# APPARATUS AND METHOD FOR TAPING ADHESIVE FILM ON SEMICONDUCTOR SUBSTRATE

## FIELD OF THE INVENTION

**[0001]** The present invention generally relates to an apparatus and a method for taping adhesive film on semiconductor substrate. More particularly, it relates to applying one support arm to hold a semiconductor substrate and one movable nozzle to supply taping gas for taping an adhesive film on the semiconductor substrate automatically along a programmable trail.

## BACKGROUND

**[0002]** During semiconductor devices manufacturing process, for various purposes, such as dicing, chip cutting, cleaning, an adhesive film is taped on a semiconductor substrate for protecting or supporting the semiconductor substrate. In the present taping method, a device side of the semiconductor substrate needs to be fixed by a vacuum adsorption way when taping the adhesive film on a back side of the semiconductor substrate. In this case, the device side of the semiconductor substrate is touched with the surface of vacuum chuck, and the surface of the device side will be pressed on the surface of the vacuum chuck by a mechanical force when taping the adhesive film on the back side of the semiconductor substrate. US patent No. 8,281,838 B2 has disclosed an apparatus for automatically taping film on wafer. The front side (device side) of the wafer is held by a vacuum chuck when bonding the back side of the wafer with a film. Without the mechanical force during the taping process, bubbles and wrinkles are hardly avoided during the taping process. With the critical feature of the semiconductor substrate becoming smaller while the technology node advancing, the structures on the device side are easy to be damaged under the mechanical force. What's more, with the semiconductor substrate becoming thinner, the risk of damage on the device side becomes higher. In addition, since the high

warpage of the thin semiconductor substrate, a method to fix the position of the semiconductor substrate during the taping process needs to be found. The warpage of the thin semiconductor substrate needs to be controlled and the mechanical damage on the device side needs to be eliminated during the taping process.

## SUMMARY

**[0003]** The present invention relates to applying a support arm for holding a thin semiconductor substrate and a taping force for taping an adhesive film on the thin semiconductor substrate automatically. The adhesion between the adhesive film and the semiconductor substrate starts along a programmable trail, normally from the center of the semiconductor substrate to the edge of the semiconductor substrate so that the adhesive film is pressed on the semiconductor substrate without bubbles and wrinkles. The semiconductor substrate can be supported without mechanical damage and the semiconductor substrate can maintain a flatness with negligible warpage.

**[0004]** One embodiment of the present invention of an apparatus for taping an adhesive film on a thin semiconductor substrate automatically is disclosed. The apparatus includes: a support arm holding a semiconductor substrate; a stage loading and locating an adhesive film above the semiconductor substrate; a rotating plate having a linear rail, the rotating plate being positioned over the adhesive film; a linear actuator mounted on the linear rail and being capable of moving along the linear rail; a gas nozzle supplying taping gas onto the adhesive film for pressing the adhesive film onto the adhesive side of the semiconductor substrate, the gas nozzle fixed on the linear actuator and moving together with the linear actuator; and a rotating actuator connected to the rotating plate and driving the rotating plate to rotate in a plane parallel to the plane of the semiconductor substrate.

**[0005]** One embodiment of the present invention of an apparatus for taping an adhesive film on a thin semiconductor substrate automatically is disclosed. The apparatus includes: a support arm holding a semiconductor substrate; a stage

connecting with the support arm for loading and locating an adhesive film above the semiconductor substrate; a gas nozzle supplying taping gas onto the adhesive film for pressing the adhesive film onto the adhesive side of the semiconductor substrate; a swing bar for supporting the gas nozzle; a swing actuator connected to the swing bar for driving the swing bar to swing; and a rotating actuator connected to the support arm for driving the support arm to rotate.

**[0006]** One embodiment of the present invention of a system is disclosed. The system includes: a taping apparatus for taping an adhesive film on a semiconductor substrate, the taping apparatus including a Bernoulli arm holding a semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm, the device side of the semiconductor substrate being contact less with the top side of the Bernoulli arm; a vacuum arm holding the back side of the semiconductor substrate and transferring the semiconductor substrate to the Bernoulli arm; and a cleaning apparatus cleaning the device side and back side of the semiconductor substrate, wherein the Bernoulli arm and the vacuum arm transfer the semiconductor substrate between the taping apparatus and the cleaning apparatus.

**[0007]** According to the present invention, a method for taping an adhesive film on a thin semiconductor substrate automatically is disclosed. The method includes steps of: holding a semiconductor substrate by a support arm; transferring an adhesive film above the adhesive side of the semiconductor substrate; moving a gas nozzle to locate over and close to the adhesive film; supplying, via the gas nozzle, taping gas onto the adhesive film for pressing the adhesive film down to the adhesive side of the semiconductor substrate; making the adhesion between the adhesive film and the semiconductor substrate start along a programmable trail; stopping supplying the taping gas; and transferring the semiconductor substrate taped with the adhesive film away from the support arm.

**[0008]** According to the present invention, a method for taping an adhesive film on a thin semiconductor substrate automatically is disclosed. The method includes steps of: transferring a semiconductor substrate into a cleaning apparatus and cleaning the device side of the semiconductor substrate by holding back side of the semiconductor substrate; taking the semiconductor substrate out of the cleaning apparatus and transferring the semiconductor substrate to a Bernoulli arm, the Bernoulli arm holding the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm, the device side of the semiconductor substrate being contact less with the top side of the Bernoulli arm; transferring the semiconductor substrate into the cleaning apparatus and cleaning the back side of the semiconductor substrate; taking the semiconductor substrate out of the cleaning apparatus and transferring the semiconductor substrate into a taping apparatus; transferring an adhesive film above the back side of the semiconductor substrate; moving a gas nozzle to locate over and close to the adhesive film; supplying, via the gas nozzle, taping gas onto the adhesive film for pressing the adhesive film down to the back side of the semiconductor substrate; making the adhesion between the adhesive film and the semiconductor substrate start along a programmable trail; stopping supplying the taping gas; and transferring the semiconductor substrate taped with the adhesive film away from the Bernoulli arm.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** FIG. 1A-1B show one exemplary apparatus for taping an adhesive film on a semiconductor substrate.

**[0010]** FIG. 2A-2B show another exemplary apparatus for taping an adhesive film on a semiconductor substrate.

**[0011]** FIG. 3A-3B show another exemplary apparatus for taping an adhesive film on a semiconductor substrate.

**[0012]** FIG. 4A-4B show another exemplary apparatus for taping an adhesive film on a semiconductor substrate.

**[0013]** FIGS. 5A and 5B show exemplary programmable trails of the adhesion between the adhesive film and the semiconductor substrate.

**[0014]** FIG. 6 shows another exemplary apparatus for taping an adhesive film on a semiconductor substrate.

**[0015]** FIGS. 7A and 7B show one exemplary method for taping an adhesive film on a semiconductor substrate.

## DETAILED DESCRIPTION

**[0016]** Please refer to FIG. 1A-1B showing one embodiment of the present invention of an apparatus for taping an adhesive film on a semiconductor substrate automatically. The apparatus includes a Bernoulli arm 1010 for providing a contact less support for a thin semiconductor substrate 1000, a stage 1022 for loading and locating an adhesive film 1020 above the semiconductor substrate 1000, a gas nozzle 1002 for providing taping gas down to the adhesive film 1020, a rotating plate 1001 mounted with a linear actuator 1004 for leading the gas nozzle 1002's motions, and a rotating actuator 1005 for driving the rotating plate 1001 to rotate.

**[0017]** The Bernoulli arm 1010 as a support arm holds the thin semiconductor substrate 1000 in a floating state, with a gap between the device side of the semiconductor substrate 1000 and the top side of the Bernoulli arm 1010. The device side of the semiconductor substrate 1000 is facing to the top side of the Bernoulli arm 1010 and is contact less with the top side of the Bernoulli arm 1010. The Bernoulli arm 1010 has a group of first injecting ports 1012 disposed at the edge of the top side of the Bernoulli arm 1010 and connecting with a first gas line for sucking the semiconductor substrate 1000 by Bernoulli effect while the first gas line supplies purified gas to the first injecting ports 1012. The Bernoulli arm 1010 has a group of

second injecting ports 1013 disposed at the center of the top side of the Bernoulli arm 1010 and connecting with a second gas line for lifting the semiconductor substrate 1000 while the second gas line supplies purified gas to the second injecting ports 1013. Preferably, the Bernoulli arm 1010 has several groups of second injecting ports 1013. Every group of second injecting ports 1013 connects with a corresponding second gas line, and the several second gas lines are controlled independently. The height of the gap between the semiconductor substrate 1000 and the Bernoulli arm 1010 can be adjusted by controlling the flow rate of the purified gas supplied to the first injecting ports 1012 and the second injecting ports 1013. At least three locating pins 1011 disposed on the Bernoulli arm 1010 restrict the semiconductor substrate 1000, preventing the semiconductor substrate 1000 horizontal movement during the entire taping process. The Bernoulli arm 1010 can have a plurality of e.g., at least three guiding pillars for guiding the semiconductor substrate 1000 to be put on the Bernoulli arm 1010 exactly. For a detailed description of substrate supporting apparatus using Bernoulli Effect, see PCT Patent Application No. PCT/CN2012/085319, entitled substrate supporting apparatus, filed on Nov, 27, 2012, the entire content of which is incorporated herein by reference. The Bernoulli arm 1010 can be moved horizontally to be under the adhesive film 1020 located on the stage 1022 for taping. The Bernoulli arm 1010 also can be moved vertically up and down, close to the adhesive film 1020 when the taping process starts or far away from the stage 1022 when the taping process ends.

**[0018]** The stage 1022 is used for automatically loading and tensioning supporting the adhesive film 1020. The stage 1022 continuously supplies the adhesive film 1020 for taping. The adhesive side of the adhesive film 1020 is facing to the back side of the semiconductor substrate 1000. In one embodiment, a film frame 1021 is automatically transferred and located on the stage 1022. The adhesive film 1020 is attached on the film frame 1021 and then the adhesive film 1020 is automatically cut to a desired size by a bevel cutter while taping. The stage 1022 is changeable to fit for different size of the film frame 1021 with diameter varying from 3 inch to 18 inch.

**[0019]** The rotating plate 1001 mounted with the linear actuator 1004 is placed above the stage 1022 and positioned over the adhesive film 1020. A vertical actuator 1006 is connected to the rotating plate 1001 for driving the rotating plate 1001 to move vertically up and down. The rotating actuator 1005 is connected to the rotating plate 1001 for driving the rotating plate 1001 to rotate in a plane parallel to the plane of the semiconductor substrate 1000. Preferably, for avoiding lines of the actuators winding, the rotating actuator 1005 drives the rotating plate 1001 to rotate at a circle clockwise and then a circle anti-clockwise alternatively. The rotating plate 1001 transversely disposes a linear rail 1003. The linear actuator 1004 is mounted on the linear rail 1003 and can move along the linear rail 1003. The linear actuator 1004 is a motor or a hydraulic type or a pneumatic type of cylinder. The movement speed of the cylinder is controlled by the flow rate of liquid or gas. The gas nozzle 1002 is fixed on the linear actuator 1004 and can move along the radial direction of the rotating plate 1001 together with the linear actuator 1004. The rotation speed of the rotating actuator 1005 and the movement speed of the linear actuator 1004 can be controlled and programmed by time, so that the trail of adhesion between the adhesive film 1020 and the semiconductor substrate 1000 follows a programmable trail. The gas nozzle 1002 is connected to a taping gas line. A supply valve is connected to the taping gas line for supplying the taping gas to the gas nozzle 1002 at a desired time. A pressure regulator and a flow rate regulator are further connected to the taping gas line to control the jetting pressure and the flow rate of the taping gas. A heating device is also connected to the taping gas line to control the temperature of the taping gas in range of 20℃ to 80℃. Once the taping gas ejected out of the gas nozzle 1002, the taping gas provides a local taping force on the adhesive film 1020, pressing the adhesive film 1020 down to the semiconductor substrate 1000. Incorporated with the rotation of the rotating plate 1001 and linear movement of the gas nozzle 1002, the adhesion between the adhesive film 1020 and the semiconductor substrate 1000 starts along a programmable trail as shown in FIG. 5A, normally from the center of the semiconductor substrate 1000 to the edge of the semiconductor substrate 1000.

**[0020]** Please refer to FIG. 2A-2B showing another embodiment of the present invention of an apparatus for taping an adhesive film on a semiconductor substrate automatically. The apparatus includes a Bernoulli arm 2010 for providing a contact less support for a thin semiconductor substrate 2000, a stage 2022 connecting with the Bernoulli arm 2010 for loading and locating an adhesive film 2020 above the semiconductor substrate 2000, a rotating actuator 2007 connected to the Bernoulli arm 2010 for driving the Bernoulli arm 2010 to rotate so the semiconductor substrate 2000 and the adhesive film 2020 rotating together with the Bernoulli arm 2010, a gas nozzle 2002 for providing taping gas down to the adhesive film 2020, a swing bar 2030 for supporting the gas nozzle 2002, and a swing actuator 2032 connected to the swing bar 2030 for driving the swing bar 2030 to swing so the gas nozzle 2002 swinging together with the swing bar 2030.

**[0021]** The Bernoulli arm 2010 as a support arm holds the thin semiconductor substrate 2000 in a floating state, with a gap between the device side of the semiconductor substrate 2000 and the top side of the Bernoulli arm 2010. The device side of the semiconductor substrate 2000 is facing to the top side of the Bernoulli arm 2010 and is contact less with the top side of the Bernoulli arm 2010. The Bernoulli arm 2010 has a group of first injecting ports 2012 disposed at the edge of the top side of the Bernoulli arm 2010 and connecting with a first gas line for sucking the semiconductor substrate 2000 by Bernoulli effect while the first gas line supplies purified gas to the first injecting ports 2012. The Bernoulli arm 2010 has a group of second injecting ports 2013 disposed at the center of the top side of the Bernoulli arm 2010 and connecting with a second gas line for lifting the semiconductor substrate 2000 while the second gas line supplies purified gas to the second injecting ports 2013. Preferably, the Bernoulli arm 1010 has several groups of second injecting ports 1013. Every group of second injecting ports 1013 connects with a corresponding second gas line, and the several second gas lines are controlled independently. The height of the gap between the semiconductor substrate 2000 and the Bernoulli arm 2010 can be adjusted by controlling the flow rate of the purified gas supplied to the first injecting

ports 2012 and the second injecting ports 2013. At least three locating pins 2011 disposed on the Bernoulli arm 2010 restrict the semiconductor substrate 2000, preventing the semiconductor substrate 2000 horizontal movement during the entire taping process. The Bernoulli arm 2010 can have a plurality of e.g., at least three guiding pillars for guiding the semiconductor substrate 2000 to be put on the Bernoulli arm 2010 exactly. For a detailed description of substrate supporting apparatus using Bernoulli Effect, see PCT Patent Application No. PCT/CN2012/085319, entitled substrate supporting apparatus, filed on Nov, 27, 2012, the entire content of which is incorporated herein by reference. The rotating actuator 2007 is connected to the Bernoulli arm 2010 for driving the Bernoulli arm 2010 to rotate so the semiconductor substrate 2000 and the stage 2022 rotate together with the Bernoulli arm 2010. Preferably, the rotating actuator 2007 drives the Bernoulli arm 2010 to rotate at a circle clockwise and then a circle anti-clockwise alternatively.

**[0022]** The stage 2022 to automatically load and tensioning support the adhesive film 2020 is mounted on the top side of the Bernoulli arm 2010 and is rotated with the Bernoulli arm 2010 simultaneously. The stage 2022 continuously supplies the adhesive film 2020 for taping. The adhesive side of the adhesive film 2020 is facing to the back side of the semiconductor substrate 2000. In one embodiment, a film frame 2021 is automatically transferred and located on the stage 2022. The adhesive film 2020 is attached on the film frame 2021 and then the adhesive film 2020 is automatically cut to a desired size by a bevel cutter while taping. The stage 2022 is changeable to fit for different size of the film frame 2021 with diameter varying from 3 inch to 18 inch.

**[0023]** The gas nozzle 2002 is disposed above the stage 2022 and is fixed on the swing bar 2030. The swing actuator 2032 is connected to the swing bar 2030 for driving the swing bar 2030 to swing so the gas nozzle 2002 swings together with the swing bar 2030. A vertical actuator 2031 is connected to the swing bar 2030 for driving the swing bar 2030 with the gas nozzle 2002 to move vertically up and down. The rotation speed of the rotating actuator 2007 and the movement speed of the swing

actuator 2032 can be controlled and programmed by time, so that the trail of the adhesion between the adhesive film 2020 and the semiconductor substrate 2000 follows a programmable trail. The gas nozzle 2002 is connected to a taping gas line. A supply valve is connected to the taping gas line for supplying the taping gas to the gas nozzle 2002 at a desired time. A pressure regulator and a flow rate regulator are further connected to the taping gas line to control the jetting pressure and the flow rate of the taping gas. A heating device is also connected to the taping gas line to control the temperature of the taping gas in range of 20℃ to 80℃. Once the taping gas ejected out of the gas nozzle 2002, the taping gas provides a local taping force on the adhesive film 2020, pressing the adhesive film 2020 down to the semiconductor substrate 2000. Incorporated with the rotation of the Bernoulli arm 2010 and the swing of the gas nozzle 2002, the adhesion between the adhesive film 2020 and the semiconductor substrate 2000 starts along a programmable trail as shown in FIG. 5B, normally from the center of the semiconductor substrate 2000 to the edge of the semiconductor substrate 2000.

**[0024]** Please refer to FIG. 3A-3B showing another embodiment of the present invention of an apparatus for taping an adhesive film on a semiconductor substrate automatically. The apparatus includes a vacuum arm 3040 for holding a semiconductor substrate 3000, a stage 3022 for loading and locating an adhesive film 3020 above the semiconductor substrate 3000, a gas nozzle 3002 for providing taping gas down to the adhesive film 3020, a rotating plate 3001 mounted with a linear actuator 3004 for leading the gas nozzle 3002's motions, and a rotating actuator 3005 for driving the rotating plate 3001 to rotate.

**[0025]** The vacuum arm 3040 as a support arm holds the semiconductor substrate 3000. In order to protect the semiconductor substrate 3000 from pressing damage, a soft and porous material is covering on the support surface of the vacuum arm 3040.

**[0026]** The stage 3022 is used for automatically loading and tensioning supporting the adhesive film 3020. The stage 3022 continuously supplies the adhesive film 3020

for taping. The adhesive side of the adhesive film 3020 is facing to the adhesive side of the semiconductor substrate 3000. In one embodiment, a film frame 3021 is automatically transferred and located on the stage 3022. The adhesive film 3020 is attached on the film frame 3021 and then the adhesive film 3020 is automatically cut to a desired size by a bevel cutter while taping. The stage 3022 is changeable to fit for different size of the film frame 3021 with diameter varying from 3 inch to 18 inch.

**[0027]** The rotating plate 3001 mounted with the linear actuator 3004 is placed above the stage 3022 and positioned over the adhesive film 3020. A vertical actuator 3006 is connected to the rotating plate 3001 for driving the rotating plate 3001 to move vertically up and down. The rotating actuator 3005 is connected to the rotating plate 3001 for driving the rotating plate 3001 to rotate in a plane parallel to the plane of the semiconductor substrate 3000. Preferably, for avoiding lines of the actuators winding, the rotating actuator 3005 drives the rotating plate 3001 to rotate at a circle clockwise and then a circle anti-clockwise alternatively. The rotating plate 3001 transversely disposes a linear rail 3003. The linear actuator 3004 is mounted on the linear rail 3003 and can move along the linear rail 3003. The linear actuator 3004 is a motor or a hydraulic type or a pneumatic type of cylinder. The movement speed of the cylinder is controlled by the flow rate of liquid or gas. The gas nozzle 3002 is fixed on the linear actuator 3004 and can move along the radial direction of the rotating plate 3001 together with the linear actuator 3004. The rotation speed of the rotating actuator 3005 and the movement speed of the linear actuator 3004 can be controlled and programmed by time, so that the trail of adhesion between the adhesive film 3020 and the semiconductor substrate 3000 follows a programmable trail. The gas nozzle 3002 is connected to a taping gas line. A supply valve is connected to the taping gas line for supplying the taping gas to the gas nozzle 3002 at a desired time. A pressure regulator and a flow rate regulator are further connected to the taping gas line to control the jetting pressure and the flow rate of the taping gas. A heating device is also connected to the taping gas line to control the temperature of the taping gas in range of 20℃ to 80℃. Once the taping gas ejected out of the gas nozzle 3002, the taping gas provides a

local taping force on the adhesive film 3020, pressing the adhesive film 3020 down to the semiconductor substrate 3000. Incorporated with the rotation of the rotating plate 3001 and linear movement of the gas nozzle 3002, the adhesion between the adhesive film 3020 and the semiconductor substrate 3000 starts along a programmable trail as shown in FIG. 5A, normally from the center of the semiconductor substrate 3000 to the edge of the semiconductor substrate 3000.

**[0028]** Please refer to FIG. 4A-4B showing another embodiment of the present invention of an apparatus for taping an adhesive film on a semiconductor substrate automatically. The apparatus includes a vacuum arm 4040 for holding a semiconductor substrate 4000, a stage 4022 connecting with the vacuum arm 4040 for loading and locating an adhesive film 4020 above the semiconductor substrate 4000, a rotating actuator 4007 connected to the vacuum arm 4040 for driving the vacuum arm 4040 to rotate so the semiconductor substrate 4000 and the adhesive film 4020 rotating together with the vacuum arm 4040, a gas nozzle 4002 for providing taping gas down to the adhesive film 4020, a swing bar 4030 for supporting the gas nozzle 4002, and a swing actuator 4032 connected to the swing bar 4030 for driving the swing bar 4030 to swing so the gas nozzle 4002 swinging together with the swing bar 4030.

**[0029]** The vacuum arm 4040 as a support arm holds the semiconductor substrate 4000. In order to protect the semiconductor substrate 4000 from pressing damage, a soft and porous material is covering on the support surface of the vacuum arm 4040. The rotating actuator 4007 is connected to the vacuum arm 4040 for driving the vacuum arm 4040 to rotate so the semiconductor substrate 4000 and the stage 4022 rotate together with the vacuum arm 4040. Preferably, the rotating actuator 4007 drives the vacuum arm 4040 to rotate at a circle clockwise and then a circle anti-clockwise alternatively.

**[0030]** The stage 4022 to automatically load and tensioning support the adhesive film 4020 is mounted on the support side of the vacumm arm 4040 and is rotated with

the vacumm arm 4040 simultaneously. The stage 4022 continuously supplies the adhesive film 4020 for taping. The adhesive side of the adhesive film 4020 is facing to the adhesive side of the semiconductor substrate 4000. In one embodiment, a film frame 4021 is automatically transferred and located on the stage 4022. The adhesive film 4020 is attached on the film frame 4021 and then the adhesive film 4020 is automatically cut to a desired size by a bevel cutter while taping. The stage 4022 is changeable to fit for different size of the film frame 4021 with diameter varying from 3 inch to 18 inch.

**[0031]** The gas nozzle 4002 is disposed above the stage 4022 and is fixed on the swing bar 4030. The swing actuator 4032 is connected to the swing bar 4030 for driving the swing bar 4030 to swing so the gas nozzle 4002 swings together with the swing bar 4030. A vertical actuator 4031 is connected to the swing bar 4030 for driving the swing bar 4030 with the gas nozzle 4002 to move vertically up and down. The rotation speed of the rotating actuator 4007 and the movement speed of the swing actuator 4032 can be controlled and programmed by time, so that the trail of the adhesion between the adhesive film 4020 and the semiconductor substrate 4000 follows a programmable trail. The gas nozzle 4002 is connected to a taping gas line. A supply valve is connected to the taping gas line for supplying the taping gas to the gas nozzle 4002 at a desired time. A pressure regulator and a flow rate regulator are further connected to the taping gas line to control the jetting pressure and the flow rate of the taping gas. A heating device is also connected to the taping gas line to control the temperature of the taping gas in range of 20℃ to 80℃. Once the taping gas ejected out of the gas nozzle 4002, the taping gas provides a local taping force on the adhesive film 4020, pressing the adhesive film 4020 down to the semiconductor substrate 4000. Incorporated with the rotation of the vacumm arm 4040 and the swing of the gas nozzle 4002, the adhesion between the adhesive film 4020 and the semiconductor substrate 4000 starts along a programmable trail as shown in FIG. 5B, normally from the center of the semiconductor substrate 4000 to the edge of the semiconductor substrate 4000.

**[0032]** Referring to FIGS. 5A and 5B, exemplary programmable trails of the adhesion between the adhesive film and the semiconductor substrate are shown. The trail is programmable to be swirl or a plurality of concentric rings by controlling the movement speed of the gas nozzle and the rotation speed of the rotating plate or the Bernoulli arm or the vacuum arm. In this case, the taping process is performed with precise control and without wrinkles and bubbles.

**[0033]** According to embodiments of the present invention, a method for taping an adhesive film on a semiconductor substrate includes the following steps.

**[0034]** Process Sequence

**[0035]** Step 102: transferring a semiconductor substrate to a support arm, the support arm holding the semiconductor substrate;

**[0036]** Step 104: transferring an adhesive film above the adhesive side of the semiconductor substrate;

**[0037]** Step 106: moving a gas nozzle to locate over and close to the adhesive film;

**[0038]** Step 108: supplying, via the gas nozzle, taping gas onto the adhesive film for pressing the adhesive film down to the adhesive side of the semiconductor substrate, for example by turning on the supply valve of the gas nozzle, wherein the taping gas is a type of compressed gas, such as clean dry air, N2, He, Ar or combination thereof; and the temperature of the taping gas is controlled in range of 20℃ to 80℃;

**[0039]** Step 110: making the adhesion between the adhesive film and the semiconductor substrate start along a programmable trail, normally from the center of the semiconductor substrate to the edge of the semiconductor substrate;

**[0040]** Step 112: stopping supplying the taping gas, for example by turning off the supply valve of the gas nozzle, after the adhesion between the adhesive film and the semiconductor substrate ends and moving the gas nozzle up;

**[0041]** Step 114: transferring the semiconductor substrate taped with the adhesive film away from the support arm.

**[0042]** In step 102, the support arm is a Bernoulli arm. The Bernoulli arm holds the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm. The device side of the semiconductor substrate is contact less with the top side of the Bernoulli arm, and the flow rate of purified gas supplied to the Bernoulli arm can be adjusted to control the height of the gap between the semiconductor substrate and the Bernoulli arm.

**[0043]** In step 102, the support arm is a vacuum arm. The support surface of the vacuum arm is covered by a soft and porous material.

**[0044]** In step 110, the programmable trail is formed by controlling the rotation speed and the linear movement speed of the gas nozzle.

**[0045]** In step 110, the programmable trail is formed by controlling the rotation speed of the support arm and the swing speed of the gas nozzle.

**[0046]** Please refer to FIG. 6 showing another exemplary system for taping an adhesive film on a semiconductor substrate. Comparing to the apparatus described above, the system of this embodiment further includes a cleaning apparatus 5070 for cleaning the device side and back side of a semiconductor substrate. A vacuum arm 5040 gets the semiconductor substrate from a load port 5050 and holds the back side of the semiconductor substrate. Then the vacuum arm 5040 takes the semiconductor substrate into the cleaning apparatus 5070. The cleaning apparatus 5070 cleans the device side of the semiconductor substrate. After the device side of the semiconductor substrate is cleaned, the vacuum arm 5040 takes the semiconductor substrate out of the cleaning apparatus 5070 and transfers the semiconductor substrate to a Bernoulli arm 5010. The Bernoulli arm 5010 holds the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm 5010. The device side of the semiconductor substrate is contact less with the top side of the Bernoulli arm 5010 and the flow rate of purified

gas supplied to the Bernoulli arm 5010 can be adjusted to control the height of the gap between the semiconductor substrate and the Bernoulli arm 5010. Then the Bernoulli arm 5010 takes the semiconductor substrate into the cleaning apparatus 5070. The cleaning apparatus 5070 cleans the back side of the semiconductor substrate. After the back side of the semiconductor substrate is cleaned, the Bernoulli arm 5010 takes the semiconductor substrate out of the cleaning apparatus 5070 and takes the semiconductor substrate into a taping apparatus 5060 for taping an adhesive film on the back side of the semiconductor substrate.

**[0047]** Please refer to FIGS. 7A and 7B showing one exemplary method of the present invention for taping an adhesive film on a semiconductor substrate automatically. During the entire taping process, the device side of the semiconductor substrate is contact less on the Bernoulli arm. It can be set as follows:

**[0048]** Process Sequence

**[0049]** Step 202: getting a semiconductor substrate 5000 de-bonded from a carrier by a vacuum arm 5040 holding the back side of the semiconductor substrate 5000, wherein the thickness of the semiconductor substrate 5000 is in the range of 30um to 1000um;

**[0050]** Step 204: transferring the semiconductor substrate 5000 by the vacuum arm 5040 into a cleaning apparatus 5070 and cleaning the device side of the semiconductor substrate 5000 in the cleaning apparatus 5070, wherein the cleaning chemicals is at least one type chosen from DIW, acid, alkaline or solvent;

**[0051]** Step 206: taking the semiconductor substrate 5000 out of the cleaning apparatus 5070 and transferring the semiconductor substrate 5000 by the vacuum arm 5040 to a Bernoulli arm 5010, the Bernoulli arm 5010 holding the semiconductor substrate 5000 in a floating state, with a gap between the device side of the semiconductor substrate 5000 and the top side of the Bernoulli arm 5010;

**[0052]** Step 208: transferring the semiconductor substrate 5000 into the cleaning apparatus 5070 by the Bernoulli arm 5010 and cleaning the back side of the

semiconductor substrate 5000 in the cleaning apparatus 5070, wherein the cleaning chemicals is at least one type chosen from DIW, acid, alkaline or solvent;

**[0053]** Step 210: taking the semiconductor substrate 5000 out of the cleaning apparatus 5070 and transferring the semiconductor substrate 5000 into a taping apparatus 5060 by the Bernoulli arm 5010;

**[0054]** Step 212: transferring an adhesive film 5020 above the back side of the semiconductor substrate 5000;

**[0055]** Step 214: moving a gas nozzle 5002 to locate over and close to the adhesive film 5020;

**[0056]** Step 216: supplying taping gas, for example by turning on the supply valve of the gas nozzle 5002, onto the adhesive film 5020 for pressing the adhesive film 5020 down to the back side of the semiconductor substrate 5000, wherein the taping gas is a type of compressed gas, such as clean dry air, N2, He, Ar or combination thereof; and the temperature of the taping gas is controlled in range of 20℃ to 80℃;

**[0057]** Step 218: making the adhesion between the adhesive film 5020 and the semiconductor substrate 5000 start along a programmable trail, normally from the center of the semiconductor substrate 5000 to the edge of the semiconductor substrate 5000;

**[0058]** Step 220: stopping supplying the taping gas, for example by turning off the supply valve of the gas nozzle 5002, after the adhesion between the adhesive film 5020 and the semiconductor substrate 5000 ends and moving the gas nozzle 5002 up;

**[0059]** Step 222: transferring the semiconductor substrate 5000 taped with the adhesive film 5020 away from the Bernoulli arm 5010.

**[0060]** The combination of the movement speed of the gas nozzle and the rotation speed of the rotating plate holding the gas nozzle or the rotating actuator of the Bernoulli arm or the vacuum arm defines the adhesion trail. The performance of the taping without bubbles and wrinkles is determined by controlling the adhesion trail. In

one embodiment of the present invention, the movement speed of the gas nozzle and the rotation speed of the rotating plate or the rotating actuator of the Bernoulli arm or the vacuum arm are kept constant. In another embodiment of the present invention, the movement speed of the gas nozzle and the rotation speed of the rotating plate or the rotating actuator of the Bernoulli arm or the vacuum arm are programmed in various setting.

What is claimed is:

1. An apparatus for taping adhesive film on semiconductor substrate comprising:

a support arm, holding a semiconductor substrate;

a stage, loading and locating an adhesive film above the semiconductor substrate;

a rotating plate, having a linear rail, the rotating plate being positioned over the adhesive film;

a linear actuator, mounted on the linear rail and being capable of moving along the linear rail;

a gas nozzle, supplying taping gas onto the adhesive film for pressing the adhesive film onto adhesive side of the semiconductor substrate, the gas nozzle fixed on the linear actuator and moving together with the linear actuator; and

a rotating actuator, connected to the rotating plate and driving the rotating plate to rotate in a plane parallel to the plane of the semiconductor substrate.

2. The apparatus of claim 1, further comprising a vertical actuator connected to the rotating plate for driving the rotating plate to move vertically up and down.

3. The apparatus of claim 1, wherein the support arm is capable to be moved vertically up and down.

4. The apparatus of claim 1, further comprising a film frame located on the stage, the adhesive film being attached on the film frame.

5. The apparatus of claim 1, wherein the support arm is a Bernoulli arm and the adhesive side of the semiconductor substrate is back side of the semiconductor substrate that is opposite to device side of the semiconductor substrate, the Bernoulli arm holds the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm, the device side of the semiconductor substrate is contact less with the top side of the Bernoulli arm.

6. The apparatus of claim 5, wherein the Bernoulli arm has a group of first injecting ports disposed at the edge of the top side of the Bernoulli arm and connecting with a first gas line for sucking the semiconductor substrate by Bernoulli effect while the first gas line supplies purified gas to the first injecting ports, and the Bernoulli arm has one or more groups of second injecting ports disposed at the center of the top side of the Bernoulli arm and connecting with one or more second gas lines for lifting the semiconductor substrate while the second gas line supplies purified gas to the second injecting ports, wherein the one or more second gas lines are controlled independently.

7. The apparatus of claim 6, wherein the height of the gap between the semiconductor substrate and the Bernoulli arm is adjustable by controlling the flow rate of the purified gas supplied to the first injecting ports and the second injecting ports.

8. The apparatus of claim 1, wherein the support arm is a vacuum arm.

9. The apparatus of claim 8, wherein the support surface of the vacuum arm is covered by a soft and porous material.

10. The apparatus of claim 1, wherein the gas nozzle is connected to a taping gas line, a supply valve is connected to the taping gas line for supplying the taping gas to the gas nozzle.

11. The apparatus of claim 10, further comprising a pressure regulator connected to the taping gas line to control the jetting pressure of the taping gas.

12. The apparatus of claim 10, further comprising a flow rate regulator connected to the taping gas line to control the flow rate of the taping gas.

13. The apparatus of claim 10, further comprising a heating device connected to the taping gas line to control the temperature of the taping gas.

14. The apparatus of claim 13, wherein the temperature of the taping gas is in range of 20℃ to 80℃.

15. The apparatus of claim 1, wherein the trail of the adhesion between the adhesive film and the semiconductor substrate is controllable by adjusting the rotation speed of the rotating plate and the linear movement speed of the linear actuator.

16. The apparatus of claim 15, wherein the trail of the adhesion between the adhesive film and the semiconductor substrate is programmable to be swirl from the center of the semiconductor substrate to the edge of the semiconductor substrate.

17. The apparatus of claim 1, wherein the rotating actuator drives the rotating plate to rotate at a circle clockwise and then a circle anti-clockwise alternatively.

18. The apparatus of claim 1, wherein the linear actuator is a motor, a hydraulic type of cylinder or a pneumatic type of cylinder.

19. The apparatus of claim 18, wherein the movement speed of the cylinder is controlled by the flow rate of liquid or gas.

20. An apparatus for taping adhesive film on semiconductor substrate comprising:

a support arm, holding a semiconductor substrate;

a stage, connecting with the support arm for loading and locating an adhesive film above the semiconductor substrate;

a gas nozzle, supplying taping gas onto the adhesive film for pressing the adhesive film onto adhesive side of the semiconductor substrate;

a swing bar, supporting the gas nozzle;

a swing actuator, connected to the swing bar for driving the swing bar to swing; and

a rotating actuator, connected to the support arm for driving the support arm to rotate.

21. The apparatus of claim 20, further comprising a vertical actuator connected to the swing bar for driving the swing bar with the gas nozzle to move vertically up and down.

22. The apparatus of claim 20, wherein the rotating actuator drives the support arm to rotate at a circle clockwise and then a circle anti-clockwise alternatively.

23. The apparatus of claim 20, wherein the support arm is a Bernoulli arm and the adhesive side of the semiconductor substrate is back side of the semiconductor substrate that is opposite to device side of the semiconductor substrate, the Bernoulli arm holds the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm, the device side of the semiconductor substrate is contact less with the top side of the Bernoulli arm.

24. The apparatus of claim 20, wherein the support arm is a vacuum arm.

25. The apparatus of claim 24, wherein the support surface of the vacuum arm is covered by a soft and porous material.

26. The apparatus of claim 20, wherein the trail of the adhesion between the adhesive film and the semiconductor substrate is controllable by adjusting the rotation speed of the rotating actuator and the swing speed of the swing actuator.

27. The apparatus of claim 26, wherein the trail of the adhesion between the adhesive film and the semiconductor substrate is programmable to be a plurality of rings from the center of the semiconductor substrate to the edge of the semiconductor substrate.

28. A system comprising:

a taping apparatus for taping adhesive film on semiconductor substrate of claim 1 or claim 20;

a Bernoulli arm being capable to hold the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm, the device side of the semiconductor substrate being contact less with the top side of the Bernoulli arm;

a vacuum arm being capable to hold the back side of the semiconductor substrate and transfer the semiconductor substrate to the Bernoulli arm; and

a cleaning apparatus for cleaning the device side and back side of the semiconductor substrate,

wherein the Bernoulli arm and the vacuum arm transfer the semiconductor substrate between the taping apparatus and the cleaning apparatus.

29. The apparatus of claim 28, wherein the semiconductor substrate is held by the Bernoulli arm when being processed in the cleaning apparatus for the back side cleaning and held by the vacuum arm when being processed in the cleaning apparatus for the device side cleaning.

30. A method for taping adhesive film on semiconductor substrate comprising:

holding the semiconductor substrate by a support arm;

transferring an adhesive film above the adhesive side of the semiconductor substrate;

moving a gas nozzle to locate over and close to the adhesive film;

supplying, via the gas nozzle, taping gas onto the adhesive film for pressing the adhesive film down to the adhesive side of the semiconductor substrate;

making the adhesion between the adhesive film and the semiconductor substrate start along a programmable trail;

stopping supplying the taping gas; and

transferring the semiconductor substrate taped with the adhesive film away from the support arm.

31. The method of claim 30, wherein the programmable trail is swirl or a plurality of concentric rings.

32. The method of claim 30, wherein the thickness of the semiconductor substrate is in the range of 30um to 1000um.

33. The method of claim 30, wherein the taping gas is compressed gas of clean dry air, N2, He, Ar or combination thereof.

34. The method of claim 30, wherein the temperature of the taping gas is in range of 20℃ to 80℃.

35. The method of claim 30, wherein the programmable trail is formed by controlling the rotation speed and the linear movement speed of the gas nozzle.

36. The method of claim 30, wherein the programmable trail is formed by controlling the rotation speed of the support arm and the swing speed of the gas nozzle.

37. The method of claim 30, wherein the support arm is a Bernoulli arm or a vacuum arm.

38. A method for taping adhesive film on semiconductor substrate comprising:

transferring a semiconductor substrate into a cleaning apparatus and cleaning the device side of the semiconductor substrate by holding back side of the semiconductor substrate;

taking the semiconductor substrate out of the cleaning apparatus and transferring the semiconductor substrate to a Bernoulli arm, the Bernoulli arm holding the semiconductor substrate in a floating state, with a gap between the device side of the semiconductor substrate and the top side of the Bernoulli arm, the device side of the semiconductor substrate being contact less with the top side of the Bernoulli arm;

transferring the semiconductor substrate into the cleaning apparatus to clean the back side of the semiconductor substrate;

taking the semiconductor substrate out of the cleaning apparatus and transferring the semiconductor substrate into a taping apparatus;

transferring an adhesive film above the back side of the semiconductor substrate;

moving a gas nozzle to locate over and close to the adhesive film;

supplying, via the gas nozzle, taping gas onto the adhesive film for pressing the adhesive film down to the back side of the semiconductor substrate;

making the adhesion between the adhesive film and the semiconductor substrate start along a programmable trail;

stopping supplying the taping gas; and

transferring the semiconductor substrate taped with the adhesive film away from the Bernoulli arm.