polymer.

{0076}

When the acid value of the (meth)acrylic polymer is in the range described above, the adhesive force between the surface protective tape and the mask material layer can be controlled. Thus, even if the Tg values are close to each other, the mask material layer and the temporary-adhesive layer of the surface protective tape can be easily detached.

{0077}

Acid groups do not form covalent bonds as in the case of a curing agent. However, since acid groups form pseudo-crosslinking between them, when acid groups are included in both the temporary-adhesive layer and the mask material layer, the adhesiveness between the temporary-adhesive layer and the mask material layer is enhanced, and the mask material is not easily peeled from the surface protective tape.

The adjustment of the acid value can be adjusted as appropriate by, for example, adjusting the amount of incorporation of acrylic acid when the (meth)acrylic polymer is polymerized.

{0078}

The mask-integrated surface protective tape of the present invention is preferably such that the adhesive force between the mask material layer 3b and the temporary-adhesive layer 3ab before irradiation with radiation is 2.0 N/25 mm or less. As the mask-integrated surface protective tape has such an adhesive force, when the surface protective tape is peeled off from a semiconductor wafer that has been thinned after grinding processing, the surface protective tape can be peeled off without damage to the semiconductor wafer or the like.

{0079}

In the present specification, the term “adhesive force” (unit: N/25 mm) is obtained by making a 25-mm width incision in a mask-integrated surface

protective tape with a cutter, and then pulling a mask material layer at a peeling rate of 300 mm/min in the direction of 180° to peel the mask material layer away from the mask-integrated surface protective tape, and measuring a stress (peeling strength) at that moment, using a TENSILON tester (AG-10kNI (trade name), manufactured by Shimadzu Corporation).

Herein, measurement of the above-described adhesive force is conducted under the conditions that an ultraviolet ray is irradiated to all over the mask-integrated surface protective tape from the substrate film side of the tape so that the accumulated radiation dose gets to 500mJ/cm^{2}. A high-pressure mercury lamp is used for the ultraviolet irradiation.

{0080}

The wafer-fixing tape 4 is required to hold the semiconductor wafer 1 and to have resistance to plasma which is sustainable even if the wafer-fixing tape is subjected to the plasma dicing step. Further, in the picking-up step, a good picking-up property and also an expansion property and the like in some cases are required.

As the foregoing wafer-fixing tape 4, a tape similar to the surface protective tape 3a may be used. Further, use may be made of any of known dicing tapes used in a conventional plasma dicing method, which are generally called as a dicing tape. Further, the use can be also made of a dicing die-bonding tape, in which an adhesion bond for die-bonding is laminated, in order to make it easy to transit to the dicing die-bonding step after picking-up.

{0081}

For the laser irradiation with which the mask material layer 3b is cut, use can be made of a laser irradiator for irradiating an ultraviolet or infrared laser light. In this laser irradiator, a laser irradiation part capable of freely moving along the street of the semiconductor wafer 1 is arranged. Laser can be irradiated, which is provided with an output controlled suitably to remove the mask material layer

3b. In particular, if CO_2 laser is used as a laser light, it is possible to obtain a large power of several to tens of watts. CO_2 laser can be preferably used for the present invention.

{0082}

In order to carry out the plasma dicing and the plasma ashing, use can be made of a plasma-etching apparatus. The plasma-etching apparatus is an apparatus, which is capable of subjecting the semiconductor wafer 1 to dry etching, and in which a sealed treatment space is made in a vacuum chamber, to place the semiconductor wafer 1 on the side of the electrode for a high-frequency wave. A gas for plasma generation is supplied from the side of a gas-supplying electrode provided facing the electrode for high-frequency wave. If a high-frequency voltage is applied to the electrode for a high-frequency wave, plasma is generated between the gas-supplying electrode and the electrode for a high-frequency wave. Therefore, the resultant plasma is used. By circulating a refrigerant in a heat-producing electrode for high-frequency wave, it is possible to prevent a temperature elevation of the semiconductor wafer 1 due to the heat of this plasma.

{0083}

In accordance with the method of producing the semiconductor chip (the method of processing the semiconductor wafer), any photolithographic step or the like becomes unnecessary, which is provided with a resist to be used in the conventional plasma dicing process, by giving a mask function in the plasma dicing to the surface protective tape protecting the patterned face. In particular, by using the surface protective tape, a technique becomes unnecessary, in which a high level of alignment, such as printing and transferring, is required for the mask formation. The mask-integrated surface protective tape can be easily laminated on the semiconductor wafer surface, and a mask can be easily formed

10 minutes thereby to remove the mask material. After that, an ultraviolet ray was irradiated (irradiation dose: 200 mJ/cm^2) from the wafer fixing tape side thereby to decrease an adhesive force of the wafer fixing tape and chips were picked up.

{0091}

In the above-described Example 1, the 25 mm-width mask-integrated surface protective tape was laminated on stainless steel as a model semiconductor wafer, as shown in the fragmentary Fig. 7(a). After that, an adhesive force was measured at a peeling angle of 180° and a peeling rate of 300 mm/min. As a result, as shown in the fragmentary Fig. 7(b), in 2.0 N/25 mm, peeling between the mask material layer and the temporary-adhesive layer was confirmed.

{0092}

After the above-described evaluation, the temporary-adhesive layer was laminated again on the mask material layer exposed on the wafer, as shown in fragmentary Fig. 7(c), and the temporary-adhesive layer was irradiated with ultraviolet radiation (500 mJ/cm^2). The adhesive force was measured at a peeling angle of 180° and a peeling rate of 300 mm/min. As shown in fragmentary Fig. 7(d), repeeling between the mask material layer and the stainless steel was confirmed. In order to check the reproducibility of this repeeling test, the repeeling test was performed ten times, and repeeling was confirmed in all of the ten times. Therefore, in Table 1, repeelability of the mask material layer is "⦿".

{0093}

[Example 2] Production of mask-integrated surface protective tape, and Production of semiconductor chip

<Production of mask-integrated surface protective tape>

Were mixed 1.5 mol% of methacrylic acid, 40.5 mol% of methyl

thereon scribe lines using a laminator DR8500III (trade name, manufactured by Nitto Seiki Co., Ltd.).

After that, the surface (wafer backing-face) opposite to the surface on which the above-described mask-integrated surface protective tape was laminated, was ground using DGP8760 (trade name, manufactured by DISCO Corporation) until a thickness of the wafer got to 50 μm. The ground wafer with the mask material was mounted on a wafer fixing tape (radiation curable dicing tape) from the wafer backing-face side using RAD-2700F (trade name, manufactured by Lintec Corporation), and was supported and fixed to a ring flame. Further, only the surface protective tape 3a was peeled while leaving only the mask material layer 3b on the wafer. After that, similarly to Example 1, an opening was formed on the scribe line and then the plasma dicing and the ashing were carried out, and after ultraviolet irradiation, chips were picked up.

{0095}

In the above-described Example 2, the 25 mm-width mask-integrated surface protective tape was laminated on stainless steel as a model semiconductor wafer, as shown in the fragmentary Fig. 7(a). After that, an adhesive force was measured at a peeling angle of 180° and a peeling rate of 300 mm/min. As a result, as shown in the fragmentary Fig. 7(b), in 2.0 N/25 mm, peeling between the mask material layer and the temporary-adhesive layer was confirmed.

{0096}

After the above-described evaluation, the temporary-adhesive layer was laminated again on the mask material layer exposed on the wafer, as shown in fragmentary Fig. 7(c), and the temporary-adhesive layer was irradiated with ultraviolet radiation (500 mJ/cm^2). The adhesive force was measured at a peeling angle of 180° and a peeling rate of 300 mm/min. As shown in fragmentary Fig. 7(d), repeeling between the mask material layer and the

3b on the wafer. Herein, from the results that only the surface protective tape 3a was peeled while leaving the mask material layer 3b, it was found that, before the ultraviolet irradiation, the adhesive force between the mask material layer and the temporary-adhesive layer was lower than the adhesive force between the mask material layer and the wafer.

After that, similarly to Example 1, an opening was formed on the scribe line and then the plasma dicing and the ashing were carried out, and after ultraviolet irradiation, chips were picked up.

{0101}

In the above-described Example 3, the 25 mm-width mask-integrated surface protective tape was laminated on stainless steel as a model semiconductor wafer, as shown in the fragmentary Fig. 7(a). After that, an adhesive force was measured at a peeling angle of 180° and a peeling rate of 300 mm/min. As a result, as shown in the fragmentary Fig. 7(b), in 1.9 N/25 mm, peeling between the mask material layer and the temporary-adhesive layer was confirmed.

{0102}

After the above-described evaluation, the temporary-adhesive layer was laminated again on the mask material exposed on the wafer, and the temporary-adhesive layer was irradiated with ultraviolet radiation (500 mJ/cm^2). The adhesive force was measured at a peeling angle of 180° and a peeling rate of 300 mm/min. As shown in fragmentary Fig. 7(d), repeeling between the mask material layer and stainless steel was confirmed at an adhesive force of 1.3 N/25 mm. In order to check the reproducibility of this repeeling test, the repeeling test was performed ten times, and repeeling was confirmed in nine times. Therefore, in Table 1, repeelability of the mask material layer is "○".

{0103}

[Comparative Example 1] Production of mask-integrated surface protective tape,