

PEELING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a peeling apparatus that peels off a protective member from a plate-shaped work piece.

Description of the Related Art

A tape mounter can render a wafer supportable by a ring frame via a dicing tape, by affixing the dicing tape to the ring frame and another surface of the wafer having a protective tape affixed to one surface of the wafer. In addition, after the dicing tape is affixed, the protective tape affixed to the wafer is peeled off (see Japanese Patent Laid-Open No. 2015-167205, for example).

SUMMARY OF THE INVENTION

When the protective tape is peeled off, a peeling tape is, for example, affixed to an outer circumferential part of the protective tape, and the protective tape is peeled off by gripping the peeling tape and pulling the peeling tape in such a direction that the peeling tape separates from the wafer. However, if a speed of pulling the protective tape when peeling off the protective tape

is fast, there is a possibility that a glue of the protective tape remains on the one surface of the wafer, or there is a possibility that the wafer is damaged. If the speed of pulling the protective tape is slow, on the other hand, an unnecessary time is taken, and thus, work efficiency is decreased.

In addition, the adhesive force of the protective tape differs according to a kind of device formed on the one surface of the wafer to which the protective tape is affixed, for example. That is, even in the case of the same protective tape, the protective tape may be made to adhere strongly or adhere weakly according to the device formed on the wafer. It is therefore necessary to change a tensile force (tensile speed) at a time of the peeling according to a difference in adhesive force.

Further, the pulling force differs between a small peeling region at a start of peeling the protective tape having a circular shape and a large peeling region when the protective tape is peeled to a part near the center of the wafer. Thus, a force received by the wafer also differs according to a position at which the protective tape is being peeled. Conventionally, however, a peeling test is repeated while the peeling speed of peeling each wafer is gradually increased, and a predetermined peeling

speed is determined to perform the peeling at the determined peeling speed, or a safe speed with a margin for excluding a possibility of damaging the wafer is set to perform the peeling. An unnecessary time is therefore taken.

It is accordingly an object of the present invention to provide a peeling apparatus that can peel off a protective member from a wafer while preventing a crack in the wafer and preventing the remaining of a glue on the wafer or the like without taking an unnecessary time when the protective member is peeled off from the wafer.

In accordance with an aspect of the present invention, there is provided a peeling apparatus that peels a protective member protecting one surface of a plate-shaped work piece from the one surface, the peeling apparatus including holding means that holds another surface of the plate-shaped work piece by a holding surface; and peeling means that grips an outer circumferential part of the protective member covering the one surface of the plate-shaped work piece held on the holding surface, peels the protective member from an outer circumference to a center of the plate-shaped work piece, and further peels the protective member from the

center to an outer circumference on an opposite side from the outer circumference. The peeling means includes a gripping unit configured to grip the outer circumferential part of the protective member; moving means that moves the gripping unit and the holding means relative to each other in a direction parallel with the holding surface, leads the gripping unit from an outer circumference to a center of the holding surface, and then moves the gripping unit passing the center of the holding surface on a straight line in such a direction that the gripping unit moves away from the center; and a tensile load measuring unit configured to measure a tensile load applied to the protective member interposed between the gripping unit and the holding surface. Peeling operation of the peeling means is optimized by measuring the tensile load applied to the protective member by the tensile load measuring unit.

Preferably, the tensile load measuring unit includes a piezoelectric element disposed in a supporting portion that supports the holding means. Preferably, the tensile load measuring unit includes a piezoelectric element disposed in a gripping unit supporting unit that supports the gripping unit.

Preferably, the protective member is a protective

tape, the plate-shaped work piece has a notch portion in an outer circumferential part of the plate-shaped work piece, the holding means includes a partial peeling unit configured to peel the protective tape in a vicinity of the notch portion from the plate-shaped work piece by thrusting up a part of the protective tape, the part being located at the notch portion but not being affixed to the plate-shaped work piece, and the gripping unit grips an outer circumferential part of the protective tape peeled by the partial peeling unit.

Preferably, the protective member is a protective tape, peeling tape affixing means that affixes a peeling tape to an outer circumferential part of the protective tape is further included, and the gripping unit grips the peeling tape affixed to the protective tape instead of gripping the outer circumferential part of the protective tape, and the tensile load measuring unit measures a tensile load applied to the peeling tape integrated with the protective tape interposed between the gripping unit and the holding surface.

Preferably, the protective member has a protruding portion slightly protruding from the outer circumference of the plate-shaped work piece, and the gripping unit grips the protruding portion.

According to the present invention, the peeling operation of the peeling means can be optimized by measuring the tensile load applied to the protective member by the tensile load measuring unit. That is, it is possible to peel off the protective member from the wafer at an optimum peeling speed while preventing a crack in the wafer and preventing the remaining of a glue on the wafer or the like without taking an unnecessary time.

When the tensile load measuring unit is formed by a piezoelectric element disposed in a supporting portion supporting the holding means, the tensile load applied to the protective member can be measured accurately.

When the tensile load measuring unit is formed by a piezoelectric element disposed in a gripping unit supporting unit supporting the gripping unit, the tensile load applied to the protective member can be measured accurately.

The protective member is a protective tape, the plate-shaped work piece has a notch portion in an outer circumferential part of the plate-shaped work piece, and the holding means includes a partial peeling unit configured to peel the protective tape in the vicinity of the notch portion from the plate-shaped work piece by thrusting up a part of the protective tape, the part

being located at the notch portion but not being affixed to the plate-shaped work piece, so that the gripping unit can easily grip the outer circumferential part of the protective tape peeled by the partial peeling unit.

When the protective member is a protective tape and peeling tape affixing means that affixes a peeling tape to an outer circumferential part of the protective tape is included, the gripping unit grips the peeling tape affixed to the protective tape instead of gripping the outer circumferential part of the protective tape, and the tensile load measuring unit measures a tensile load applied to the peeling tape integrated with the protective tape interposed between the gripping unit and the holding surface instead of measuring a tensile load applied to the protective tape. It is thereby possible to optimize the peeling operation of the peeling means.

When the protective member has a protruding portion slightly protruding from the outer circumference of the plate-shaped work piece, the gripping unit can easily grip the protruding portion of the outer circumferential part of the protective member.

The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the

invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing some preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view illustrating a peeling apparatus according to a first embodiment;

FIG. 2 is a sectional view of assistance in explaining a case in which a protective tape is peeled off from a plate-shaped work piece by moving holding means in an X-axis direction and moving a gripping unit in a horizontal direction with respect to the holding surface of the holding means while a tensile load is measured by a gripping unit side tensile load measuring unit;

FIG. 3 is a sectional view of assistance in explaining a case in which the protective tape is peeled off from the plate-shaped work piece by moving the holding means in the X-axis direction but not moving the gripping unit while a tensile load is measured by a table side tensile load measuring unit;

FIG. 4 is a sectional view of assistance in explaining the holding means including a partial peeling

unit that peels the protective tape in the vicinity of a notch portion of the plate-shaped work piece from the plate-shaped work piece;

FIG. 5 is a perspective view of assistance in explaining a peeling apparatus according to a second embodiment;

FIG. 6 is a sectional view illustrating a state in which a gripping clamp of a gripping unit grips a protruding portion when the peeling apparatus according to the second embodiment starts peeling off a protective member;

FIG. 7 is a sectional view of assistance in explaining a state in which the gripping clamp of the gripping unit has peeled a part of the protruding portion from the outer circumferential edge of a plate-shaped work piece when the peeling apparatus according to the second embodiment starts peeling off the protective member;

FIG. 8 is a sectional view of assistance in explaining a state in which the protective member is made to conform to the side surface of a rotating roller after the gripping clamp of the gripping unit peels a part of the protruding portion from the outer circumferential edge of the plate-shaped work piece when the peeling

apparatus according to the second embodiment starts peeling off the protective member;

FIG. 9 is a sectional view of assistance in explaining a case in which the protective member is peeled off from the plate-shaped work piece by moving holding means in a Y-axis direction and moving the gripping unit in an obliquely downward direction with respect to the holding surface of the holding means while a tensile load is measured by a gripping unit side tensile load measuring unit; and

FIG. 10 is a sectional view of assistance in explaining a case in which the protective member is peeled off from the plate-shaped work piece by moving the holding means in the Y-axis direction but not moving the gripping unit while a tensile load is measured by a pad side tensile load measuring unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First Embodiment of Peeling Apparatus)

A peeling apparatus 1 according to a first embodiment illustrated in FIG. 1 is an example of a peeling apparatus that, by using a band-shaped peeling tape 83, peels off a protective tape 81 as a protective member affixed to one surface 800 of a plate-shaped work

piece 80, the one surface 800 being an upper surface of the plate-shaped work piece 80 in FIG. 1. The peeling apparatus 1 includes at least holding means 30 that holds another surface 801 of the plate-shaped work piece 80 by a holding surface 302; and peeling means 4 that grips an outer circumferential part of the protective tape 81 covering the one surface 800 of the plate-shaped work piece 80 held on the holding surface 302, peels the protective tape 81 from an outer circumference to a center of the plate-shaped work piece 80, and further peels the protective tape 81 from the center to an outer circumference on an opposite side of the wafer.

The plate-shaped work piece 80 illustrated in FIG. 1 is, for example, a semiconductor wafer having silicon as a base material and having a circular external shape. The one surface 800 of the plate-shaped work piece 80 is demarcated in a lattice manner by a plurality of planned dividing lines 804 orthogonally intersecting each other. A device 805 such as an integrated circuit (IC) is formed in each of regions demarcated in a lattice manner in the one surface 800.

In the present embodiment, the protective member affixed so as to cover the whole of the one surface 800 of the plate-shaped work piece 80 is, for example, the

protective tape 81 that includes a substrate layer formed of a resin having a certain degree of flexibility (for example, a polyolefin resin or the like) and an adhesive layer (glue layer) on the substrate layer.

It is to be noted that the plate-shaped work piece 80 may be formed by gallium arsenide, sapphire, ceramic, resin, gallium nitride, silicon carbide, or the like other than silicon, and that the protective member is not limited to the protective tape 81.

A dicing tape 82 having a larger diameter than the plate-shaped work piece 80, for example, is affixed to the other surface 801 (lower surface in FIG. 1) as an opposite surface of the plate-shaped work piece 80 from the one surface 800. Then, an outer circumferential portion of a glue layer of the dicing tape 82 is also affixed to an annular frame 84. Thus, the plate-shaped work piece 80 is supported by the annular frame 84 via the dicing tape 82 and can be handled by the annular frame 84.

The peeling apparatus 1 has a base 10 in the shape of a rectangular parallelepiped extending in an X-axis direction. Table moving means 13 that causes the holding means 30 to reciprocate in the X-axis direction is disposed on the base 10. The table moving means 13

includes a ball screw 130 disposed on the base 10, a motor 132 connected to one end of the ball screw 130, a pair of guide rails 131 extending in parallel with the ball screw 130, and a movable member 133 movable in the X-axis direction. The holding means 30 is disposed on the upper surface of the movable member 133 via a supporting portion 31. The pair of guide rails 131 is in sliding contact with the lower surface of the movable member 133. The ball screw 130 is screwed in a nut not illustrated that is disposed on the lower surface of the movable member 133. When the ball screw 130 rotates by being driven by the motor 132, the holding means 30 moves in the X-axis direction along the guide rails 131 together with the movable member 133.

The table moving means 13 is a part of the peeling means 4. The table moving means 13 functions as moving means that moves a gripping unit 41 and the holding means 30 relative to each other in the X-axis direction parallel with the holding surface 302, leads the gripping unit 41 from the outer circumference to the center of the holding surface 302, and then moves the gripping unit 41 passing the center of the holding surface 302 on a straight line in such a direction that the gripping unit 41 moves away from the center.

In the present embodiment, the holding means 30 is a holding table. The holding means 30 includes a sucking portion 300 that is formed by a porous member or the like and sucks the plate-shaped work piece 80, and a frame body 301 that supports the sucking portion 300. The sucking portion 300 communicates with an unillustrated suction source such as a vacuum generating apparatus. A suction force produced by suction of the suction source is transmitted to the flat holding surface 302 as an exposed surface of the sucking portion 300. The holding means 30 can thereby suck and hold the plate-shaped work piece 80 on the holding surface 302.

The periphery of the holding means 30 is, for example, surrounded by frame fixing means 32 that fixes the annular frame 84. The frame fixing means 32 that has an annular external shape as viewed in plan and on which the annular frame 84 is to be mounted is configured to suck and fix the annular frame 84 by a suction force produced by the suction source not illustrated. The frame fixing means 32 can be moved up and down in a Z-axis direction (vertical direction) by piston mechanisms 33 arranged at equal intervals in a circumferential direction. Incidentally, in place of the frame fixing means 32, a plurality of mechanical clamps opened and

closed by a spring or the like may be arranged on the periphery of the holding means 30.

The peeling means 4 includes, for example, a tensile load measuring unit 35 formed by piezoelectric elements arranged in the supporting portion 31 supporting the holding means 30. The tensile load measuring unit 35 serves as a tensile load measuring unit that measures a tensile load applied to the protective tape 81 interposed between the gripping unit 41, which is illustrated in FIG. 1 and will be described later, and the holding surface 302. In the following, the tensile load measuring unit 35 will be referred to as a table side tensile load measuring unit 35.

In the present embodiment, the supporting portion 31 supporting the holding means 30, for example, has a cylindrical shape, and the table side tensile load measuring unit 35 is disposed in a part of the supporting portion 31 which is connected to the movable member 133 of the table moving means 13. That is, the table side tensile load measuring unit 35 is disposed so as to be sandwiched between the supporting portion 31 and the movable member 133 from an upward-downward direction (Z-axis direction) and support the weight of the holding means 30 mounted on the supporting portion 31. In the

present embodiment, the table side tensile load measuring unit 35 is disposed below the holding means 30 so as to be in two parts opposed to each other in the X-axis direction. That is, the table side tensile load measuring unit 35 includes a first table side tensile load measuring unit 351 and a second table side tensile load measuring unit 352.

A piezoelectric element as the first table side tensile load measuring unit 351 (second table side tensile load measuring unit 352) is, for example, formed in a flat plate shape or a columnar shape by a material such as barium titanate (BaTiO_3), lead zirconate titanate (PZT), lithium niobate (LiNbO_3), or lithium tantalate (LiTaO_3). The piezoelectric element can convert a load applied thereto into a voltage signal, and output the voltage signal to control unit 19 that controls the whole of the peeling apparatus 1.

The peeling means 4 that peels off the protective tape 81 of the plate-shaped work piece 80 held by the holding means 30 is disposed above a movement path of the holding means 30. The peeling means 4 includes, for example, tape cutting means 40 that cuts the peeling tape 83 to a predetermined length; peeling tape supply means 42 that draws out the peeling tape 83 from a tape roll

831 wound with the peeling tape 83 in a roll shape and supplies the peeling tape 83 to the protective tape 81 affixed to the one surface 800 of the plate-shaped work piece 80; peeling tape affixing means 44 that affixes the peeling tape 83 to an outer circumferential part of the protective tape 81; the gripping unit 41 that grips the peeling tape 83 affixed to the protective tape 81; and X-axis direction moving means 46 that moves the peeling tape affixing means 44 and the gripping unit 41 in the X-axis direction.

The X-axis direction moving means 46 functions as moving means that moves the gripping unit 41 and the holding means 30 relative to each other in the X-axis direction parallel with the holding surface 302, leads the gripping unit 41 from the outer circumference to the center of the holding surface 302, and then moves the gripping unit 41 passing the center of the holding surface 302 on a straight line in such a direction that the gripping unit 41 moves away from the center.

Specifically, the X-axis direction moving means 46 includes a ball screw 460 having an axis in the X-axis direction; a pair of guide rails 461 arranged in parallel with the ball screw 460; a motor 462 that is coupled to the ball screw 460 and rotates the ball screw 460; and a

movable plate 463 that has an internal nut screwed on the ball screw 460 and has a side portion in sliding contact with the guide rails 461. When the motor 462 rotates the ball screw 460, the movable plate 463 correspondingly reciprocates in the X-axis direction while guided by the guide rails 461, and the peeling tape affixing means 44 and the gripping unit 41 attached to the movable plate 463 also reciprocate in the X-axis direction.

The peeling tape supply means 42 includes a roll tube 420 mounted with the tape roll 831; a pair of guide rollers 421 that guide the peeling tape 83 drawn out from the tape roll 831 downward; and a pair of feeding rollers 422 disposed on a downward side of the pair of guide rollers 421. A control mechanism not illustrated applies a back tension to the roll tube 420, and thus, a state of tension is adjusted so as not to cause a slack in the peeling tape 83 drawn out from the tape roll 831. The pair of guide rollers 421 can fold back the peeling tape 83 while sandwiching the peeling tape 83, and guide the peeling tape 83 to the pair of feeding rollers 422 while applying a tension. The pair of feeding rollers 422 can feed the peeling tape 83 to the gripping unit 41.

The peeling tape 83 is, for example, a heat seal of a two-layer structure including a substrate and an

adhesive layer which is bonded to the outer circumferential part of the protective tape 81 by applying heat to the adhesive layer. A material for the substrate is, for example, a resin such as polyethylene terephthalate. The adhesive layer is, for example, formed by a thermosetting resin such as an epoxy resin. The adhesion of the peeling tape 83 to the protective tape 81 is set stronger than the adhesion of the protective tape 81 to the plate-shaped work piece 80. Such a peeling tape 83 is wound in a state in which the adhesive layer is located on the inside (lower surface side in an extended state) to form the tape roll 831. It is to be noted that the peeling tape 83 is not limited to the heat seal.

A gripping unit supporting unit 48 is attached to a support 480 fixed to a side surface of the movable plate 463 of the X-axis direction moving means 46 illustrated in FIG. 1, and further a pair of gripping claws 412 constituting the gripping unit 41 can be moved up and down by the gripping unit supporting unit 48.

The pair of gripping claws 412 includes, for example, a fixed claw 4121 in substantially the shape of an L as viewed from the side and a movable claw 4122 that is disposed so as to be opposed to the fixed claw 4121 in the Z-axis direction and which is capable of approaching

or being separated from the fixed claw 4121. In the gripping unit 41, one end of the peeling tape 83 can be gripped between the fixed claw 4121 and the movable claw 4122 by making the movable claw 4122 approach the fixed claw 4121. Then, the gripping unit supporting unit 48 can position the pair of gripping claws 412 gripping the peeling tape 83 at a height position appropriate for tape affixation above the protective tape 81 of the plate-shaped work piece 80 held by the holding means 30. On the other hand, the state of gripping the one end of the peeling tape 83 in the gripping unit 41 can be released by separating the movable claw 4122 from the fixed claw 4121.

The peeling tape affixing means 44 illustrated in FIG. 1 is disposed between the pair of feeding rollers 422 and the gripping unit 41. The peeling tape affixing means 44 includes a support 440 fixed to the side surface of the movable plate 463 of the X-axis direction moving means 46, a pressing plate raising and lowering mechanism 441 formed by an air cylinder or the like and supported by the support 440, and a pressing plate 442 capable of being moved up and down by the pressing plate raising and lowering mechanism 441.

A heater not illustrated that generates heat by

being fed with a current is attached to the pressing plate 442. When the pressing plate 442 is lowered by the pressing plate raising and lowering mechanism 441 and the peeling tape 83 is pressed and affixed to the outer circumferential part of the protective tape 81, a part of the peeling tape 83 can thermally be welded to the protective tape 81 by heating the pressing plate 442 by the heater not illustrated. Thus, the peeling tape 83 can excellently be affixed to the protective tape 81.

The tape cutting means 40 is, for example, disposed between the pair of feeding rollers 422 and the peeling tape affixing means 44. The tape cutting means 40 includes a mounting base 400 having a mounting surface 404 on which the adhesive layer side (lower side) of the peeling tape 83 is to be mounted, and a groove 405 that traverses the mounting surface 404 in the width direction of the peeling tape 83 (Y-axis direction orthogonal to the X-axis direction within a horizontal plane); a cutter 401 advanced within the groove 405 along the extending direction of the groove 405; cutter moving means 402 as a ball screw mechanism that supports the cutter 401 via cutter raising and lowering means 403 and moves the cutter 401 in the extending direction (Y-axis direction) of the groove 405; and the cutter raising and lowering

means 403 that is formed by an air cylinder or the like and raises and lowers the cutter 401 in the Z-axis direction with respect to the mounting surface 404.

The peeling means 4 includes, for example, a tensile load measuring unit 47 formed by piezoelectric elements arranged in the gripping unit supporting unit 48 supporting the gripping unit 41, as a tensile load measuring unit that measures a tensile load applied to the protective tape 81 interposed between the gripping unit 41 and the holding surface 302. In the following, the tensile load measuring unit 47 will be referred to as a gripping unit side tensile load measuring unit 47. The gripping unit side tensile load measuring unit 47 includes, for example, a vertical direction load measuring piezoelectric element 471 and a horizontal direction load measuring piezoelectric element 472. Incidentally, it suffices for the peeling apparatus 1 to include at least one of the table side tensile load measuring unit 35 and the gripping unit side tensile load measuring unit 47, as a tensile load measuring unit.

The gripping unit supporting unit 48 is, for example, an electric cylinder or the like in which a piston rod 483 can move up and down in the Z-axis direction from the inside of a cylinder tube 484. The

vertical direction load measuring piezoelectric element 471, for example, has a cylindrical external shape and is disposed integrally with the piston rod 483 such that two rods are vertically coupled to each other to form one piston rod 483.

The horizontal direction load measuring piezoelectric element 472 is, for example, formed in a flat plate shape and is disposed in a part where a distal end portion of the piston rod 483 and the fixed claw 4121 are coupled to each other in a state of being sandwiched by both members from both sides in the X-axis direction. Incidentally, the vertical direction load measuring piezoelectric element 471 and the horizontal direction load measuring piezoelectric element 472 are formed of a material similar to that of the table side tensile load measuring unit 35 described earlier. A collecting box 17 into which the protective tape 81 peeled off by the peeling means 4 is dropped and which collects the protective tape 81, for example, is disposed in a position below a movement path of the gripping unit 41.

The peeling apparatus 1 includes, for example, the control unit 19 that controls each configuration of the apparatus. The control unit 19 includes a central processing unit (CPU) performing arithmetic processing

according to a control program, a storage medium such as a memory, and the like. The control unit 19 is electrically connected to the table moving means 13, the X-axis direction moving means 46, the gripping unit supporting unit 48 such as an electric cylinder that vertically moves the gripping unit 41, and the like via a wired or wireless communication path not illustrated. Control of moving speed in the X-axis direction of the holding means 30 sucking and holding the plate-shaped work piece 80 and positioning control of the holding means 30 with respect to the gripping unit 41 and the like are performed under control on the table moving means 13 by the control unit 19. In addition, control of moving speed of the gripping unit 41 gripping the peeling tape 83 affixed to the protective tape 81 of the plate-shaped work piece 80, positioning control of the gripping unit 41, and the like are performed under control on the X-axis direction moving means 46 and the gripping unit supporting unit 48 by the control unit 19. Incidentally, for example, the control of the X-axis direction moving means 46 by the control unit 19 is performed by control of rotational speed of the motor 462. In addition, the control unit 19 can receive, from the table side tensile load measuring unit 35 and the gripping unit side tensile

load measuring unit 47, information regarding tensile loads measured by the respective load measuring units.

In a case where the motor 132 of the table moving means 13 is a servomotor, for example, a rotary encoder of the servomotor is connected to the control unit 19 having a function as a servo amplifier. After an operating signal is supplied from an output interface of the control unit 19 to the servomotor, the rotary encoder outputs the rotational speed of the servomotor as an encoder signal to an input interface of the control unit 19. Then, the control unit 19 that have received the encoder signal can successively identify an amount of movement of the holding means 30 on the basis of the rotational angle of the motor 132, and thereby successively identify the position in the X-axis direction of the holding means 30.

Next, a case where the protective tape 81 is peeled off from the plate-shaped work piece 80 by using the peeling apparatus 1 illustrated in FIG. 1 will be described. First, the plate-shaped work piece 80 integrated with the annular frame 84 is mounted on the holding surface 302 of the holding means 30 in a state in which the protective tape 81 is oriented upward, and the annular frame 84 is mounted on the frame fixing means 32

disposed on the peripheral side of the holding means 30. Next, the suction source not illustrated is actuated, so that the holding surface 302 sucks and holds the plate-shaped work piece 80, and the frame fixing means 32 sucks and fixes the annular frame 84. Then, the annular frame 84 is, for example, lowered to a position lower than the holding surface 302.

The pair of guide rollers 421 illustrated in FIG. 1 feeds the peeling tape 83 from the tape roll 831 toward the gripping unit 41. When the adhesive layer side (inside) of the peeling tape 83 is mounted on the mounting surface 404 of the mounting base 400 of the tape cutting means 40 and further one end of the peeling tape 83 is positioned on the upper surface of the fixed claw 4121 of the gripping unit 41, the movable claw 4122 approaches the fixed claw 4121, and the gripping unit 41 grips the one end of the peeling tape 83. Next, the X-axis direction moving means 46 moves the gripping unit 41 in a -X direction, so that the gripped peeling tape 83 is pulled in the same direction. In this stage, the pressing plate 442 of the peeling tape affixing means 44 and the cutter 401 of the tape cutting means 40 stand by on the upward side of the peeling tape 83.

The holding means 30, for example, moves in a +X

direction and positions the outer circumferential part of the protective tape 81 directly below the peeling tape affixing means 44. Next, the pressing plate 442 heated by the internally provided heater not illustrated is lowered, and the peeling tape 83 is pressed against the outer circumferential part of the protective tape 81 from above by a lower end of the pressing plate 442, thereby thermally welding the adhesive layer of the peeling tape 83 to the protective tape 81.

In this state, the cutter 401 is positioned at the position of one end of the groove 405 of the mounting base 400 exposed from one lateral edge side of the peeling tape 83. Further, the cutter raising and lowering means 403 lowers the cutter 401 until a lowermost end of the cutter 401 reaches the inside of the groove 405. Further, the cutter 401 travels in a -Y direction along the extending direction of the groove 405, and thereby, the cutter 401 cuts the peeling tape 83. After the cutter 401 cuts the peeling tape 83, the cutter 401 and the pressing plate 442 rise in a +Z direction and retract from the peeling tape 83.

(Embodiment A of Peeling off Protective Tape 81 in Peeling Apparatus 1)

A case where, upon peeling off the protective tape

81, the holding means 30 is moved in the X-axis direction and where the gripping unit 41 is positioned at a predetermined distance from the holding surface 302 of the holding means 30 and is thereafter moved in a horizontal direction will be described.

The gripping unit 41 gripping the peeling tape 83 moves in the +Z direction, and a part of the protective tape 81 is peeled from the one surface 800 of the plate-shaped work piece 80. Next, the X-axis direction moving means 46 moves the gripping unit 41 in the -X direction. In addition, the table moving means 13 moves the holding means 30 in the +X direction. The gripping unit 41 is thus relatively moved from the outer circumferential edge to the center of the plate-shaped work piece 80 in a radial direction such that the protective tape 81 is peeled off from the plate-shaped work piece 80. Incidentally, the occurrence of a break in the protective tape 81 which may occur during the peeling of the protective tape 81 may be suppressed by disposing a rotating roller not illustrated above the movement path of the holding means 30 and then performing the peeling while the protective tape 81 is brought into contact with the rotating roller.

Incidentally, for example, because it is sufficient

if the protective tape 81 can be peeled off from the plate-shaped work piece 80 by relatively moving the gripping unit 41 from the outer circumferential edge to the center of the plate-shaped work piece 80 in the radial direction, the protective tape 81 may be peeled off by moving only the gripping unit 41 in the -X direction without moving the holding means 30 in the +X direction, for example.

In the present embodiment, upon peeling off the protective tape 81 from the above-described plate-shaped work piece 80, the gripping unit side tensile load measuring unit 47 illustrated in FIG. 2 can accurately measure a tensile load applied to the peeling tape 83 integrated with the protective tape 81 interposed between the gripping unit 41 and the holding surface 302.

The measurement of the tensile load by the gripping unit side tensile load measuring unit 47 is, for example, performed by the vertical direction load measuring piezoelectric element 471 and the horizontal direction load measuring piezoelectric element 472. Incidentally, as illustrated in FIG. 2, a part of the configurations of the peeling means 4, the holding means 30, and the like are simplified.

In FIG. 2, an arrow F1 directed obliquely upward

represents a tensile load F1 applied to the peeling tape 83 integrated with the protective tape 81 interposed between the gripping unit 41 and the holding surface 302 of the holding means 30. The tensile load F1 is a tensile load F1 obtained by combining an X-axis direction tensile load Fx1 whose direction illustrated in FIG. 2 is the -X direction and a Z-axis direction tensile load Fz1 whose direction is the +Z direction. Then, the following Equation 1 holds from the Pythagorean theorem.

$$(X\text{-axis direction tensile load } Fx1)^2 + (Z\text{-axis direction tensile load } Fz1)^2 = (\text{tensile load } F1)^2 \dots (\text{Equation 1})$$

Here, the horizontal direction load measuring piezoelectric element 472 measures the X-axis direction tensile load Fx1 at predetermined time intervals. Specifically, the X-axis direction tensile load Fx1 slightly deforms the horizontal direction load measuring piezoelectric element 472, and a potential difference corresponding to the load occurs in the horizontal direction load measuring piezoelectric element 472. When the potential difference occurs in the horizontal direction load measuring piezoelectric element 472, a load detection signal is sent from the horizontal direction load measuring piezoelectric element 472 to the

control unit 19 illustrated in FIG. 1 in each measurement. In addition, the vertical direction load measuring piezoelectric element 471 measures the Z-axis direction tensile load F_{z1} at predetermined time intervals and sends a load detection signal to the control unit 19 in each measurement.

The control unit 19 performs arithmetic processing that substitutes an actually measured value of the X-axis direction tensile load F_{x1} and an actually measured value of the Z-axis direction tensile load F_{z1} into the Equation 1, and thereby measures the tensile load F_1 at predetermined time intervals. Then, the control unit 19 uses the tensile load F_1 measured at predetermined time intervals, as information for optimizing the operation of peeling off the protective tape 81 by the peeling means 4. That is, on the basis of the value of the tensile load F_1 measured at predetermined time intervals, the control unit 19 optimizes the speed of movement in the -X direction of the gripping unit 41 by the X-axis direction moving means 46, for example. As a result, feedback control is performed such that the tensile load F_1 applied when the gripping unit 41 peels off the peeling tape 83 integrated with the protective tape 81 becomes such an optimum tensile load that prevents a crack in the

plate-shaped work piece 80 and prevents the remaining of a glue on the plate-shaped work piece 80 or the like. In addition, the peeling speed of the gripping unit 41 is not too slow, so that the protective tape 81 is peeled from the plate-shaped work piece 80 without taking an unnecessary time.

When the protective tape 81 is completely peeled off from the one surface 800 of the plate-shaped work piece 80, the gripping unit 41 gripping the peeling tape 83 affixed to the protective tape 81 is moved to a position above the collecting box 17. Then, the gripping unit 41 releases the gripping of the peeling tape 83 and drops the protective tape 81 and the peeling tape 83 into the collecting box 17.

As in the present embodiment, because the protective member protecting the plate-shaped work piece 80 is the protective tape 81 and the peeling tape affixing means 44 that affixes the peeling tape 83 to the outer circumferential part of the protective tape 81 is provided, the gripping unit 41 grips the peeling tape 83 affixed to the protective tape 81 instead of gripping the outer circumferential part of the protective tape 81, and the gripping unit side tensile load measuring unit 47 measures the tensile load applied to the peeling tape 83

integrated with the protective tape 81 interposed between the gripping unit 41 and the holding surface 302 instead of measuring the tensile load applied to the protective tape 81. The peeling operation of the peeling means 4 can thus be optimized.

(Embodiment B of Peeling off Protective Tape 81 in Peeling Apparatus 1)

A case where, as illustrated in FIG. 3, the holding means 30 is moved in the X-axis direction and the gripping unit 41 is not moved by the X-axis direction moving means 46 when the protective tape 81 is further peeled off after the gripping unit 41 gripping the peeling tape 83 is moved in the +Z direction and a part of the protective tape 81 is peeled from the one surface 800 of the plate-shaped work piece 80, will be described. In the present case, the gripping unit 41 is stopped at a predetermined height position and a predetermined position P2 in the X-axis direction, and the control unit 19 recognizes the height position and the position P2 in the X-axis direction at which the gripping unit 41 is located.

The protective tape 81 is peeled from the plate-shaped work piece 80 by moving the holding means 30 in the +X direction by the table moving means 13 and

relatively moving the gripping unit 41 whose movement is stopped, from the outer circumferential edge to the center of the plate-shaped work piece 80 in the radial direction. Incidentally, the occurrence of a break in the protective tape 81 which may occur during the peeling of the protective tape 81 may be suppressed by disposing a rotating roller not illustrated above the movement path of the holding means 30 and then performing the peeling while the protective tape 81 is brought into contact with the rotating roller.

In the present embodiment, upon peeling off the protective tape 81 from the above-described plate-shaped work piece 80, the table side tensile load measuring unit 35 measures a tensile load applied to the peeling tape 83 integrated with the protective tape 81 interposed between the gripping unit 41 and the holding surface 302.

In FIG. 3, an arrow F2 represents a tensile load F2 applied to the peeling tape 83 integrated with the protective tape 81 interposed between the gripping unit 41 and the holding surface 302 of the holding means 30. The tensile load F2 is a tensile load F2 obtained by combining an X-axis direction tensile load F_{x2} whose direction is the -X direction and a Z-axis direction tensile load F_{z2} whose direction is the +Z direction, the

X-axis direction tensile load F_{x2} and the Z-axis direction tensile load F_{z2} being illustrated in FIG. 3.

An arrow R1 illustrated in FIG. 3 represents a first measured load R1 that can be measured in the Z-axis direction at predetermined time intervals by the first table side tensile load measuring unit 351. The first measured load R1, for example, has a direction in a -Z direction. Information regarding the value of the first measured load R1 is sent to the control unit 19 at predetermined time intervals.

An arrow R2 represents a second measured load R2 that can be measured in the Z-axis direction at predetermined time intervals by the second table side tensile load measuring unit 352. The second measured load R2, for example, has a direction in the +Z direction. Information regarding the value of the second measured load R2 is sent to the control unit 19 at predetermined time intervals.

A distance L2 in the X-axis direction between the first table side tensile load measuring unit 351 and the second table side tensile load measuring unit 352 illustrated in FIG. 3 is an apparatus design value recognized by the control unit 19 in advance and is a constant.

A changing distance M in the X-axis direction from the first table side tensile load measuring unit 351 to the gripping unit 41 whose movement in the X-axis direction is stopped and which is located at the position P2 is a variable that changes when the holding means 30 moves in the X-axis direction. Incidentally, the control unit 19 can grasp the position of the first table side tensile load measuring unit 351 moving together with the movable member 133, on the basis of the encoder signal fed back from the rotary encoder of the motor 132 (servomotor 132) of the table moving means 13 to the control unit 19. Therefore, the control unit 19 can also successively recognize the value of the changing distance M at predetermined time intervals.

A distance N in the Z-axis direction between the first table side tensile load measuring unit 351 whose height position is recognized by the control unit 19 and the gripping unit 41 stopped at the position P2 is a constant recognized by the control unit 19 in advance.

The following Equation 2 holds from the Pythagorean theorem.

$$(X\text{-axis direction tensile load } F_{x2})^2 + (Z\text{-axis direction tensile load } F_{z2})^2 = (\text{tensile load } F_2)^2 \dots (\text{Equation 2})$$

In addition, the following Equation 3 holds from a balance of forces in the Z-axis direction.

(Z-axis direction tensile load F_{z2}) = (first measured load $R1$) + (second measured load $R2$) ... (Equation 3)

Further, the following Equation 4 holds from a balance of moments about the first table side tensile load measuring unit 351 in a case where the first table side tensile load measuring unit 351 is assumed to be an origin.

(X-axis direction tensile load F_{x2}) × (distance N as a constant) = (second measured load $R2$) × (distance $L2$) + (Z-axis direction tensile load F_{z2}) × (changing distance M) ... (Equation 4)

From the Equation 3, the control unit 19 can measure the Z-axis direction tensile load F_{z2} at predetermined time intervals. In addition, the control unit 19 can measure the X-axis direction tensile load F_{x2} at predetermined time intervals from the following Equation 5 obtained by modifying the Equation 4.

(X-axis direction tensile load F_{x2}) = {(second measured load $R2$) × (distance $L2$) + (Z-axis direction tensile load F_{z2}) × (changing distance M)}/(distance N as a constant) ... (Equation 5)

The control unit 19 performs arithmetic processing that substitutes the value of the X-axis direction tensile load F_{x2} and the value of the Z-axis direction tensile load F_{z2} into the Equation 2, and thereby measures the tensile load F_2 at predetermined time intervals. Then, the control unit 19 uses the tensile load F_2 measured at predetermined time intervals, as information for optimizing the operation of peeling off the protective tape 81 by the peeling means 4. That is, on the basis of the value of the tensile load F_2 measured at predetermined time intervals, the control unit 19 optimizes the speed of movement of the holding means 30 by the table moving means 13, for example. As a result, feedback control is performed such that the tensile load F_2 applied when the gripping unit 41 peels off the peeling tape 83 integrated with the protective tape 81 becomes such an optimum tensile load that prevents a crack in the plate-shaped work piece 80 and prevents the remaining of a glue on the plate-shaped work piece 80 or the like. In addition, the peeling speed of the gripping unit 41 moving in the X-axis direction relative to the moving holding means 30 is not too slow, so that the protective tape 81 is peeled from the plate-shaped work piece 80 without taking an unnecessary time.

When the table side tensile load measuring unit 35, that is, the first table side tensile load measuring unit 351 and the second table side tensile load measuring unit 352, are formed by piezoelectric elements arranged in the supporting portion 31 supporting the holding means 30 as in the present embodiment, the tensile load applied to the protective tape 81 as the protective member can be measured accurately.

When the protective tape 81 is completely peeled off from the one surface 800 of the plate-shaped work piece 80, the gripping unit 41 gripping the peeling tape 83 affixed to the protective tape 81 is moved to a position above the collecting box 17. Then, the gripping unit 41 releases the gripping of the peeling tape 83 and drops the protective tape 81 and the peeling tape 83 into the collecting box 17.

The peeling apparatus 1 of the first embodiment according to the present invention is not limited to the foregoing embodiment and may, needless to say, be implemented in various different forms within the scope of the technical concept thereof. In addition, the shape and the like of each constituent element of the peeling apparatus 1 illustrated in the accompanying drawings are not limited to this either and can be changed as

appropriate within a scope in which effects of the present invention can be exerted.

For example, as illustrated in FIG. 4, the plate-shaped work piece 80 may have a notch portion 806 in an outer circumferential part thereof. The notch portion 806 is, for example, a notch as a mark indicating a crystal orientation. The notch portion 806 is formed in the outer circumferential edge of the plate-shaped work piece 80 in a state of being recessed inward in the radial direction toward the center of the plate-shaped work piece 80. Alternatively, the notch portion 806 may be an orientation flat. In this case, the notch portion 806 is formed by flatly cutting away a part of the periphery of the plate-shaped work piece 80.

As illustrated in FIG. 4, for example, the holding means 30 illustrated in FIG. 1 may include a partial peeling unit 34 that peels the protective tape 81 in the vicinity of the notch portion 806 from the plate-shaped work piece 80 by thrusting up a part of the protective tape 81 which is located at the notch portion 806 of the plate-shaped work piece 80 but is not affixed to the plate-shaped work piece 80. Then, for example, the gripping unit 41 illustrated in FIG. 1 may grip the outer circumferential part of the protective tape 81 which is

peeled off by the partial peeling unit 34, and peel off the protective tape 81 from the plate-shaped work piece 80.

A circular through hole 341 that constitutes the partial peeling unit 34 and penetrates the holding surface 302 and the lower surface of the holding means 30 (lower surface of the frame body 301) is formed in the periphery of the holding surface 302 so as to correspond to the notch portion 806 of the plate-shaped work piece 80 mounted on the holding surface 302. Specifically, the through hole 341 is disposed in the holding surface 302 such that a distance from the center of the plate-shaped work piece 80 to the notch portion 806 coincides with a distance from the center of the holding surface 302 to the through hole 341.

In addition, the diameter of the through hole 341 is, for example, set slightly smaller than the width of the notch portion 806. A thrusting pin 342 that thrusts up a part of the protective tape 81 affixed to the one surface 800 of the plate-shaped work piece 80 is provided immediately below the through hole 341 of the partial peeling unit 34 so as to be vertically movable by a vertical driving unit 345. The thrusting pin 342 is formed in a rod shape extending in the upward-downward

direction. The outside diameter of the thrusting pin 342 is slightly smaller than that of the through hole 341. An end (upper end) of the thrusting pin 342, for example, has a pointed shape, so that the thrusting pin 342 can pierce the dicing tape 82 affixed to the other surface 801 of the plate-shaped work piece 80.

In addition, a jetting hole not illustrated that jets a fluid from the end, for example, is formed in the thrusting pin 342 along the extending direction of the thrusting pin 342. A lower end of the jetting hole is connected with a fluid supply source 347 via a valve 346. When the valve 346 is opened, a fluid is supplied into the thrusting pin 342 from the fluid supply source 347. It is to be noted that the fluid supplied from the fluid supply source 347 is not particularly limited. Suppose in the present embodiment that a compressed air is used as the fluid.

The vertical driving unit 345 is, for example, formed by a guide actuator driven by air or a motor. The vertical driving unit 345 can vertically move the thrusting pin 342 while guiding the thrusting pin 342 in the upward-downward direction within the through hole 341 of the holding means 30.

Thus, the thrusting pin 342 is configured to be

raised by the vertical driving unit 345 while air is jetted from the outlet of the jetting hole, and to pierce the dicing tape 82. In addition, the thrusting pin 342 can project from the holding surface 302 after piercing the dicing tape 82, and thrust up the protective tape 81 over the notch portion 806 of the plate-shaped work piece 80. That is, while the protective tape 81 is floated by jetting air from the jetting hole of the thrusting pin 342, the thrusting pin 342 is further raised to thrust up the outer circumferential part of the protective tape 81, or while the thrusting pin 342 is raised to thrust up the outer circumferential part of the protective tape 81, air is jetted from the jetting hole, and therefore, the outer circumferential part of the protective tape 81 is peeled off from the plate-shaped work piece 80.

Then, the gripping unit 41 illustrated in FIG. 4 can peel off the protective tape 81 from the plate-shaped work piece 80 while gripping the outer circumferential part of the protective tape 81 peeled off by the partial peeling unit 34.

(Second Embodiment of Peeling Apparatus)

A peeling apparatus 2 according to the present invention which is illustrated in FIG. 5 (the peeling apparatus will hereinafter be referred to as the peeling

apparatus 2 according to a second embodiment) is an example of a peeling apparatus that peels off a protective member 85 affixed to one surface 800 of a plate-shaped work piece 80, the one surface 800 being a lower surface of the plate-shaped work piece 80 in FIG.

5. The peeling apparatus 2 includes at least holding means 50 that holds another surface 801 of the plate-shaped work piece 80 by a holding surface 502; and peeling means 6 that grips an outer circumferential part of the protective member 85 covering the one surface 800 of the plate-shaped work piece 80 held on the holding surface 502, peels the protective member 85 from an outer circumference to a center of the plate-shaped work piece 80, and further peels the protective member 85 from the center to an outer circumference on an opposite side from the outer circumference.

The protective member 85 affixed so as to cover the whole of the one surface 800 of the plate-shaped work piece 80 which surface faces downward is, for example, a protective member including a resin film 87 (see FIG. 6) and a circular sheet 86. The resin film 87 is formed in a protective member forming apparatus not illustrated, by pressing the one surface 800 of the plate-shaped work piece 80 against a liquid resin supplied onto the

circular sheet 86 having a larger diameter than the plate-shaped work piece 80 to spread the liquid resin from the center to the outer circumference side of the plate-shaped work piece 80, distributing the liquid resin on the whole of the one surface 800, and thereafter curing the liquid resin by irradiating the liquid resin with ultraviolet rays, for example. In the present embodiment, the protective member 85 includes a protruding portion 850 illustrated in FIG. 6. The protruding portion 850 is formed by the circular sheet 86 and the resin film 87 and slightly protrudes outward in the radial direction from the outer circumference of the plate-shaped work piece 80.

A column 21 is erected on a rearward side (-X direction side) of a base 20 of the peeling apparatus 2 illustrated in FIG. 5. An upper portion of the front surface on the +X direction side of the column 21 is provided with pad moving means 60 that causes the holding means 50 disposed on a movable plate 601 to reciprocate in the Y-axis direction through rotating a ball screw 600 by a motor 602.

The pad moving means 60 is a part of the peeling means 6. The pad moving means 60 functions as moving means that moves a gripping unit 61 and the holding means

50 relative to each other in the Y-axis direction parallel with the holding surface 502, leads the gripping unit 61 from an outer circumference to a center of the holding surface 502, and then moves the gripping unit 61 passing the center of the holding surface 502 on a straight line in such a direction that the gripping unit 61 moves away from the center.

Pad raising and lowering means 66 that causes the holding means 50 to reciprocate in the Z-axis direction is disposed on the movable plate 601. The pad raising and lowering means 66 causes the holding means 50 disposed on a movable plate 661 to reciprocate in the Z-axis direction through rotating a ball screw 660 by a motor 662.

The holding means 50 that holds the other surface 801 of the plate-shaped work piece 80 by the holding surface 502 is supported by an arm portion 52 that has one end fixed on the movable plate 661 and extends in the X-axis direction, and is attached to the lower surface side of another end on the +X direction side of the arm portion 52 via a supporting portion 53.

As illustrated in FIG. 6, the holding means 50 in the present embodiment is a suction holding pad. The holding means 50 includes a sucking portion 500 that is

formed by a porous member and sucks the plate-shaped work piece 80, and a frame body 501 that supports the sucking portion 500. The sucking portion 500 communicates with a suction source not illustrated via a suction pipe 509 and via a resin tube, a joint, or the like. A suction force produced by the suction source is transmitted to the flush holding surface 502 formed by an exposed surface of the sucking portion 500 and a lower surface of the frame body 501. The holding means 50 thereby sucks and holds the plate-shaped work piece 80 on the holding surface 502.

The supporting portion 53 illustrated in FIG. 5 has an external shape in the form of an annular plate, for example. The upper surface of the supporting portion 53 is connected to the lower surface of the arm portion 52 by a fixing bolt not illustrated or the like. A pad side tensile load measuring unit 64 is attached to the lower surface of the supporting portion 53. The pad side tensile load measuring unit 64 serves as a tensile load measuring unit that measures a tensile load applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502.

The pad side tensile load measuring unit 64 is formed by piezoelectric elements arranged on the

supporting portion 53 supporting the holding means 50. That is, for example, the pad side tensile load measuring unit 64 is piezoelectric elements such as barium titanate formed in a cylindrical shape or a prismatic shape, and is disposed in two parts opposed to each other in the Y-axis direction (only one part is illustrated in FIG. 5) so as to couple the supporting portion 53 and the holding means 50 to each other and support the weight of the holding means 50. That is, the pad side tensile load measuring unit 64 includes a first pad side tensile load measuring unit 641 and a second pad side tensile load measuring unit 642 illustrated in FIG. 6.

On an intermediate portion of the front surface on the +X direction side of the column 21 illustrated in FIG. 5, that is, below the movement path of the holding means 50, the following are arranged alongside of each other in order from the +Z direction side: a rotating roller 211 having an axis in the X-axis direction; constituent elements of the peeling means 6; a mounting table 27 on which the protective member 85 peeled off from the plate-shaped work piece 80 is to be mounted; and dropping means 26 that drops the protective member 85 peeled off and mounted on the mounting table 27 into a dust box 28.

The peeling means 6 includes the gripping unit 61 that grips the outer circumferential part of the protective member 85 (protruding portion 850 as the outer circumferential part in the present embodiment); moving means 63 that moves the gripping unit 61 and the holding means 50 relative to each other in a direction parallel with the holding surface 502 (Y-axis direction), leads the gripping unit 61 from the outer circumference to the center of the holding surface 502, and then moves the gripping unit 61 passing the center of the holding surface 502 on a straight line in such a direction that the gripping unit 61 moves away from the center; and the pad side tensile load measuring unit 64 as a tensile load measuring unit that measures a tensile load applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502.

Incidentally, the moving means 63 will be referred to as gripping unit moving means 63 in the following description. The gripping unit moving means 63 includes a ball screw 630 having an axis in the Y-axis direction; a pair of guide rails 631 arranged in parallel with the ball screw 630; a motor 632 that rotates the ball screw 630; and a movable block 633 having an internal nut screwed on the ball screw 630 and having a side portion

in sliding contact with the guide rails 631. When the motor 632 rotates the ball screw 630, the movable block 633 correspondingly moves in the Y-axis direction while guided by the guide rails 631, and the gripping unit 61 disposed on the movable block 633 moves in the Y-axis direction as the movable block 633 moves.

An arm type housing 681 that rotatably supports a spindle 680 whose axial direction is the X-axis direction is attached to a side surface of the movable block 633. A coupling block 614 that supports the gripping unit 61 is attached to a coupling member 616 disposed on a distal end on the +X direction side of the spindle 680, via a vertical direction load measuring piezoelectric element 673 of a gripping unit side tensile load measuring unit 67. A clamp base portion 610 that supports a gripping clamp 612 of the gripping unit 61 is attached to the coupling block 614 via a horizontal direction load measuring piezoelectric element 674 of the gripping unit side tensile load measuring unit 67. In addition, though not illustrated, the arm type housing 681 can be raised and lowered in the Z-axis direction by raising and lowering means such as a ball screw mechanism not illustrated, and the gripping unit 61 can also be raised and lowered in the Z-axis direction.

The gripping clamp 612 can sandwich a gripping target between a pair of gripping plates that can approach and separate from each other. The angle of the gripping clamp 612 with respect to the gripping target can be changed by rotation of the spindle 680.

The gripping unit side tensile load measuring unit 67 as a tensile load measuring unit that measures a tensile load applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502 of the holding means 50 includes, for example, the horizontal direction load measuring piezoelectric element 674 of barium titanate or the like which is formed in a flat plate shape, and the vertical direction load measuring piezoelectric element 673 in a flat plate shape which is formed of a similar material. The vertical direction load measuring piezoelectric element 673 is disposed in a state of being sandwiched from the Z-axis direction between the lower surface of the block-shaped coupling member 616 attached to the distal end side of the spindle 680 and the upper surface of the coupling block 614. In addition, the horizontal direction load measuring piezoelectric element 674 is disposed in a state of being sandwiched by the coupling block 614 and the clamp base portion 610 of the gripping

unit 61 from both sides in the Y-axis direction.

The rotating roller 211 illustrated in FIG. 5, for example, has an external shape formed in a cylindrical shape. The rotating roller 211 is rotated about an axis in the X-axis direction by a motor not illustrated. For example, the rotating roller 211 plays a role of preventing a break that can occur in the resin film 87 illustrated in FIG. 6 during the peeling of the protective member 85, by abutting against the protective member 85. Incidentally, the rotating roller 211 may be movable in the Y-axis direction.

The mounting table 27 on which the protective member 85 peeled from the plate-shaped work piece 80 is mounted, for example, has a substantially rectangular external shape and has a mounting surface in a duckboard shape. Specifically, the mounting table 27 has a configuration obtained by aligning plate-shaped linear members 271 in parallel with each other with longitudinal directions thereof set in the Y-axis direction and at equal intervals in the X-axis direction so as to form gaps between the linear members 271, and then coupling and fixing one end on the +Y axis direction side of each linear member 271 by a rod-shaped coupling part not illustrated. For example, the mounting table 27 is fixed

to a side surface on the +X direction side of the column 21 by the rod-shaped coupling part not illustrated which couples each linear member 271, and the mounting table 27 is disposed below the movement path of the gripping unit.

The dropping means 26 that drops the protective member 85 mounted on the mounting table 27 includes a ball screw 260 having an axis in the Y-axis direction; a pair of guide rails 261 arranged in parallel with the ball screw 260; a motor 262 that rotates the ball screw 260; a movable member 263 in substantially the shape of an L as viewed from the side, the movable member 263 having an internal nut screwed on the ball screw 260 and having a side portion 2631 in sliding contact with the guide rails 261; and thrusting pins 2634 arranged on the movable member 263.

The movable member 263 includes, for example, the side portion 2631 screwed on the ball screw 260 and a pin base portion 2632 formed so as to project to the +X direction side from the side surface of an upper end part of the side portion 2631. The two thrusting pins 2634 projecting in the +Z direction are disposed on the upper surface of the pin base portion 2632. The thrusting pins 2634 are arranged so as to be separated from each other by a predetermined distance in the X-axis direction. When

the motor 262 rotates the ball screw 260, the movable member 263 correspondingly moves in the Y-axis direction while guided by the guide rails 261, and the thrusting pins 2634 disposed on the movable member 263 move in the Y-axis direction so as to pass through the gaps between the linear members 271 of the mounting table 27.

The dust box 28 that houses the peeled protective member 85 is disposed on the base 20. The dust box 28, for example, has an external shape formed in a substantially rectangular parallelepipedic shape and opens below an end on the +Y direction side of the mounting table 27. A transmissive optical sensor including a light emitting unit 280 (on the -Y direction side) and a light receiving unit 281 (on the +Y direction side), for example, is disposed on an upper portion of the dust box 28. The protective members 85 peeled from plate-shaped work pieces 80 and mounted on the mounting table 27 are dropped into the dust box 28 by the dropping means 26. If the protective members 85 are piled up to a predetermined height within the dust box 28, inspection light emitted from the light emitting unit 280 is interrupted by the protective members 85, and an amount of light received by the light receiving unit 281 decreases. The optical sensor then detects that an amount

of protective members 85 to be collected is accumulated within the dust box 28.

A table holding base 22 is attached at a position within a movable range of the gripping unit 61 of the peeling means 6 on the front surface of the column 21, for example. A transfer table 221 that mounts the plate-shaped work piece 80 from which the protective member 85 is to be peeled off is disposed on the table holding base 22. The transfer table 221 can suck and hold the plate-shaped work piece 80 mounted on the holding surface of the transfer table 221 in a state in which the one surface 801 is oriented upward, for example. Incidentally, a configuration in which the transfer table 221 is not disposed on the table holding base 22 may also be adopted.

A plurality of (for example, eight) pieces of outside part peeling means 23 that grip the protruding portion 850 and peel the outside part of the protective member 85 from the plate-shaped work piece 80 are arranged on the table holding base 22 at fixed intervals in a circumferential direction with the transfer table 221 at a center. Incidentally, FIG. 5 illustrates a configuration of outside part peeling means 23 in detail on an enlarged scale.

The outside part peeling means 23 include a protruding portion gripping unit 230 that grips the protruding portion 850; a vertical moving unit not illustrated that moves the protruding portion gripping unit 230 in the Z-axis direction (vertical direction); and a horizontal moving unit 234 that moves the protruding portion gripping unit 230 in the horizontal direction.

As illustrated in FIG. 3, the horizontal moving unit 234 causes the protruding portion gripping unit 230 that is disposed on a slider 2342 formed in the shape of an L as viewed from the side, for example, via a vertical moving unit not illustrated, to reciprocate in the radial direction of the transfer table 221 by rotating a ball screw 2341 extending in the horizontal direction by a motor 2340. The vertical moving unit not illustrated is, for example, formed by a ball screw mechanism or the like.

The protruding portion gripping unit 230 includes a gripping base 2301 in a substantially rectangular parallelepipedic shape, a cylinder mechanism 2303 disposed on a side surface of the gripping base 2301, and a gripping plate 2302 moved up and down in the Z-axis direction by the cylinder mechanism 2303. The protruding

portion gripping unit 230 can sandwich a gripping target between the upper surface of the gripping base 2301 and the lower surface of the gripping plate 2302. Each protruding portion gripping unit 230 is disposed such that an opening part between the gripping plate 2302 and the gripping base 2301 is directed to the transfer table 221 side.

The peeling apparatus 2 includes, for example, control unit 29 that controls each configuration of the apparatus. The control unit 29 includes a CPU performing arithmetic processing according to a control program, a storage medium such as a memory, and the like. The control unit 29 is electrically connected to the pad moving means 60, the pad raising and lowering means 66, the gripping unit moving means 63, and the like via a wired or wireless communication path not illustrated. Control of moving speed in the Y-axis direction and the Z-axis direction of the holding means 50 sucking and holding the plate-shaped work piece 80 and positioning control of the holding means 50 with respect to the gripping unit 61 and the like are performed under control on the pad moving means 60 and the pad raising and lowering means 66 by the control unit 29. In addition, control of moving speed of the gripping unit 61 gripping

the protruding portion 850 of the protective member 85 protecting the plate-shaped work piece 80, positioning control of the gripping unit 61, and the like are performed under control on the gripping unit moving means 63 by the control unit 29. In addition, the control unit 19 can receive, from the pad side tensile load measuring unit 64 and the gripping unit side tensile load measuring unit 67, information regarding tensile loads measured by the respective load measuring units.

In a case where the motor 602 of the pad moving means is a servomotor, for example, a rotary encoder of the servomotor is connected to the control unit 29 having a function as a servo amplifier. After an operating signal is supplied from an output interface of the control unit 29 to the servomotor, the rotary encoder outputs the rotational speed of the servomotor as an encoder signal to an input interface of the control unit 29. Then, the control unit 29 that have received the encoder signal can successively identify an amount of movement of the holding means 50 on the basis of the rotational angle of the servomotor, and thereby successively identify the position in the Y-axis direction of the holding means 50.

In the following, operation of the peeling

apparatus 2 in a case where the protective member 85 is peeled off from the plate-shaped work piece 80 illustrated in FIG. 5 will be described. First, the plate-shaped work piece 80 after being ground, for example, as illustrated in FIG. 5 is mounted on the transfer table 221 such that the other surface 801 as a ground surface is on an upper side. The holding means 50 is moved in the +Y direction and is positioned above the plate-shaped work piece 80 such that the center of the holding surface 502 substantially coincides with the center of the other surface 801 of the plate-shaped work piece 80. Further, the holding means 50 is lowered, and the holding surface 502 is brought into contact with the other surface 801 of the plate-shaped work piece 80. Further, a suction force produced by suction of a suction source not illustrated is transmitted to the holding surface 502. The holding means 50 thereby sucks and holds the other surface 801 of the plate-shaped work piece 80 with the protective member 85 on a lower side.

The holding means 50 sucking and holding the plate-shaped work piece 80, for example, rises and separates the plate-shaped work piece 80 from the transfer table 221. Next, the protruding portion gripping units 230 are positioned, by vertical moving units not illustrated, to

a predetermined height position at which the protruding portion gripping units 230 can grip the protruding portion 850 of the protective member 85.

In addition, each horizontal moving unit 234 moves each protruding portion gripping unit 230 in the horizontal direction and performs positioning in the radial direction between the protruding portion gripping unit 230 and the protruding portion 850 of the protective member 85. The gripping plate 2302 is lowered by the cylinder mechanism 2303, and the protruding portion gripping unit 230 grips the protruding portion 850 of the protective member 85. Incidentally, for example, the gripping of the protruding portion 850 of the protective member 85 of the plate-shaped work piece 80 by the protruding portion gripping unit 230 may be performed in a state in which the plate-shaped work piece 80 is held on the transfer table 221.

Next, each horizontal moving unit 234 moves each protruding portion gripping unit 230 gripping the protruding portion 850 of the protective member 85 of the plate-shaped work piece 80, to the outside in the radial direction of the plate-shaped work piece 80. The protruding portion gripping unit 230 thereby pulls and expands the protruding portion 850 to the outside in the

radial direction. Then, the above-described movement of the protruding portion gripping unit 230 easily peels off the resin film 87 adhering to the outer circumferential part of the plate-shaped work piece 80 from the outer circumferential edge of the plate-shaped work piece 80 to the outside in the radial direction due to an expansion force applied to the resin film 87 (see FIG. 6) adhering to the outer circumferential part of the plate-shaped work piece 80 and an adhesive force acting between the circular sheet 86 and the resin film 87.

Next, for example, each protruding portion gripping unit 230 is lowered to a predetermined height position, and the protruding portion 850 of the protective member 85 is peeled by being pulled downward from the plate-shaped work piece 80 to a certain extent. The protruding portion gripping unit 230 thereafter releases the protruding portion 850 of the protective member 85. Consequently, for example, the protruding portion 850 is partly peeled at at least a total of eight positions of the outer circumferential part of the plate-shaped work piece 80 at equal angles in the circumferential direction with the center of the plate-shaped work piece 80 as a reference.

Next, the holding means 50 sucking and holding the

plate-shaped work piece 80 is lowered after being moved in the -Y direction until positioned above the rotating roller 211, and the side surface of the rotating roller 211 is made to abut against about an outer circumferential portion on the +Y direction side of the lower surface of the protective member 85. The gripping unit moving means 63 moves the gripping unit 61 in the -Y direction as illustrated in FIG. 6, positioning is performed between the gripping clamp 612 and the protruding portion 850 of the protective member 85, and the gripping clamp 612 grips the protruding portion 850. In the example illustrated in FIG. 6, the gripping unit 61 grips the protruding portion 850 of an outside part not peeled from the plate-shaped work piece 80 in the outside part of the protective member 85. However, the gripping unit 61 may grip the protruding portion 850 of an outside part peeled from the plate-shaped work piece 80 (protruding portion 850 on the -Y direction side in FIG. 6) in the outside part of the protective member 85.

After the gripping clamp 612 grips the protruding portion 850 as illustrated in FIG. 6, for example, the gripping clamp 612 slightly moves to the +Y direction side, so that an outer circumferential part of the resin film 87 is peeled off from the outer circumferential edge

of the plate-shaped work piece 80. Next, as illustrated in FIG. 7 to FIG. 8, the spindle 680 is rotated by 180 degrees in a clockwise direction as viewed from the +X direction side. The gripping clamp 612 thereby pulls the protective member 85 in the -Z direction while the resin film 87 of the protective member 85 is gently bent so as to conform to the side surface of the rotating roller 211 in a state in which the rotating roller 211 supports the lower surface side of the protective member 85. Thus, a part of the protective member 85 is peeled from the one surface 800 of the plate-shaped work piece 80.

(Embodiment C of Peeling off Protective Member 85 in Peeling Apparatus 2)

A case where, in further peeling off the protective member 85, the holding means 50 is moved in the Y-axis direction or where the gripping unit 61 is moved in the Y-axis direction with respect to the holding surface 502 of the holding means 50 will be described.

The gripping unit moving means 63 illustrated in FIG. 5 moves the gripping unit 61 in the -Y direction, as illustrated in FIG. 9. The holding means 50 may also be moved in the +Y direction by the pad moving means 60 (see FIG. 5). The gripping unit 61 is relatively moved in the radial direction from the outer circumferential edge to

the center of the plate-shaped work piece 80, and the protective member 85 is peeled from the plate-shaped work piece 80. In addition, while the rotating roller 211 rotates about an axis in the X-axis direction and a state is maintained in which the resin film 87 of the protective member 85 is gently bent so as to conform to the side surface of the rotating roller 211, the protective member 85 is peeled off from the outer circumferential edge on the +Y direction side of the plate-shaped work piece 80 to the center of the plate-shaped work piece 80. When a break occurs in the resin film 87 during the peeling of the protective member 85, the resin film 87 may partly be left on the plate-shaped work piece 80 after the peeling, or the one surface 800 of the plate-shaped work piece 80 may be damaged by application of an instantaneous impulsive force from the resin film 87 to the one surface 800 of the plate-shaped work piece 80 due to a reaction caused by the break in the resin. However, such problems can be prevented because the side surface of the rotating roller 211 abuts against the circular sheet 86.

In the present embodiment, upon peeling the protective member 85 from the above-described plate-shaped work piece 80, the gripping unit side tensile load

measuring unit 67 can accurately measure a tensile load applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502. The measurement of the tensile load by the gripping unit side tensile load measuring unit 67 is, for example, performed by the vertical direction load measuring piezoelectric element 673 and the horizontal direction load measuring piezoelectric element 674.

In FIG. 9, an arrow F3 represents a tensile load F3 applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502 of the holding means 50. Because the plate-shaped work piece 80 and the gripping unit 61 are separated from each other by a predetermined distance in the Z-axis direction, the tensile load F3 is a tensile load F3 obtained by combining a Y-axis direction tensile load Fy3 whose direction is the -Y direction and a Z-axis direction tensile load Fz3 whose direction is the -Z direction, the Y-axis direction tensile load Fy3 and the Z-axis direction tensile load Fz3 being illustrated in FIG. 9. Then, the following Equation 11 holds from the Pythagorean theorem.

$$(Y\text{-axis direction tensile load } Fy3)^2 + (Z\text{-axis direction tensile load } Fz3)^2 = (\text{tensile load } F3)^2$$

$F3)^2 \dots(\text{Equation 11})$

Here, the Y-axis direction tensile load $Fy3$ is accurately measured by the horizontal direction load measuring piezoelectric element 674 at predetermined time intervals, and a load detection signal is sent to the control unit 29 in each measurement. In addition, the Z-axis direction tensile load $Fz3$ is accurately measured by the vertical direction load measuring piezoelectric element 673 at predetermined time intervals, and a load detection signal is sent to the control unit 29 in each measurement.

The control unit 29 performs arithmetic processing that substitutes an actually measured value of the Y-axis direction tensile load $Fy3$ and an actually measured value of the Z-axis direction tensile load $Fz3$ into the Equation 11, and thereby measures the tensile load $F3$ at predetermined time intervals. Then, the control unit 29 uses the tensile load $F3$ measured at predetermined time intervals, as information for optimizing the operation of peeling off the protective member 85 by the peeling means 6. That is, on the basis of the value of the tensile load $F3$ measured at predetermined time intervals, the control unit 29 optimizes the speed of moving the gripping unit 61 by the gripping unit moving means 63, for example. As

a result, feedback control is performed such that the tensile load F_3 applied when the gripping unit 61 peels off the protective member 85 becomes such an optimum tensile load that prevents a crack in the plate-shaped work piece 80 and prevents the remaining of a glue on the plate-shaped work piece 80 or the like. In addition, the peeling speed of the gripping unit 61 is not too slow, so that the protective member 85 is peeled from the plate-shaped work piece 80 without taking an unnecessary time.

When the protective member 85 is completely peeled off from the one surface 800 of the plate-shaped work piece 80, the gripping unit 61 gripping the protruding portion 850 of the protective member 85 is moved to a position above the mounting table 27 illustrated in FIG. 5. Then, the gripping unit 61 releases the gripping of the protruding portion 850, and drops the protective member 85 onto the mounting table 27.

(Embodiment D of Peeling off Protective Member 85 in Peeling Apparatus 2)

A case where, upon peeling off the protective member 85, the holding means 50 is moved in the Y-axis direction and where the gripping unit 61 is not moved in the Y-axis direction as in the embodiment C will be described. In this case, the rotating roller 211 is, for

example, moved in the same direction as the moving direction of the holding means 50. In the present case, the gripping unit 61 rotated by 90 degrees as illustrated in FIG. 10 from the state illustrated in FIG. 8 is stopped at a predetermined height position and a position P3 in the Y-axis direction, and the control unit 29 illustrated in FIG. 5 recognizes the height position and the position P3 in the Y-axis direction at which the gripping unit 61 is located.

The protective member 85 is peeled from the plate-shaped work piece 80 by moving the holding means 50 in the +Y direction by the pad moving means 60 and relatively moving the gripping unit 61 whose movement is stopped from the outer circumferential edge to the center of the plate-shaped work piece 80 in the radial direction. Incidentally, a crack or the like is prevented in the resin film 87 because the side surface of the rotating roller 211 abuts against the circular sheet 86.

In the present embodiment, upon peeling the protective member 85 from the above-described plate-shaped work piece 80, the pad side tensile load measuring unit 64 measures a tensile load applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502. In FIG. 10, an arrow F4 represents a

tensile load F_4 applied to the protective member 85 interposed between the gripping unit 61 and the holding surface 502 of the holding means 50. The tensile load F_4 is a tensile load F_4 obtained by combining a Y-axis direction tensile load F_{y4} whose direction is the -Y direction and a Z-axis direction tensile load F_{z4} whose direction is the -Z direction, the Y-axis direction tensile load F_{y4} and the Z-axis direction tensile load F_{z4} being illustrated in FIG. 10.

An arrow R_4 illustrated in FIG. 10 represents a first measured load R_4 that can be measured in the Z-axis direction at predetermined time intervals by the first pad side tensile load measuring unit 641. The first measured load R_4 , for example, has a direction in the +Z direction. An arrow R_5 represents a second measured load R_5 that can be measured in the Z-axis direction at predetermined time intervals by the second pad side tensile load measuring unit 642. The second measured load R_5 , for example, has a direction in the -Z direction. A distance L_4 in the Y-axis direction between the first pad side tensile load measuring unit 641 and the second pad side tensile load measuring unit 642 is an apparatus design value recognized by the control unit 29 in advance and is a constant.

A changing distance M1 in the Y-axis direction from the first pad side tensile load measuring unit 641 to the gripping unit 61 whose movement in the Y-axis direction is stopped and which is located at the position P3 is a variable that changes when the holding means 50 moves in the Y-axis direction. Incidentally, the control unit 29 can grasp the position of the first pad side tensile load measuring unit 641 moving together with the movable plate 601 on the basis of the encoder signal fed back from the rotary encoder of the motor 602 (servomotor 602) of the pad moving means 60 illustrated in FIG. 5 to the control unit 29. Therefore, the control unit 29 can also successively recognize the value of the changing distance M1 at predetermined time intervals. A distance N1 in the Z-axis direction between the first pad side tensile load measuring unit 641 and the gripping unit 61 stopped at the position P3 is an apparatus design value recognized by the control unit 29 in advance and is a constant.

The following Equation 12 holds from the Pythagorean theorem.

$$(Y\text{-axis direction tensile load } F_{y4})^2 + (Z\text{-axis direction tensile load } F_{z4})^2 = (\text{tensile load } F_4)^2 \dots (\text{Equation 12})$$

In addition, the following Equation 13 holds from a

balance of forces in the Z-axis direction.

(Z-axis direction tensile load F_{z4}) = (first measured load R_4) + (second measured load R_5) ... (Equation 13)

Further, the following Equation 14 holds from a balance of moments about the first pad side tensile load measuring unit 641 in a case where the first pad side tensile load measuring unit 641 is assumed to be an origin.

(Y-axis direction tensile load F_{y4}) × (distance N_1) = (second measured load R_5) × (distance L_4) + (Z-axis direction tensile load F_{z4}) × (changing distance M_1) ... (Equation 14)

From the Equation 13, the control unit 29 can measure the Z-axis direction tensile load F_{z4} at predetermined time intervals. In addition, the control unit 29 can measure the Y-axis direction tensile load F_{y4} at predetermined time intervals from the following Equation 15 obtained by modifying the Equation 14.

(Y-axis direction tensile load F_{y4}) = {(second measured load R_5) × (distance L_4) + (Z-axis direction tensile load F_{z4}) × (changing distance M_1)} / (distance N_1) ... (Equation 15)

The control unit 29 performs arithmetic processing

that substitutes the value of the Y-axis direction tensile load F_{y4} and the value of the Z-axis direction tensile load F_{z4} into the Equation 12, and thereby measures the tensile load F_4 at predetermined time intervals. Then, the control unit 29 uses the tensile load F_4 measured at predetermined time intervals, as information for optimizing the operation of peeling off the protective member 85 by the peeling means 6. That is, on the basis of the value of the tensile load F_4 measured at predetermined time intervals, the control unit 29 optimizes the speed of movement of the holding means 50 by the pad moving means 60, for example. As a result, feedback control is performed such that the tensile load F_4 applied when the gripping unit 61 peels off the peeling tape 83 integrated with the protective member 85 becomes such an optimum tensile load that prevents a crack in the plate-shaped work piece 80 and prevents the remaining of a glue on the plate-shaped work piece 80 or the like. In addition, the peeling speed of the gripping unit 61 moving in the Y-axis direction relative to the moving holding means 50 is not too slow, so that the protective member 85 is peeled from the plate-shaped work piece 80 without taking an unnecessary time.

When the protective member 85 is completely peeled

off from the one surface 800 of the plate-shaped work piece 80, the gripping unit 61 gripping the protruding portion 850 of the protective member 85 is moved to a position above the mounting table 27 illustrated in FIG. 5. Then, the gripping unit 61 releases the gripping of the protruding portion 850 and drops the protective member 85 onto the mounting table 27.

The present invention is not limited to the details of the above described preferred embodiments. The scope of the invention is defined by the appended claims and all changes and modifications as fall within the equivalence of the scope of the claims are therefore to be embraced by the invention.

WHAT IS CLAIMED IS:

1. A peeling apparatus that peels a protective member protecting one surface of a plate-shaped work piece from the one surface, the peeling apparatus comprising:

holding means that holds another surface of the plate-shaped work piece by a holding surface; and

peeling means that grips an outer circumferential part of the protective member covering the one surface of the plate-shaped work piece held on the holding surface, peels the protective member from an outer circumference to a center of the plate-shaped work piece, and further peels the protective member from the center to an outer circumference on an opposite side from the outer circumference, in which

the peeling means includes

a gripping unit configured to grip the outer circumferential part of the protective member,

moving means that moves the gripping unit and the holding means relative to each other in a direction parallel with the holding surface, leads the gripping unit from an outer circumference to a center of the holding surface, and then moves the gripping unit passing the center of the holding surface on a straight

line in such a direction that the gripping unit moves away from the center, and

a tensile load measuring unit configured to measure a tensile load applied to the protective member interposed between the gripping unit and the holding surface, and

peeling operation of the peeling means is optimized by measuring the tensile load applied to the protective member by the tensile load measuring unit.

2. The peeling apparatus according to claim 1, wherein

the tensile load measuring unit includes a piezoelectric element disposed in a supporting portion that supports the holding means.

3. The peeling apparatus according to claim 1, wherein

the tensile load measuring unit includes a piezoelectric element disposed in a gripping unit supporting unit that supports the gripping unit.

4. The peeling apparatus according to claim 1, wherein

the protective member is a protective tape,

the plate-shaped work piece has a notch portion in an outer circumferential part of the plate-shaped work

piece,

the holding means includes a partial peeling unit configured to peel the protective tape in a vicinity of the notch portion from the plate-shaped work piece by thrusting up a part of the protective tape, the part being located at the notch portion but not being affixed to the plate-shaped work piece, and

the gripping unit grips an outer circumferential part of the protective tape peeled by the partial peeling unit.

5. The peeling apparatus according to claim 1, claim 2, or claim 3, wherein

the protective member is a protective tape,

peeling tape affixing means that affixes a peeling tape to an outer circumferential part of the protective tape is further included, and

the gripping unit grips the peeling tape affixed to the protective tape instead of gripping the outer circumferential part of the protective tape, and the tensile load measuring unit measures a tensile load applied to the peeling tape integrated with the protective tape interposed between the gripping unit and the holding surface.

6. The peeling apparatus according to claim 1,

wherein

the protective member has a protruding portion slightly protruding from the outer circumference of the plate-shaped work piece, and

the gripping unit grips the protruding portion.