. It is preferred that only one surface of the base material be subjected to the embossing treatment, and the embossing-treated surface be the surface on the pressure-sensitive adhesive layer side. When the surface on the pressure-sensitive adhesive layer side is subjected to the embossing treatment, the adhesiveness between the pressure-sensitive adhesive layer and the base material can be improved. It is preferred that the surface of the base material opposite to the pressure-sensitive adhesive layer be not subjected to the embossing treatment. When the surface of the base material opposite to the pressure-sensitive adhesive layer is not subjected to the embossing treatment, and hence the surface is smoothened, such a dicing tape that the white color area of the binarized image is large can be obtained. The arithmetic average surface roughness

Ra (JIS B 0601) of the embossing-untreated surface of the base material is preferably less than 1.0 μm , more preferably 0.8 μm or less, still more preferably 0.5 μm or less, particularly preferably from 0.01 μm to 1 μm . In addition, the arithmetic average surface roughness Ra (JIS B 0601) of the embossing-treated surface of the base material is preferably from 1.0 μm to 3 μm , more preferably from 1.4 μm to 2 μm . When the arithmetic average surface roughness Ra of the embossing-treated surface of the base material is more than 3 μm , there is a risk in that a void is liable to be formed between the pressure-sensitive adhesive layer and the base material, and hence the white color area of the binarized image reduces. In addition, when the Ra is less than 1 μm , the blocking may occur at the time of the storage of the base material.

The thickness of the base material is preferably from 30 μm to 300 μm , more preferably from 53 μm to 200 μm , still more preferably from 70 μm to 160 μm .

The total light transmittance of the base material is preferably 70% or more, more preferably 80% or more, still more preferably 90% or more, particularly preferably 95% or more. The upper limit of the total light transmittance of the base material is, for example, 98% (preferably 99%).

The tensile modulus of elasticity of the base material at 22°C

is preferably from 50 MPa to 120 MPa, more preferably from 70 MPa to 90 MPa. When the tensile modulus of elasticity falls within such range, a dicing tape excellent in expandability can be obtained. The measurement of the tensile modulus of elasticity of the base material is performed with a tensile tester (manufactured by Shimadzu Corporation, "AG-IS") under the conditions of a chuck-to-chuck distance of 50 mm, a tensile rate of 300 mm/min, and a base material width of 10 mm.

C. Pressure-sensitive Adhesive Layer

C-1. Pressure-sensitive Adhesive Layer of Single-layer Construction

In one embodiment, the pressure-sensitive adhesive layer includes a single layer. The pressure-sensitive adhesive layer may include any appropriate pressure-sensitive adhesive. Examples of the pressure-sensitive adhesive include an acrylic pressure-sensitive adhesive, a rubber-based pressure-sensitive adhesive, a silicone-based pressure-sensitive adhesive, and a polyvinyl ether-based pressure-sensitive adhesive.

In one embodiment, the pressure-sensitive adhesive layer includes an active energy ray-curable pressure-sensitive adhesive. When the pressure-sensitive adhesive layer includes the active energy ray-curable pressure-sensitive adhesive, a dicing tape having the following feature can be obtained: its

pressure-sensitive adhesive strength is reduced by irradiation with an active energy ray (typically UV light) after dicing, and hence the pick-up of a workpiece (e.g., a semiconductor chip) diced into small pieces may be facilitated.

The active energy ray-curable pressure-sensitive adhesive may contain a base polymer showing a pressure-sensitive adhesive property. A monomer forming the base polymer is, for example, a hydrophilic monomer. Any appropriate monomer having a polar group may be used as the hydrophilic monomer. Specific examples thereof include: carboxyl group-containing monomers, such as acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxypentyl acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid; acid anhydride monomers, such as maleic anhydride and itaconic anhydride; hydroxyl group-containing monomers, such as 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 6-hydroxyhexyl (meth)acrylate, 8-hydroxyoctyl (meth)acrylate, 10-hydroxydecyl (meth)acrylate, 12-hydroxylauryl (meth)acrylate, and (4-hydroxymethylcyclohexyl) methyl methacrylate; sulfonic acid group-containing monomers, such as styrenesulfonic acid, allylsulfonic acid, 2-(meth)acrylamido-2-methylpropanesulfonic acid, (meth)acrylamidopropanesulfonic acid, sulfopropyl (meth)acrylate, and (meth)acryloyloxynaphthalenesulfonic acid; phosphoric acid group-containing monomers, such as 2-hydroxyethylacryloyl

phosphate; (N-substituted)amide-based monomers, such as (meth)acrylamide, N,N-dimethyl(meth)acrylamide, N-butyl(meth)acrylamide, N-methylol(meth)acrylamide, N-methylolpropane(meth)acrylamide, and acryloylmorpholine; aminoalkyl(meth)acrylate-based monomers, such as aminoethyl(meth)acrylate, N,N-dimethylaminoethyl(meth)acrylate, and t-butylaminoethyl(meth)acrylate; alkoxyalkyl(meth)acrylate-based monomers, such as methoxyethyl(meth)acrylate and ethoxyethyl(meth)acrylate; maleimide-based monomers, such as N-cyclohexylmaleimide, N-isopropylmaleimide, N-laurylmaleimide, and N-phenylmaleimide; itaconimide-based monomers, such as N-methyl itaconimide, N-ethyl itaconimide, N-butyl itaconimide, N-octyl itaconimide, N-2-ethylhexyl itaconimide, N-cyclohexyl itaconimide, and N-lauryl itaconimide; succinimide-based monomers, such as N-(meth)acryloyloxymethylene succinimide, N-(meth)acryloyl-6-oxyhexamethylene succinimide, and N-(meth)acryloyl-8-oxyoctamethylene succinimide; vinyl-based monomers, such as vinyl acetate, vinyl propionate, N-vinylpyrrolidone, methylvinylpyrrolidone, vinylpyridine, vinylpiperidone, vinylpyrimidine, vinylpiperazine, vinylpyrazine, vinylpyrrole, vinylimidazole, vinyloxazole, vinylmorpholine, N-vinylcarboxylic acid amides, styrene, α -methylstyrene, and N-vinylcaprolactam; cyanoacrylate monomers, such as acrylonitrile and methacrylonitrile; epoxy group-containing acrylic monomers, such as glycidyl(meth)acrylate; glycol-based acrylate monomers,

such as polyethylene glycol (meth)acrylate, polypropylene glycol (meth)acrylate, methoxyethylene glycol (meth)acrylate, and methoxypolypropylene glycol (meth)acrylate; acrylate-based monomers each having, for example, a heterocycle, a halogen atom, or a silicon atom, such as tetrahydrofurfuryl (meth)acrylate, fluorine (meth)acrylate, and silicon (meth)acrylate; and polyfunctional monomers, such as hexanediol di(meth)acrylate, (poly)ethylene glycol di(meth)acrylate, (poly)propylene glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate, pentaerythritol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, pentaerythritol tri(meth)acrylate, dipentaerythritol hexa(meth)acrylate, epoxy acrylate, polyester acrylate, and urethane acrylate. A hydroxyl group-containing monomer and/or an (N-substituted) amide-based monomer may be suitably used as the hydrophilic monomer. The hydrophilic monomers may be used alone or in combination thereof.

The hydrophilic monomer may be used in combination with a hydrophobic monomer. The hydrophobic monomer only needs to be a monomer having a hydrophobic property, and any appropriate monomer can be used. Specific examples thereof include: vinyl alkyl or aryl ethers each having an alkyl or aryl group having 9 to 30 carbon atoms, such as vinyl 2-ethylhexanoate, vinyl laurate, vinyl stearate, and stearyl vinyl ether; alkyl esters each having 6 to 30 carbon atoms, such as hexyl (meth)acrylate, heptyl

(meth)acrylate, octyl (meth)acrylate, isooctyl acrylate, isononyl acrylate, decyl (meth)acrylate, isodecyl (meth)acrylate, dodecyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, benzyl (meth)acrylate, lauryl (meth)acrylate, oleyl (meth)acrylate, palmityl (meth)acrylate, and stearyl (meth)acrylate; unsaturated vinyl esters of (meth)acrylic acid derived from an aliphatic acid and a fatty alcohol; a monomer derived from cholesterol; and olefin monomers, such as 1-butene, 2-butene, 1-pentene, 1-hexene, 1-octene, isobutylene, and isoprene. The hydrophobic monomers may be used alone or in combination thereof. The hydrophobic monomer to be used in the present invention refers to a monomer which has a solubility in 100 g of water of 0.02 g or less.

The base polymer may further contain a monomer component other than the hydrophilic monomer and the hydrophobic monomer. Examples of the other monomer component include alkyl acrylates, such as butyl acrylate and ethyl acrylate. The other monomer components may be used alone or in combination thereof.

The base polymer may further contain a constituent unit derived from an isocyanate-based compound having a curable functional group in a molecule thereof. The base polymer containing the constituent unit derived from the isocyanate-based compound can be obtained by, for example, causing a substituent that a constituent unit derived from the hydrophilic monomer has

(e.g., a OH group) and the NCO group of the isocyanate-based compound to react with each other. Examples of the isocyanate-based compound include methacryloyl isocyanate, 2-methacryloyloxyethyl isocyanate, 2-acryloyloxyethyl isocyanate, and m-isopropenyl- α,α -dimethylbenzyl isocyanate.

The weight-average molecular weight of the base polymer forming the pressure-sensitive adhesive is preferably from 300,000 to 2,000,000, more preferably from 500,000 to 1,500,000. The weight-average molecular weight may be measured by GPC (solvent: THF).

The active energy ray-curable pressure-sensitive adhesive may contain a photopolymerization initiator.

Any appropriate initiator may be used as the photopolymerization initiator. Examples of the photopolymerization initiator include: α -ketol-based compounds, such as 4-(2-hydroxyethoxy)phenyl (2-hydroxy-2-propyl)ketone, α -hydroxy- α,α' -dimethylacetophenone, 2-methyl-2-hydroxypropiophenone, and 1-hydroxycyclohexyl phenyl ketone; acetophenone-based compounds, such as methoxyacetophenone, 2,2-dimethoxy-2-phenylacetophenone, 2,2-diethoxyacetophenone, and 2-methyl-1-[4-(methylthio)-phenyl]-2-morpholinopropane-1; benzoin ether-based compounds, such as benzoin ethyl ether, benzoin

isopropyl ether, and anisoin methyl ether; ketal-based compounds, such as benzyl dimethyl ketal; aromatic sulfonyl chloride-based compounds, such as 2-naphthalenesulfonyl chloride; photoactive oxime-based compounds, such as 1-phenone-1,1-propanedione-2-(o-ethoxycarbonyl)oxime; benzophenone-based compounds, such as benzophenone, benzoylbenzoic acid, and 3,3'-dimethyl-4-methoxybenzophenone; thioxanthone-based compounds, such as thioxanthone, 2-chlorothioxanthone, 2-methylthioxanthone, 2,4-dimethylthioxanthone, isopropylthioxanthone, 2,4-dichlorothioxanthone, 2,4-diethylthioxanthone, and 2,4-diisopropylthioxanthone; camphorquinone; halogenated ketones; acylphosphinoxides; and acylphosphonates. The usage amount of the photopolymerization initiator may be set to any appropriate amount.

A commercially available product may be used as the photopolymerization initiator. Examples thereof include products available under the product names "IRGACURE 651", "IRGACURE 184", "IRGACURE 369", "IRGACURE 819", and "IRGACURE 2959" from BASF.

The active energy ray-curable pressure-sensitive adhesive preferably contains a cross-linking agent. Examples of the cross-linking agent include an isocyanate-based cross-linking agent, an epoxy-based cross-linking agent, an oxazoline-based

cross-linking agent, an aziridine-based cross-linking agent, a melamine-based cross-linking agent, a peroxide-based cross-linking agent, a urea-based cross-linking agent, a metal alkoxide-based cross-linking agent, a metal chelate-based cross-linking agent, a metal salt-based cross-linking agent, a carbodiimide-based cross-linking agent, and an amine-based cross-linking agent.

When the pressure-sensitive adhesive layer is of a single-layer construction, the content of the cross-linking agent is preferably from 0.5 part by weight to 10 parts by weight, more preferably from 1 part by weight to 8 parts by weight with respect to 100 parts by weight of the base polymer of the pressure-sensitive adhesive. When the content falls within such range, a pressure-sensitive adhesive layer whose modulus of elasticity is appropriately adjusted can be formed.

In one embodiment, an isocyanate-based cross-linking agent is preferably used. The isocyanate-based cross-linking agent is preferred because the agent may react with many kinds of functional groups. Specific examples of the isocyanate-based cross-linking agent include: lower aliphatic polyisocyanates, such as butylene diisocyanate and hexamethylene diisocyanate; alicyclic isocyanates, such as cyclopentylene diisocyanate, cyclohexylene diisocyanate, and isophorone diisocyanate; aromatic isocyanates,

such as 2,4-tolylene diisocyanate, 4,4'-diphenylmethane diisocyanate, and xylylene diisocyanate; and isocyanate adducts, such as a trimethylolpropane/tolylene diisocyanate trimer adduct (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "Coronate L"), a trimethylolpropane/hexamethylene diisocyanate trimer adduct (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "Coronate HL"), and an isocyanurate body of hexamethylene diisocyanate (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "Coronate HX"). Of those, a cross-linking agent having 3 or more isocyanate groups is preferably used.

The active energy ray-curable pressure-sensitive adhesive may further contain any appropriate additive as required. Examples of the additive include an active energy ray polymerization accelerator, a radical scavenger, a tackifier, a plasticizer (e.g., a trimellitate-based plasticizer or a pyromellitate-based plasticizer), a pigment, a dye, a filler, an age resistor, a conductive material, an antistatic agent, a UV absorber, a light stabilizer, a peeling modifier, a softener, a surfactant, a flame retardant, and an antioxidant.

When the pressure-sensitive adhesive layer is of a single-layer construction, the tensile modulus of elasticity of the pressure-sensitive adhesive layer at 22°C is preferably from

0.05 MPa to 1 MPa, more preferably from 0.1 MPa to 0.8 MPa, still more preferably from 0.15 MPa to 0.6 MPa. When the tensile modulus of elasticity falls within such range, a pressure-sensitive adhesive layer having a sufficient strength can be formed, and the pressure-sensitive adhesive layer and the base material can be satisfactorily brought into close contact with each other to suppress the occurrence of a void near an interface between the base material and the pressure-sensitive adhesive layer. As a result, such a dicing tape that the white color area of the binarized image is large can be obtained. In particular, in the case where a base material whose surface on the pressure-sensitive adhesive layer side is subjected to an embossing treatment is used, a void is typically liable to occur, but when the tensile modulus of elasticity of the pressure-sensitive adhesive layer is set within the range, the occurrence of a void can be suppressed. In other words, when the tensile modulus of elasticity is more than 1 MPa, at the time of the lamination of the pressure-sensitive adhesive layer on the embossed surface of the base material, the pressure-sensitive adhesive layer may not follow the unevenness of the base material. In addition, when the tensile modulus of elasticity is less than 0.5 MPa, there is a risk in that the pressure-sensitive adhesive layer does not keep a fixed form, and does not have sufficient characteristics. When the pressure-sensitive adhesive layer includes an active energy ray-curable pressure-sensitive adhesive as described above, its

tensile modulus of elasticity at 22°C before active energy ray irradiation preferably falls within the range. A method of measuring the tensile modulus of elasticity of the pressure-sensitive adhesive layer is described later.

In one embodiment, when the pressure-sensitive adhesive layer is of a single-layer construction, the tensile modulus of elasticity of the pressure-sensitive adhesive layer at 22°C after irradiation with UV light (460 mJ/cm²) is preferably from 50 MPa to 3,000 MPa, more preferably from 100 MPa to 1,500 MPa, still more preferably from 200 MPa to 1,000 MPa. When the tensile modulus of elasticity falls within such range, a dicing tape excellent in pick-up property can be obtained.

When the pressure-sensitive adhesive layer is of a single-layer construction, the thickness of the pressure-sensitive adhesive layer is preferably from 5 µm to 470 µm, more preferably from 7 µm to 247 µm, still more preferably from 10 µm to 130 µm. When the thickness falls within such range, in the case where the pressure-sensitive adhesive layer is formed on the embossing-treated surface of the base material, the pressure-sensitive adhesive layer may satisfactorily fill the embossment to prevent the occurrence of an unnecessary void. As a result, such a dicing tape that the white color area of the binarized image is large can be obtained.

The total light transmittance of the pressure-sensitive adhesive layer is preferably 70% or more, more preferably 80% or more, still more preferably 90% or more, particularly preferably 95% or more. The upper limit of the total light transmittance of the pressure-sensitive adhesive layer is, for example, 98% (preferably 99%).

The haze value of the pressure-sensitive adhesive layer is preferably 20% or less, more preferably 10% or less, still more preferably 5% or less. The lower limit of the haze value of the pressure-sensitive adhesive layer is, for example, 1%.

C-2. Pressure-sensitive Adhesive Layer of Two-layer Construction

In one embodiment, the pressure-sensitive adhesive layer includes two layers. For convenience, a pressure-sensitive adhesive layer on the base material side is hereinafter defined as a first pressure-sensitive adhesive layer, and a pressure-sensitive adhesive layer opposite to the base material is hereinafter defined as a second pressure-sensitive adhesive layer. The first pressure-sensitive adhesive layer and the second pressure-sensitive adhesive layer may be distinguished from each other by their difference in tensile modulus of elasticity. The first pressure-sensitive adhesive layer is preferably less elastic

than the second pressure-sensitive adhesive layer is. When the first pressure-sensitive adhesive layer that is lowly elastic is arranged on the base material side, the pressure-sensitive adhesive layer and the base material can be satisfactorily brought into close contact with each other to suppress the occurrence of a void near the interface between the base material and the pressure-sensitive adhesive layer. As a result, such a dicing tape that the white color area of the binarized image is large can be obtained. In addition, when the pressure-sensitive adhesive layer includes the second pressure-sensitive adhesive layer that is highly elastic, a dicing tape that may contribute to high-accuracy dicing can be obtained.

The tensile modulus of elasticity of the first pressure-sensitive adhesive layer at 22°C is preferably from 0.05 MPa to 1 MPa, more preferably from 0.06 MPa to 0.8 MPa, still more preferably from 0.07 MPa to 0.5 MPa. When the tensile modulus of elasticity falls within such range, the pressure-sensitive adhesive layer and the base material can be satisfactorily brought into close contact with each other to significantly suppress the occurrence of a void near the interface between the base material and the pressure-sensitive adhesive layer. As a result, such a dicing tape that the white color area of the binarized image is large can be obtained. In particular, in the case where a base material whose surface on the pressure-sensitive adhesive layer side is subjected to an embossing treatment is used, a void is typically liable to

occur, but when the tensile modulus of elasticity of the pressure-sensitive adhesive layer is set within the range, the occurrence of a void can be suppressed. When the first pressure-sensitive adhesive layer includes an active energy ray-curable pressure-sensitive adhesive, its tensile modulus of elasticity at 22°C before active energy ray irradiation preferably falls within the range.

In one embodiment, the tensile modulus of elasticity of the first pressure-sensitive adhesive layer at 22°C after irradiation with UV light (460 mJ/cm²) is preferably from 50 MPa to 3,000 MPa, more preferably from 100 MPa to 1,500 MPa, still more preferably from 200 MPa to 1,000 MPa. When the tensile modulus of elasticity falls within such range, a dicing tape excellent in pick-up property can be obtained.

The tensile modulus of elasticity of the second pressure-sensitive adhesive layer at 22°C is preferably from 0.1 MPa to 2 MPa, more preferably from 0.15 MPa to 1.5 MPa, still more preferably from 0.2 MPa to 1 MPa. When the tensile modulus of elasticity falls within such range, a dicing tape in which the entirety of the pressure-sensitive adhesive layer has moderate rigidity, and which may contribute to high-accuracy dicing can be obtained. When the second pressure-sensitive adhesive layer includes an active energy ray-curable pressure-sensitive adhesive,

its tensile modulus of elasticity at 22°C before active energy ray irradiation preferably falls within the range.

The thickness of the first pressure-sensitive adhesive layer is preferably from 5 μm to 468 μm , more preferably from 7 μm to 244 μm . When the thickness of the first pressure-sensitive adhesive layer is 5 μm or more, in the case where the first pressure-sensitive adhesive layer is formed on the embossing-treated surface of the base material, the first pressure-sensitive adhesive layer may satisfactorily fill the embossment to prevent the occurrence of an unnecessary void. As a result, such a dicing tape that the white color area of the binarized image is large can be obtained. In addition, when the thickness of the first pressure-sensitive adhesive layer is 468 μm or less, a dicing tape that facilitates the pick-up of a workpiece (e.g., a semiconductor chip) diced into small pieces can be obtained.

The thickness of the second pressure-sensitive adhesive layer is preferably from 2 μm to 465 μm , more preferably from 3 μm to 240 μm .

When the pressure-sensitive adhesive layer is of a two-layer construction, the total thickness of the pressure-sensitive adhesive layer is preferably from 7 μm to 470 μm , more preferably

from 10 μm to 247 μm , still more preferably from 15 μm to 130 μm .

When the pressure-sensitive adhesive layer is of a two-layer construction, the total light transmittance of the pressure-sensitive adhesive layer is preferably 70% or more, more preferably 80% or more, still more preferably 90% or more, particularly preferably 95% or more. The upper limit of the total light transmittance of the pressure-sensitive adhesive layer is, for example, 98% (preferably 99%).

When the pressure-sensitive adhesive layer is of a two-layer construction, the haze value of the pressure-sensitive adhesive layer is preferably 20% or less, more preferably 10% or less, still more preferably 5% or less. The lower limit of the haze value of the pressure-sensitive adhesive layer is, for example, 1%.

A pressure-sensitive adhesive described in the section C-1 may be used as a pressure-sensitive adhesive forming each of the first pressure-sensitive adhesive layer and the second pressure-sensitive adhesive layer. An active energy ray-curable pressure-sensitive adhesive is preferably used.

The cross-linking agent content of the active energy ray-curable pressure-sensitive adhesive forming the first pressure-sensitive adhesive layer is preferably from 0.005 part

by weight to 5 parts by weight, more preferably from 0.02 part by weight to 3 parts by weight with respect to 100 parts by weight of the base polymer of the pressure-sensitive adhesive. When the content falls within such range, a pressure-sensitive adhesive layer whose modulus of elasticity is appropriately adjusted, that satisfactorily fills the embossed surface of the base material, and that may hold a fixed form can be formed.

The cross-linking agent content of the active energy ray-curable pressure-sensitive adhesive forming the second pressure-sensitive adhesive layer is preferably from 1 part by weight to 20 parts by weight, more preferably from 2 parts by weight to 10 parts by weight with respect to 100 parts by weight of the base polymer of the pressure-sensitive adhesive. When the content falls within such range, a pressure-sensitive adhesive layer whose modulus of elasticity and pressure-sensitive adhesive strength (pressure-sensitive adhesive strength that may achieve both the holding of a wafer at the time of its dicing and the pick-up of chips after the dicing) are appropriately adjusted can be formed.

D. Method of producing Dicing Tape

The dicing tape may be produced by any appropriate method. The dicing tape may be obtained by, for example, applying the pressure-sensitive adhesive onto the base material. Various methods, such as bar coater coating, air knife coating, gravure

coating, gravure reverse coating, reverse roll coating, lip coating, die coating, dip coating, offset printing, flexographic printing, and screen printing, can each be adopted as a method for the application. In addition, for example, a method involving separately forming the pressure-sensitive adhesive layer on a release liner and then bonding the resultant to the base material may be adopted.

Examples

Now, the present invention is specifically described by way of Examples. However, the present invention is by no means limited to these Examples. Test and evaluation methods in Examples are as described below. In addition, the terms "part(s)" and "%" are by weight unless otherwise stated.

(1) Modulus of Elasticity of Pressure-sensitive Adhesive Layer

Pressure-sensitive adhesives prepared in Examples and Comparative Examples were each applied between a pair of PET separators to form a pressure-sensitive adhesive layer (having a thickness of 20 μm), and the pressure-sensitive adhesive layer was aged in a dryer under an environment at 50°C for 48 hours. After that, the pressure-sensitive adhesive layer was cut into a size measuring 50 mm by 30 mm, and the separators were peeled. After that, the remainder was rolled so that no air bubbles were included

therein. Thus, a rod-shaped sample having a length of 30 mm and a diameter of 1.13 mm was produced.

A SS curve representing the tensile modulus of elasticity of the rod-shaped sample was measured with a tensile tester (manufactured by Orientec Corporation, product name: "RTC-1150A") under the conditions of a measurement temperature of 22°C, a chuck-to-chuck distance of 10 mm, and a rate of 10 mm/min. An initial modulus of elasticity was determined from the rise of the SS curve, and was defined as the tensile modulus of elasticity of the pressure-sensitive adhesive layer.

(2) Wettability of Base Material

The wettabilities of both surfaces of a base material were measured in conformity with JIS K6768.

(3) Arithmetic Average Surface Roughness Ra of Base Material

The arithmetic average surface roughness (line roughness) Ra of the surface of a base material opposite to a pressure-sensitive adhesive layer was measured with P-15 manufactured by KLA-Tencor Corporation in conformity with JIS B 0601-2001.

(4) Total Light Transmittance

The total light transmittance of a dicing tape was measured with a haze meter available under the product name "HM-150" from

Murakami Color Research Laboratory in conformity with JIS K 7361.

(5) Haze Value

The haze value of a dicing tape was measured with a haze meter available under the product name "HM-150" from Murakami Color Research Laboratory in conformity with JIS K 7136.

(6) Transmittance for Light having Wavelength of 1,064 nm

The transmittance of a dicing tape for light having a wavelength of 1,064 nm was measured with SolidSpec-3700 manufactured by Shimadzu Corporation.

(7) Measurement of White Color Area of Binarized Image

A dicing tape was crimped onto a Si wafer mirror surface. The dicing tape was observed from its base material side with a laser microscope VK-X150 (manufactured by Keyence Corporation) whose lightness had been set to 80, and an observed image (range: 5.8 mm×4.4 mm, its brightness was 256 gray scale levels) was captured in a PC. The observed image was converted into a binarized image with ImageJ (free software) through the use of a brightness of 140, that is, a 140-th gray scale level from the low-brightness side of the 256 gray scale levels of the brightness as a boundary (through the use of 55% of the maximum brightness as a threshold), and the ratio of a white color area (high-brightness portion) was determined by predetermined macro processing.

(8) Evaluation of Apparatus Visibility before Stealth Dicing

A silicon wafer and a ring frame were bonded to a dicing tape, and the camera visibility of the resultant in the case of the following apparatus was determined and evaluated by the following criteria.

Used apparatus: DAL7360 (SDE05) manufactured by DISCO Corporation

SD camera: A camera for height adjustment. The camera is brought into focus on the back surface of the wafer through the dicing tape, and the inside of the control system of the apparatus is caused to recognize the coordinates of the height at which the camera is in focus as the position of the back surface of the wafer. A position to be irradiated with laser in the wafer is determined with respect to the height of the back surface of the wafer. The operation of determining the position to be irradiated with the laser is continuously repeated during dicing.

IR camera: A camera for the recognition of the pattern of the silicon wafer. A camera to be used to recognize the pattern on the front surface of the wafer through the dicing tape to determine the position at which the laser irradiation is started in the apparatus (to perform the setting of the XY coordinates of the position).

<Evaluation Criteria>

o.....The positions can be recognized with the SD camera and the IR camera without problems.

x.....The accuracy of the height recognition and/or the pattern recognition is poor, and hence the driving of the apparatus in an automatic mode becomes impossible.

(9) Evaluation of Division Suitability

A silicon wafer and a ring frame were bonded to a dicing tape, and modified portions were formed in the wafer by laser irradiation through the dicing tape under the following division conditions.

(Division Conditions)

Used apparatus: DAL7360 (SDE05) manufactured by DISCO Corporation

Power: 0.25 W

Defocus amount: -2.5 μm

Feed rate: 350 mm/sec

Frequency: 80 kHz

Number of passes: 2 (1 mapping pass+1 processing pass)

Silicon wafer: A diameter of 200 mm ϕ and a thickness of 50 μm

Chip size: 5 mm $\times$ 5 mm

After that, the silicon wafer was singulated by expanding the

peripheral portion of the dicing tape with an expanding apparatus (manufactured by DISCO Corporation, product name: "DDS-2300") in an expanding amount of 10 mm, and at an expanding rate of 20 mm/sec and an expanding temperature of 22°C.

The sections of chips obtained by the singulation were observed with a digital microscope (manufactured by Keyence Corporation, product name: "VHX-1000"). A case in which the portions modified with the laser were linearly formed at constant intervals was indicated by Symbol "o", and a case in which the intervals between the modified portions were nonuniform (modified layer disappearance) and/or a line connecting the modified portions did not become a straight line (meandering) was indicated by Symbol "x".

[Production Example 1] Production of Active Energy Ray-curable Pressure-sensitive Adhesive (1)

100 Parts by weight of 2-methoxyethyl acrylate, 27 parts by weight of acryloylmorpholine, and 22 parts by weight of 2-hydroxyethyl acrylate were mixed to prepare a monomer composition.

Subsequently, nitrogen was introduced into a reaction vessel including a nitrogen inlet tube, a thermometer, and a stirrer. Under a nitrogen atmosphere, 500 parts by weight of ethyl acetate,

149 parts by weight of the monomer composition, and 0.2 part by weight of azobisisobutyronitrile (AIBN) were loaded into the vessel, and were stirred at 60°C for 24 hours. After that, the mixture was cooled to room temperature to provide an acrylic copolymer solution A1 containing an acrylic copolymer a1 (weight-average molecular weight: 600,000). 24 Parts by weight of 2-methacryloyloxyethyl isocyanate was added to, and caused to react with, the resultant acrylic copolymer solution A1 to add an NCO group to a terminal OH group in a 2-hydroxyethyl acrylate side chain in the copolymer. Thus, an acrylic copolymer solution A2 containing an acrylic copolymer a2 having a carbon-carbon double bond at a terminal thereof and having a weight-average molecular weight of 800,000 was obtained.

An active energy ray-curable pressure-sensitive adhesive (1) was obtained by adding 3 parts by weight of a cross-linking agent (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "CORONATE L"), 7 parts by weight of a photopolymerization initiator (manufactured by Ciba Japan K.K., product name: "IRGACURE 184"), and 30 parts by weight of a UV curing aid (manufactured by Shin Nakamura Chemical Co., Ltd., product name: "NK OLIGO U-6LPA") to the acrylic copolymer solution A2 containing 100 parts by weight of the acrylic copolymer a2.

[Production Example 2] Production of Active Energy

Ray-curable Pressure-sensitive Adhesive (2)

An active energy ray-curable pressure-sensitive adhesive (2) was obtained in the same manner as in Production Example 1 except that the compounding amount of the cross-linking agent (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "CORONATE L") was changed to 0.6 part by weight.

[Production Example 3] Production of Active Energy Ray-curable Pressure-sensitive Adhesive (3)

An active energy ray-curable pressure-sensitive adhesive (3) was obtained in the same manner as in Production Example 1 except that the compounding amount of the cross-linking agent (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "CORONATE L") was changed to 0.025 part by weight.

[Production Example 4] Production of Active Energy Ray-curable Pressure-sensitive Adhesive (4)

An active energy ray-curable pressure-sensitive adhesive (4) was obtained in the same manner as in Production Example 1 except that the compounding amount of the cross-linking agent (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "CORONATE L") was changed to 4 parts by weight.

[Production Example 5] Production of Base Material (1)

High-pressure polyethylene (PE) (manufactured by Sumitomo

Chemical Co., Ltd., product name: "SUMIKATHENE F213-P") was used as a base material formation material.

The base material formation material was loaded into an extruder, and was subjected to T-die melt coextrusion (extruder: manufactured by GM Engineering Co., Ltd., product name: "GM30-28", T-die: feed block system; extrusion temperature: 240°C) to provide a film having a thickness of 100 μm while one surface of the film was subjected to an embossing treatment (surface roughness Ra: 1.42 μm). The thickness of the film was controlled by the shape of the outlet of the T-die. Both surfaces of the resultant film were subjected to a corona treatment. Thus, a base material (1) was obtained. The surface roughness Ra of the embossed surface is a numerical value obtained by measurement with VK-X150 manufactured by Keyence Corporation.

[Production Example 6] Production of Base Material (2)

A base material (2) was obtained in the same manner as in Production Example 5 except that only the embossing-treated surface of the film was subjected to a corona treatment.

[Production Example 7] Production of Base Material (3)

A mixture of 100 parts by weight of high-pressure polyethylene (PE) (manufactured by Sumitomo Chemical Co., Ltd., product name: "SUMIKATHENE F213-P") and 1 part by weight of a lubricant

(manufactured by Mitsubishi Chemical Corporation, product name: "AMIDE Ap-1") was used as a base material formation material.

The base material formation material was loaded into an extruder, and was subjected to T-die melt coextrusion (extruder: manufactured by GM Engineering Co., Ltd., product name: "GM30-28", T-die: feed block system; extrusion temperature: 240°C) to provide a film having a thickness of 100 μm while one surface of the film was subjected to an embossing treatment (surface roughness Ra: 1.42 μm). The thickness of the film was controlled by the shape of the outlet of the T-die. The embossing-treated surface of the resultant film was subjected to a corona treatment. Thus, a base material (3) was obtained.

[Example 1]

The active energy ray-curable pressure-sensitive adhesive (1) was applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer having a thickness of 15 μm .

A dicing tape was obtained by transferring the pressure-sensitive adhesive layer onto a base material with a hand roller. "NSO FILM 100 μm TRANSPARENT" manufactured by Okura Industrial Co., Ltd. was used as the base material. The film is

a film that has one surface subjected to a corona treatment and is not subjected to an embossing treatment. The pressure-sensitive adhesive layer was laminated on the corona-treated surface.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Example 2]

A dicing tape was obtained in the same manner as in Example 1 except that: the active energy ray-curable pressure-sensitive adhesive (2) was used instead of the active energy ray-curable pressure-sensitive adhesive (1); and the base material (2) produced in Production Example 6 was used as a base material. The pressure-sensitive adhesive layer was laminated on the embossing-treated surface of the base material.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Example 3]

The active energy ray-curable pressure-sensitive adhesive (3) was applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer "a" having a thickness of 7 μm .

The active energy ray-curable pressure-sensitive adhesive (1) was separately applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer "b" having a thickness of 8 μm .

The pressure-sensitive adhesive layer "a" was transferred onto the base material (2) with a hand roller, and the pressure-sensitive adhesive layer "b" was further transferred onto the pressure-sensitive adhesive layer "a" therewith. Thus, a dicing tape (formed of the base material (2), the first pressure-sensitive adhesive layer "a", and the second pressure-sensitive adhesive layer "b") was obtained. The first pressure-sensitive adhesive layer "a" was laminated on the embossing-treated surface of the base material.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Example 4]

The active energy ray-curable pressure-sensitive adhesive (3) was applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer "a" having a thickness

of 7 μm .

The active energy ray-curable pressure-sensitive adhesive (4) was separately applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer "c" having a thickness of 8 μm .

The pressure-sensitive adhesive layer "a" was transferred onto the base material (2) with a hand roller, and the pressure-sensitive adhesive layer "c" was further transferred onto the pressure-sensitive adhesive layer "a" therewith. Thus, a dicing tape (formed of the base material (2), the first pressure-sensitive adhesive layer "a", and the second pressure-sensitive adhesive layer "c") was obtained. The first pressure-sensitive adhesive layer "a" was laminated on the embossing-treated surface of the base material.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Example 5]

A dicing tape was obtained in the same manner as in Example 4 except that the base material (3) was used instead of the base material (2).

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Comparative Example 1]

A dicing tape was obtained in the same manner as in Example 1 except that the base material (1) produced in Production Example 5 was used as a base material. The pressure-sensitive adhesive layer was laminated on the embossing-treated surface of the base material.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Comparative Example 2]

A dicing tape was obtained in the same manner as in Example 2 except that the base material (1) produced in Production Example 5 was used as a base material. The pressure-sensitive adhesive layer was laminated on the embossing-treated surface of the base material.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

[Comparative Example 3]

The active energy ray-curable pressure-sensitive adhesive (3) was applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer "a'" having a thickness of 5 μm .

The active energy ray-curable pressure-sensitive adhesive (4) was separately applied to the silicone-treated surface of a PET separator (thickness: 38 μm), and was then heated at 120°C for 2 minutes to form a pressure-sensitive adhesive layer "c'" having a thickness of 10 μm .

The pressure-sensitive adhesive layer "a'" was transferred onto the base material (2) with a hand roller, and the pressure-sensitive adhesive layer "c'" was further transferred onto the pressure-sensitive adhesive layer "a'" therewith. Thus, a dicing tape (formed of the base material (2), the first pressure-sensitive adhesive layer "a'", and the second pressure-sensitive adhesive layer "c'") was obtained. The first pressure-sensitive adhesive layer "a'" was laminated on the embossing-treated surface of the base material.

The resultant dicing tape was subjected to the evaluations (1) to (9). The results are shown in Table 1.

Table 1

		Example 1	Example 2	Example 3	Example 4	Example 5
Material		PE	PE	PE	PE	PE (having added thereto lubricant)
Base material	Corona treatment	One surface (surface on pressure-sensitive adhesive layer side)	One surface (embossed surface)	One surface (embossed surface)	One surface (embossed surface)	One surface (embossed surface)
	Embossing treatment	None	One surface (surface on pressure-sensitive adhesive layer side)	One surface (surface on pressure-sensitive adhesive layer side)	One surface (surface on pressure-sensitive adhesive layer side)	One surface (surface on pressure-sensitive adhesive layer side)
	Wettability of surface opposite to pressure-sensitive adhesive layer (mN/m)	40 or more	38	38	38	38
	Wettability of surface on pressure-sensitive adhesive layer side (mN/m)	40 or more	43	43	43	43
Pressure-sensitive adhesive layer	Active energy ray-curable pressure-sensitive adhesive	(1)	(2)	First pressure-sensitive adhesive layer: (3) Second pressure-sensitive adhesive layer: (1)	First pressure-sensitive adhesive layer: (3) Second pressure-sensitive adhesive layer: (4)	First pressure-sensitive adhesive layer: (3) Second pressure-sensitive adhesive layer: (4)
	Thickness	15 μm	15 μm	First pressure-sensitive adhesive layer: 7 μm Second pressure-sensitive adhesive layer: 8 μm	First pressure-sensitive adhesive layer: 7 μm Second pressure-sensitive adhesive layer: 8 μm	First pressure-sensitive adhesive layer: 7 μm Second pressure-sensitive adhesive layer: 8 μm
	Modulus of elasticity	0.27 MPa	0.15 MPa	First pressure-sensitive adhesive layer: 0.11 MPa Second pressure-sensitive adhesive layer: 0.27 MPa	First pressure-sensitive adhesive layer: 0.11 MPa Second pressure-sensitive adhesive layer: 0.31 MPa	First pressure-sensitive adhesive layer: 0.11 MPa Second pressure-sensitive adhesive layer: 0.31 MPa
	White color area of binarized image (%)	99	88.6	85.1	83.8	84.2
	Arithmetic average surface roughness Ra of base material (μm)	0.02	0.03	0.03	0.03	0.03
	Total light transmittance (%)	92	91.4	91.5	91.4	91.6
	Haze (%)	8.7	2.8	3.3	3.6	2.9
	Transmittance @1,064 nm (%)	92.1	92.6	92.4	92.1	92.5
	Evaluation of apparatus visibility before stealth dicing	o	o	o	o	o
	Evaluation of division suitability	o	o	o	o	o

		Comparative Example 1	Comparative Example 2	Comparative Example 3
Base material	Material	PE	PE	PE
	Corona treatment	Both surfaces	Both surfaces	One surface (embossed surface)
	Embossing treatment	One surface (surface on pressure-sensitive adhesive layer side)	One surface (surface on pressure-sensitive adhesive layer side)	One surface (surface on pressure-sensitive adhesive layer side)
	Wettability of surface opposite to pressure-sensitive adhesive layer (mN/m)	43	38	38
Pressure-sensitive adhesive layer	Wettability of surface on pressure-sensitive adhesive layer side (mN/m)	43	43	43
	Active energy ray-curable pressure-sensitive adhesive	(1)	(2)	First pressure-sensitive adhesive layer: (3) Second pressure-sensitive adhesive layer: (4)
	Thickness	15 μm	15 μm	First pressure-sensitive adhesive layer: 5 μm Second pressure-sensitive adhesive layer: 10 μm
	Modulus of elasticity	0.27 MPa	0.15 MPa	First pressure-sensitive adhesive layer: 0.11 MPa Second pressure-sensitive adhesive layer: 0.31 MPa
	White color area of binarized image (%)	23.6	35	61.1
		Arithmetic average surface roughness Ra of base material (μm)	0.06	0.03
		Total light transmittance (%)	91	92
		Haze (%)	6.6	3.8
		Transmittance @1,064 nm (%)	91	91.5
		Evaluation of apparatus visibility before stealth dicing	x	o
		Evaluation of division suitability	x	x

As is apparent from Table 1, when the dicing tape of the present invention is used, the white color area of a binarized image is equal to or more than the specific value, and hence in a stealth dicing step, camera detection through the dicing tape, that is, the recognition of a pattern on the surface of a semiconductor wafer, the detection of a position in the height direction of the semiconductor wafer, or the like with a camera (e.g., an IR camera or a SD camera) can be performed with high accuracy. In addition, a modified layer can be satisfactorily formed in the semiconductor wafer. In each of Examples, the white color area of the binarized image was able to be increased because: the blocking of a base material was prevented; and the dicing tape was formed so that no void was produced near an interface between the base material and a pressure-sensitive adhesive layer by, for example, eliminating the embossing of the base material or adjusting the modulus of elasticity of the pressure-sensitive adhesive layer. It is shown that in Comparative Example 3, the surface roughness of the base material is relatively small, but the white color area of the binarized image is equal to or less than the specific value, and hence the accuracy of dicing is poor.

What is claimed is:

1. A dicing tape, comprising:

a base material, wherein only one surface of the base material is subjected to an embossing treatment to form an embossing-treated surface; and

a pressure-sensitive adhesive layer arranged on the embossing-treated surface of the base material,

wherein, the arithmetic average surface roughness Ra (JIS B 0601) of the embossing-treated surface of the base material is from 1.0 μm to 3 μm , and wherein when an image having brightness of 256 gray scale levels, which is obtained through observation from a base material side of the dicing tape with a laser microscope, is binarized into a white color portion and a black color portion through use of 55% of maximum brightness as a threshold, a ratio of an area of the white color portion to an area of the image is 80% or more.

2. The dicing tape according to claim 1, wherein one surface of the base material has a wettability of 40 mN/m or less.

3. The dicing tape according to claim 2, wherein the base material is arranged so that the surface having a wettability of 40 mN/m or less comprises a surface opposite to the pressure-sensitive adhesive layer.

4. The dicing tape according to claim 1, wherein the base material contains a polyethylene-based resin.

5. The dicing tape according to claim 1, wherein at least one surface of the base material comprises a corona-treated surface.

6. The dicing tape according to claim 1, wherein the pressure-sensitive adhesive layer has a tensile modulus of elasticity at 22°C of from 0.05 MPa to 1 MPa.

7. The dicing tape according to claim 1,
wherein the pressure-sensitive adhesive layer is of a two-layer construction, and

wherein the dicing tape comprises the base material, a first pressure-sensitive adhesive layer, and a second pressure-sensitive adhesive layer in the stated order.

8. The dicing tape according to claim 7, wherein the first pressure-sensitive adhesive layer has a tensile modulus of elasticity at 22°C of from 0.05 MPa to 1 MPa.

9. The dicing tape according to claim 7 or 8, wherein the second pressure-sensitive adhesive layer has a tensile modulus of elasticity at 22°C of from 0.1 MPa to 2 MPa.

10. The dicing tape according to claim 7, wherein the first pressure-sensitive adhesive layer has a thickness of from 5 μm to 468 μm .