WAFER PROCESSING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a wafer processing method for dividing a wafer along a plurality of division lines to obtain a plurality of individual device chips, the division lines being formed on the front side of the wafer to thereby define a plurality of separate regions where a plurality of devices are individually formed.

Description of the Related Art

In a fabrication process for device chips to be used in electronic equipment such as mobile phones and personal computers, a plurality of crossing division lines (streets) are first set on the front side of a wafer formed of a semiconductor, for example, thereby defining a plurality of separate regions on the front side of the wafer. In each separate region, a device such as an integrated circuit (IC), a large-scale integrated circuit (LSI), and a light emitting diode (LED) is next formed. Thereafter, a ring frame having an inside opening is prepared, in which an adhesive tape called a dicing tape is previously attached in its peripheral portion to the ring frame so as to close the inside opening of the

ring frame. Thereafter, a central portion of the adhesive tape is attached to the back side or the front side of the wafer such that the wafer is accommodated in the inside opening of the ring frame. In this manner, the wafer, the adhesive tape, and the ring frame are united together to form a frame unit. Thereafter, the wafer included in this frame unit is processed to be divided along each division line, thereby obtaining a plurality of individual device chips including the respective devices.

For example, a laser processing apparatus is used to divide the wafer. The laser processing apparatus includes a chuck table for holding the wafer through the adhesive tape and a laser processing unit for focusing a laser beam inside the wafer held on the chuck table, the laser beam having a transmission wavelength to the wafer. In dividing the wafer by using this laser processing apparatus, the frame unit is placed on the chuck table, and the wafer is held through the adhesive tape on the upper surface of the chuck table. In this condition, the chuck table and the laser processing unit are relatively moved in a direction parallel to the upper surface of the chuck table. At the same time, the laser beam is applied from the laser processing unit to the wafer along each

division line. When the laser beam is focused inside the wafer, a modified layer serving as a division start point is formed in the wafer along each division line (see Japanese Patent No. 3408805).

Thereafter, the frame unit is transferred from the laser processing apparatus to another apparatus, and the adhesive tape is expanded in a radially outward direction, so that the wafer is divided into individual device chips. When the device chips thus formed are picked up from the adhesive tape, ultraviolet light is applied to the adhesive tape in advance, for example, to thereby reduce the adhesion of the adhesive tape. Thereafter, each device chip is picked up from the adhesive tape. As a processing apparatus capable of producing the device chips with high efficiency, there is a processing apparatus capable of continuously performing the operation for dividing the wafer and the operation for applying ultraviolet light to the adhesive tape (see Japanese Patent No. 3076179, for example).

SUMMARY OF THE INVENTION

The adhesive tape includes a base layer formed from a polyvinyl chloride sheet, for example, and an adhesive layer formed on the base layer. In the laser processing

apparatus, the laser beam is focused inside the wafer in order to form a modified layer which serves as a division start point, inside the wafer, and part of leaked light of the laser beam reaches the adhesive layer of the adhesive tape. As a result, the adhesive layer of the adhesive tape attached to the back side or the front side of the wafer is melted by the heat due to the application of the laser beam to the wafer at the position below or around each division groove formed in the wafer, and a part of the adhesive layer melted is fixed to the back side or the front side of each device chip obtained from the wafer. In this case, in the step of picking up each device chip from the adhesive tape, ultraviolet light is applied to the adhesive tape to reduce the adhesion of the adhesive tape. However, the part of the adhesive layer melted and fixed to the back side or the front side of each device chip attached to the adhesive tape is yet left on the back side or the front side of each device chip picked up from the adhesive tape. As a result, the quality of each device chip is degraded.

It is therefore an object of the present invention to provide a wafer processing method which can prevent the adherence of the adhesive layer to the back side or the front side of each device chip obtained from a wafer,

thereby suppressing a degradation in quality of each device chip due to the adherence of the adhesive layer.

In accordance with an aspect of the present invention, there is provided a wafer processing method for dividing a wafer along a plurality of division lines to obtain a plurality of individual device chips, the division lines being formed on a front side of the wafer to thereby define a plurality of separate regions where a plurality of devices are individually formed. The wafer processing method includes a ring frame preparing step of preparing a ring frame having an inside opening for accommodating the wafer, a polyester sheet providing step of positioning the wafer in the inside opening of the ring frame and providing a polyester sheet on a back side or the front side of the wafer and on a back side of the ring frame, a uniting step of heating the polyester sheet as applying a pressure to the polyester sheet after performing the polyester sheet providing step, thereby uniting the wafer and the ring frame through the polyester sheet by thermocompression bonding to form a frame unit in a condition where the front side of the wafer and the front side of the ring frame are exposed upward, a dividing step of positioning a focal point of a laser beam inside the wafer, the laser beam having a

transmission wavelength to the wafer, and applying the laser beam to the wafer along each division line, thereby forming a modified layer in the wafer along each division line to divide the wafer into the individual device chips, after performing the uniting step, and a pickup step of heating the polyester sheet in each of the plurality of separate regions corresponding to each device chip, pushing up each device chip through the polyester sheet, and then picking up each device chip from the polyester sheet after performing the dividing step.

Preferably, the uniting step includes a step of applying infrared light to the polyester sheet, thereby performing the thermocompression bonding.

Preferably, the polyester sheet is larger in size than the ring frame, and the uniting step includes an additional step of cutting the polyester sheet after heating the polyester sheet, thereby removing a part of the polyester sheet outside an outer circumference of the ring frame.

Preferably, the pickup step includes a step of expanding the polyester sheet to thereby increase a spacing between any adjacent ones of the device chips.

Preferably, the polyester sheet is formed of a

material selected from the group consisting of polyethylene terephthalate and polyethylene naphthalate.

In the case that the polyester sheet is formed of polyethylene terephthalate, the polyester sheet is heated in the range of 250°C to 270°C in the uniting step. In the case that the polyester sheet is formed of polyethylene naphthalate, the polyester sheet is heated in the range of 160°C to 180°C in the uniting step.

Preferably, the wafer is formed of a material selected from the group consisting of silicon, gallium nitride, gallium arsenide, and glass.

In the wafer processing method according to a preferred embodiment of the present invention, the wafer and the ring frame are united by using the polyester sheet having no adhesive layer in place of an adhesive tape having an adhesive layer, thereby forming the frame unit composed of the wafer, the ring frame, and the polyester sheet united together. The uniting step of uniting the wafer and the ring frame through the polyester sheet is realized by thermocompression bonding. After performing the uniting step, a laser beam having a transmission wavelength to the wafer is applied to the wafer to thereby form a modified layer inside the wafer along each division line, so that the wafer is divided

along each division line to obtain individual device chips attached to the polyester sheet. Thereafter, in each of the plurality of separate regions corresponding to each device chip in the polyester sheet, the polyester sheet is heated, and each device chip is pushed up through the polyester sheet, whereby each device chip is then picked up from the polyester sheet. Each device chip picked up is next mounted on a predetermined mounting substrate or the like. Note that, when the polyester sheet is heated in picking up each device chip, the adhesion of the polyester sheet is decreased, so that it is possible to reduce a load applied to each device chip.

In forming a modified layer inside the wafer, leaked light of the laser beam reaches the polyester sheet. However, since the polyester sheet has no adhesive layer, there is no problem that the adhesive layer may be melted to be fixed to the back side or the front side of each device chip. That is, according to one aspect of the present invention, the frame unit can be formed by using the polyester sheet having no adhesive layer, so that an adhesive tape having an adhesive layer is not required. As a result, it is possible to prevent the problem that the quality of each device chip is degraded by the adherence of the adhesive layer to each device chip.

Thus, the wafer processing method according to one aspect of the present invention can exhibit the effect that the adhesive layer does not adhere to the back side or the front side of each device chip obtained from the wafer, thereby suppressing a degradation in quality of each device chip due to the adherence of the adhesive layer.

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 depicting a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a schematic perspective view of the front side of a wafer;

FIG. 1B is a schematic perspective view of the back side of the wafer;

FIG. 2 is a schematic perspective view depicting a manner of positioning the wafer and a ring frame on a holding surface of a chuck table;

FIG. 3 is a schematic perspective view depicting a

polyester sheet providing step;

FIG. 4 is a schematic perspective view depicting a uniting step;

FIG. 5 is a schematic perspective view depicting a modification of the uniting step;

FIG. 6 is a schematic perspective view depicting another modification of the uniting step;

FIG. 7A is a schematic perspective view depicting a manner of cutting the polyester sheet after performing the uniting step;

FIG. 7B is a schematic perspective view of a frame unit formed by performing the step depicted in FIG. 7A;

FIG. 8A is a schematic perspective view depicting a dividing step;

FIG. 8B is a schematic sectional view depicting the dividing step;

FIG. 9 is a schematic perspective view depicting a manner of loading the frame unit to a pickup apparatus after performing the dividing step;

FIG. 10A is a schematic sectional view depicting a standby condition where the frame unit is fixed to a frame support table set at an initial position in a pickup step using the pickup apparatus depicted in FIG. 9; and

FIG. 10B is a schematic sectional view depicting a working condition where the frame support table holding the frame unit with the polyester sheet is lowered to expand the polyester sheet in the pickup step.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to the attached drawings. There will first be described a wafer to be processed by a wafer processing method according to this preferred embodiment. FIG. 1A is a schematic perspective view of the front side of a wafer 1. FIG. 1B is a schematic perspective view of the back side of the wafer. The wafer 1 is a substantially disc-shaped substrate formed of a material such as silicon (Si), silicon carbide (SiC), gallium nitride (GaN), and gallium arsenide (GaAs). The wafer 1 may be formed of any other semiconductor materials. Further, the wafer 1 may be formed of a material such as sapphire, glass, and quartz. Examples of the glass include alkaline glass, nonalkaline glass, soda lime glass, lead glass, borosilicate glass, and silica glass. The wafer 1 has a front side 1a and a back side 1b. A plurality of crossing division lines 3 are formed on the front side 1a of the wafer 1 to thereby

define a plurality of respective separate regions where a plurality of devices 5 such as ICs, LSIs, and LEDs are formed. The crossing division lines 3 are composed of a plurality of parallel division lines 3 extending in a first direction and a plurality of parallel division lines 3 extending in a second direction perpendicular to the first direction. In the processing method for the wafer 1 according to this preferred embodiment, a plurality of modified layers are formed inside the wafer along the respective crossing division lines 3 in the wafer 1, thereby dividing the wafer 1 into a plurality of individual device chips each including the device 5 with the modified layers as division start points.

In forming a modified layer in the wafer 1, a laser beam having a transmission wavelength to the wafer 1 is applied to the wafer 1 along each of the division lines 3, thereby focusing the laser beam inside the wafer 1. At this time, the laser beam may be applied to the wafer 1 from the front side 1a depicted in FIG. 1A or from the back side 1b depicted in FIG. 1B. Note that, in a case where the laser beam may be applied to the wafer 1 from the back side 1b, alignment means including an infrared camera is used to detect each of the division lines 3 from the front side 1a through the wafer 1, so that the

laser beam is applied to the wafer 1 along each of the division lines 3.

The laser processing to form a modified layer in the wafer 1 is performed by using a laser processing apparatus 12 (see FIG. 8). Prior to loading the wafer 1 into the laser processing apparatus 12, the wafer 1 is united with a polyester sheet 9 (see FIG. 3) and a ring frame 7 (see FIG. 2) to thereby form a frame unit 11 (see FIG. 8). Thus, the wafer 1 is loaded in the form of the frame unit 11 into the laser processing apparatus 12 and then processed by the laser processing apparatus 12. Then, the polyester sheet 9 is expanded to divide the wafer 1, thereby obtaining the individual device chips, in which each device chip is supported to the polyester sheet 9. Thereafter, the polyester sheet 9 is further expanded to thereby increase the spacing between any adjacent ones of the device chips. Thereafter, each device chip is picked up by using a pickup apparatus. The ring frame 7 is formed of a rigid material such as metal, and it has a circular inside opening 7a having a diameter larger than that of the wafer 1. The outside shape of the ring frame 7 is substantially circular. The ring frame 7 has a front side 7b and a back side 7c. In forming the frame unit, the wafer 1 is accommodated in the inside

opening 7a of the ring frame 7 and positioned in such a manner that the center of the wafer 1 substantially coincides with the center of the inside opening 7a.

The polyester sheet 9 is a flexible (expandable) resin sheet, and it has a flat front side and a flat back side. The polyester sheet 9 is a circular sheet having a diameter larger than the outer diameter of the ring frame 7. The polyester sheet 9 has no adhesive layer. The polyester sheet 9 is a sheet of a polymer (polyester) synthesized by polymerizing dicarboxylic acid (a compound having two carboxyl groups) and diol (a compound having two hydroxyl groups) as a monomer. Examples of the polyester sheet 9 include a polyethylene terephthalate sheet and a polyethylene naphthalate sheet. The polyester sheet 9 is transparent or translucent to visible light. As a modification, the polyester sheet 9 may be opaque. Since the polyester sheet 9 has no adhesive property, it cannot be attached to the wafer 1 and the ring frame 7 at room temperature. However, the polyester sheet 9 is a thermoplastic sheet, so that, when the polyester sheet 9 is heated to a temperature near its melting point under a predetermined pressure in a condition where the polyester sheet 9 is in contact with the wafer 1 and the ring frame 7, the polyester sheet 9 is partially melted and thereby

bonded to the wafer 1 and the ring frame 7. That is, by applying heat and pressure to the polyester sheet 9 in the condition where the polyester sheet 9 is in contact with the wafer 1 and the ring frame 7, the polyester sheet 9 can be bonded to the wafer 1 and the ring frame 7. Thusly, in the processing method for the wafer 1 according to this preferred embodiment, all of the wafer 1, the ring frame 7, and the polyester sheet 9 are united by thermocompression bonding as mentioned above, thereby forming the frame unit.

The steps of the processing method for the wafer 1 according to this preferred embodiment will now be described. Prior to uniting the wafer 1, the polyester sheet 9, and the ring frame 7, a polyester sheet providing step is performed by using a chuck table 2 having a holding surface 2a depicted in FIG. 2. FIG. 2 is a schematic perspective view depicting a manner of positioning the wafer 1 and the ring frame 7 on the holding surface 2a of the chuck table 2. That is, the polyester sheet providing step is performed on the holding surface 2a of the chuck table 2 as depicted in FIG. 2. The chuck table 2 has a circular porous member having a diameter larger than the outer diameter of the ring frame 7. The porous member constitutes a central

upper portion of the chuck table 2. The porous member has an upper surface functioning as the holding surface 2a of the chuck table 2. A suction passage (not depicted) is formed in the chuck table 2, in which one end of the suction passage is connected to the porous member. Further, a vacuum source 2b (see FIG. 3) is connected to the other end of the suction passage. The suction passage is provided with a selector 2c (see FIG. 3) for switching between an ON condition and an OFF condition. When the ON condition is established by the selector 2c, a vacuum produced by the vacuum source 2b is applied to a workpiece placed on the holding surface 2a of the chuck table 2, thereby holding the workpiece on the chuck table 2 under suction.

In the polyester sheet providing step, the wafer 1 and the ring frame 7 are first placed on the holding surface 2a of the chuck table 2 as depicted in FIG. 2. In this condition, the wafer 1 is positioned in the inside opening 7a of the ring frame 7. At this time, taking it into consideration which of the front side 1a or the back side 1b is to be an application surface to be applied by the laser beam in the later dividing step, an orientation of the wafer 1 is selected. For example, in a case where the front side 1a is selected as the application surface,

the front side 1a is orientated downward. Alternatively, for example, in a case where the back side 1b is selected as the application surface, the back side 1b is orientated downward. A wafer processing method according to the preferred embodiment will be described below taking the case where the front side 1a is selected as the application surface of the laser beam as an example. However, the orientation of the wafer 1 is not limited to this.

After the wafer 1 and the frame 7 are placed on the holding surface 2a of the chuck table 2, the polyester sheet 9 is provided on the back side 1b (or the front side 1a) (upper surface) of the wafer 1 and on the back side 7c (upper surface) of the ring frame 7. FIG. 3 is a schematic perspective view depicting a manner of providing the polyester sheet 9 on the wafer 1 and the ring frame 7. That is, as depicted in FIG. 3, the polyester sheet 9 is provided so as to fully cover the wafer 1 and the ring frame 7. In the polyester sheet providing step, the diameter of the polyester sheet 9 is set larger than the diameter of the holding surface 2a of the chuck table 2. Unless the diameter of the polyester sheet 9 is larger than the diameter of the holding surface 2a, there may arise a problem such that, when the

vacuum from the vacuum source 2b is applied to the holding surface 2a of the chuck table 2 in a uniting step to be performed later, the vacuum may leak from any gap between the polyester sheet 9 and the holding surface 2a because the holding surface 2a is not fully covered with the polyester sheet 9, so that a pressure cannot be properly applied to the polyester sheet 9.

In the processing method for the wafer 1 according to this preferred embodiment, a uniting step is next performed in such a manner that the polyester sheet 9 is heated to unite the wafer 1 and the ring frame 7 through the polyester sheet 9 by thermocompression bonding. FIG. 4 is a schematic perspective view depicting the uniting step according to this preferred embodiment. As depicted in FIG. 4, the polyester sheet 9 transparent or translucent to visible light is provided so as to fully cover the wafer 1, the ring frame 7, and the holding surface 2a of the chuck table 2, which are all depicted by broken lines in FIG. 4. In the uniting step, the selector 2c is operated to establish the ON condition where the vacuum source 2b is in communication with the porous member of the chuck table 2, i.e., the holding surface 2a of the chuck table 2, so that a vacuum produced by the vacuum source 2b is applied to the

polyester sheet 9 provided on the chuck table 2. Accordingly, the polyester sheet 9 is brought into close contact with the wafer 1 and the ring frame 7 by the atmospheric pressure applied to the upper surface of the polyester sheet 9.

Thereafter, the polyester sheet 9 is heated in a condition where the polyester sheet 9 is sucked by the vacuum source 2b, thereby performing thermocompression bonding. In this preferred embodiment depicted in FIG. 4, for example, the heating of the polyester sheet 9 is effected by a heat gun 4 provided above the chuck table 2. The heat gun 4 includes heating means such as a heating wire and an air blowing mechanism such as a fan. Accordingly, the heat gun 4 can heat ambient air and blow the heated air. In a condition where the vacuum from the vacuum source 2b is applied to the polyester sheet 9, the heat gun 4 is operated to supply hot air 4a to the upper surface of the polyester sheet 9. Accordingly, when the polyester sheet 9 is heated to a predetermined temperature, the polyester sheet 9 is bonded to the wafer 1 and the ring frame 7 by thermocompression bonding.

Another method for heating the polyester sheet 9 may be adopted. For example, any member heated to a predetermined temperature may be pressed on the polyester

sheet 9 against the wafer 1 and the ring frame 7. FIG. 5 is a schematic perspective view depicting such a modification of the uniting step. As depicted in FIG. 5, the polyester sheet 9 transparent or translucent to visible light is provided so as to fully cover the wafer 1, the ring frame 7, and the holding surface 2a of the chuck table 2, which are all depicted by broken lines in FIG. 5. In this modification depicted in FIG. 5, a heat roller 6 including a heat source is used. More specifically, the vacuum produced by the vacuum source 2b is first applied to the polyester sheet 9, so that the polyester sheet 9 is brought into close contact with the wafer 1 and the ring frame 7 by the atmospheric pressure applied to the upper surface of the polyester sheet 9.

Thereafter, the heat roller 6 is heated to a predetermined temperature, and next placed on the holding surface 2a of the chuck table 2 at one end lying on the outer circumference of the holding surface 2a as depicted in FIG. 5. Thereafter, the heat roller 6 is rotated about its axis to roll on the chuck table 2 through the polyester sheet 9 from the above one end to another end diametrically opposite to the above one end. As a result, the polyester sheet 9 is bonded to the wafer 1 and the ring frame 7 by thermocompression bonding. In the case

that a force for pressing the polyester sheet 9 is applied by the heat roller 6, the thermocompression bonding is effected at a pressure higher than atmospheric pressure. Preferably, a cylindrical surface of the heat roller 6 is coated with fluororesin. Further, the heat roller 6 may be replaced by any iron-like pressure member having a flat base plate and containing a heat source. In this case, the pressure member is heated to a predetermined temperature to thereby provide a hot plate, which is next pressed on the polyester sheet 9 held on the chuck table 2.

Still another method for heating the polyester sheet 9 may be adopted in the following manner. FIG. 6 is a schematic perspective view depicting such another modification of the uniting step. As depicted in FIG. 6, the polyester sheet 9 transparent or translucent to visible light is provided so as to fully cover the wafer 1, the ring frame 7, and the holding surface 2a of the chuck table 2, which are all depicted by broken lines in FIG. 6. In this modification depicted in FIG. 6, an infrared lamp 8 is provided above the chuck table 2 to heat the polyester sheet 9. The infrared lamp 8 can apply infrared light 8a having an absorption wavelength to at least the material of the polyester sheet 9. Also in the

modification depicted in FIG. 6, the vacuum produced by the vacuum source 2b is first applied to the polyester sheet 9, so that the polyester sheet 9 is brought into close contact with the wafer 1 and the ring frame 7 by the atmospheric pressure applied to the upper surface of the polyester sheet 9. Thereafter, the infrared lamp 8 is operated to apply the infrared light 8a to the polyester sheet 9, thereby heating the polyester sheet 9. As a result, the polyester sheet 9 is bonded to the wafer 1 and the ring frame 7 by thermocompression bonding.

When the polyester sheet 9 is heated to a temperature near its melting point by performing any one of the above methods, the polyester sheet 9 is bonded to the wafer 1 and the ring frame 7 by thermocompression bonding. After bonding the polyester sheet 9, the selector 2c is operated to establish the OFF condition where the communication between the porous member of the chuck table 2 and the vacuum source 2b is canceled. Accordingly, the suction holding by the chuck table 2 is canceled.

Thereafter, the polyester sheet 9 is circularly cut along the outer circumference of the ring frame 7 to remove an unwanted peripheral portion of the polyester sheet 9. FIG. 7A is a schematic perspective view

depicting a manner of cutting the polyester sheet 9. As depicted in FIG. 7A, a disc-shaped (annular) cutter 10 is used to cut the polyester sheet 9. The cutter 10 has a central through hole 10a in which a rotating shaft 10b is fitted. Accordingly, the cutter 10 is rotatable about the axis of the rotating shaft 10b. First, the cutter 10 is positioned above the ring frame 7. At this time, the rotating shaft 10b is set so as to extend in the radial direction of the chuck table 2. Thereafter, the cutter 10 is lowered until the outer circumference (cutting edge) of the cutter 10 comes into contact with the polyester sheet 9 placed on the ring frame 7. That is, the polyester sheet 9 is caught between the cutter 10 and the ring frame 7, so that the polyester sheet 9 is cut by the cutter 10 to form a cut mark 9a. Further, the cutter 10 is rolled on the polyester sheet 9 along a circular line set between the inner circumference of the ring frame 7 (i.e., the periphery of the inside opening 7a of the ring frame 7) and the outer circumference of the ring frame 7, thereby circularly forming the cut mark 9a along the above circular line. As a result, a predetermined central portion of the polyester sheet 9 is surrounded by the circular cut mark 9a. Thereafter, a remaining peripheral portion of the polyester sheet 9 outside the circular cut

mark 9a is removed. That is, an unwanted peripheral portion of the polyester sheet 9 including an outermost peripheral portion outside the outer circumference of the ring frame 7 can be removed.

The cutter 10 may be replaced by an ultrasonic cutter for cutting the polyester sheet 9. Further, a vibration source for vibrating the cutter 10 at a frequency in an ultrasonic band may be connected to the cutter 10. Further, in cutting the polyester sheet 9, the polyester sheet 9 may be cooled to be hardened in order to facilitate the cutting operation. By cutting the polyester sheet 9 as mentioned above, a frame unit 11 depicted in FIG. 7B is formed, in which the frame unit 11 is composed of the wafer 1, the ring frame 7, and the polyester sheet 9 united together. That is, the wafer 1 and the ring frame 7 are united with each other through the polyester sheet 9 to form the frame unit 11 as depicted in FIG. 7B. FIG. 7B is a schematic perspective view of the frame unit 11 in a condition where the front side 1a of the wafer 1 and the front side 7b of the ring frame 7 are exposed upward.

In performing the thermocompression bonding as mentioned above, the polyester sheet 9 is heated preferably to a temperature lower than or equal to the

melting point of the polyester sheet 9. If the heating temperature is higher than the melting point of the polyester sheet 9, there is a possibility that the polyester sheet 9 may be melted to such an extent that the shape of the polyester sheet 9 cannot be maintained. Further, the polyester sheet 9 is heated preferably to a temperature higher than or equal to the softening point of the polyester sheet 9. If the heating temperature is lower than the softening point of the polyester sheet 9, the thermocompression bonding cannot be properly performed. Accordingly, the polyester sheet 9 is heated preferably to a temperature higher than or equal to the softening point of the polyester sheet 9 and lower than or equal to the melting point of the polyester sheet 9. Further, there is a case that the softening point of the polyester sheet 9 may be unclear. To cope with such a case, in performing the thermocompression bonding, the polyester sheet 9 is heated preferably to a temperature higher than or equal to a preset temperature and lower than or equal to the melting point of the polyester sheet 9, the preset temperature being lower by 20°C than the melting point of the polyester sheet 9.

In the case that the polyester sheet 9 is a polyethylene terephthalate sheet, the heating temperature

in the uniting step is preferably set in the range of 250°C to 270°C. Further, in the case that the polyester sheet 9 is a polyethylene naphthalate sheet, the heating temperature in the uniting step is preferably set in the range of 160°C to 180°C.

The heating temperature is defined herein as the temperature of the polyester sheet 9 to be heated in performing the uniting step. As the heat sources included in the heat gun 4, the heat roller 6, and the infrared lamp 8 mentioned above, some kind of heat source capable of setting an output temperature has been put into practical use. However, even when such a heat source is used to heat the polyester sheet 9, the temperature of the polyester sheet 9 does not reach the output temperature set above in some case. To cope with such a case, the output temperature of the heat source may be set to a temperature higher than the melting point of the polyester sheet 9 in order to heat the polyester sheet 9 to a predetermined temperature.

After performing the uniting step mentioned above, a dividing step is performed in such a manner that the wafer 1 in the condition of the frame unit 11 is processed by a laser beam to form a plurality of modified layers inside the wafer 1 along the plural crossing

division lines 3, thereby dividing the wafer 1 into individual device chips. The dividing step is performed by using a laser processing apparatus 12 depicted in FIG. 8A in this preferred embodiment. FIG. 8A is a schematic perspective view depicting the dividing step. FIG. 8B is a schematic sectional view depicting the dividing step. As depicted in FIG. 8A, the laser processing apparatus 12 includes a laser processing unit 14 for applying a laser beam 16 to the wafer 1 and a chuck table (not depicted) for holding the wafer 1. The laser processing unit 14 includes a laser oscillator (not depicted) for generating the laser beam 16 having a transmission wavelength to the wafer 1 (having a wavelength transmittable to the wafer 1). The chuck table has an upper surface as a holding surface for holding the wafer 1. The chuck table is movable in a direction parallel to the upper surface thereof, that is, movable in a feeding direction. The laser beam 16 generated from the laser oscillator in the laser processing unit 14 is applied to the wafer 1 held on the chuck table. The laser processing unit 14 further includes a processing head 14a having a mechanism for positioning a focal point 14b of the laser beam 16 at a predetermined vertical position inside the wafer 1.

In performing laser processing to the wafer 1, the

frame unit 11 is placed on the chuck table in the condition where the front side 1a of the wafer 1 is exposed upward. Accordingly, the wafer 1 is held through the polyester sheet 9 on the chuck table. Thereafter, the chuck table is rotated to make the division lines 3 extending in the first direction on the front side 1a of the wafer 1 parallel to a feeding direction in the laser processing apparatus 12. Further, the chuck table and the laser processing unit 14 are relatively moved to adjust a relative position, thereby positioning the processing head 14a directly above an extension of a predetermined one of the division lines 3 extending in the first direction. Thereafter, the focal point 14b of the laser beam 16 is positioned at a predetermined vertical position. Thereafter, the laser beam 16 is applied from the laser processing unit 14 inside the wafer 1. At the same time, the chuck table and the laser processing unit 14 are relatively moved in the feeding direction parallel to the upper surface of the chuck table. Specifically, the focal point 14b of the laser beam 16 is positioned inside the wafer 1, and the laser beam 16 is applied to the wafer 1 along the predetermined division lines 3. As a result, the modified layer 3a is formed inside the wafer 1. Note that, in FIG. 8A, the modified layer 3a

formed inside the wafer 1 is depicted with broken lines. Accordingly, a division groove 3a is formed in the wafer 1 along the predetermined division line 3 by the laser beam 16. The division groove 3a has a depth from the front side 1a to the back side 1b of the wafer 1. In this dividing step, the laser beam 16 may be applied under the following processing conditions. The following processing conditions are merely illustrative.

Wavelength: 1064 nm

Repetition frequency: 50 kHz

Average power: 1 W

Feed speed: 200 mm/s

After forming the modified layer 3a inside the wafer 1 along the predetermined division line 3, the chuck table and the laser processing unit 14 are moved in an indexing direction perpendicular to the feeding direction to similarly perform laser processing along the next division line 3 extending in the first direction. Thereafter, laser processing is similarly performed along all of the other division lines 3 extending in the first direction. Thus, a plurality of similar modified layers 3a are formed along all of the division lines 3 extending in the first direction. Thereafter, the chuck table is rotated 90 degrees about its vertical axis perpendicular

to the holding surface thereof to similarly perform laser processing along all of the division lines 3 extending in the second direction perpendicular to the first direction. Thus, a plurality of similar modified layers 3a are formed along all of the division lines 3 extending in the second direction.

When the laser beam 16 is focused inside the wafer 1 by the laser processing unit 14 to form the modified layer 3a, leaked light of the laser beam 16 reaches the polyester sheet 9 below the wafer 1. For example, in a case where the frame unit 11 adopts an adhesive tape instead of the polyester sheet 9, when the leaked light of the laser beam 16 is applied to an adhesive layer of the adhesive tape, the adhesive layer of the adhesive tape is melted, so that part of the adhesive layer is fixed to the back side 1b of the wafer 1. In this case, the part of the adhesive layer is left on the back side of each of the device chips formed by dividing the wafer 1. As a result, a degradation in quality of each device chip is caused. In contrast, in the wafer processing method according to the present embodiment, the polyester sheet 9 having no adhesive layer is used in the frame unit 11. Accordingly, even if the leaked light of the laser beam 16 reaches the polyester sheet 9, the adhesive

layer is not fixed to the back side 1b of the wafer 1. Thus, quality of each device chip formed from the wafer 1 is favorably maintained.

Next, the polyester sheet 9 is expanded in a radially outward direction, so that the wafer 1 is divided into individual device chips. After performing the dividing step, a pickup step is performed to pick up each device chip from the polyester sheet 9. Expansion of the polyester sheet 9 is performed by using a pickup apparatus 18 depicted in a lower portion of FIG. 9. FIG. 9 is a schematic perspective view depicting a manner of loading the frame unit 11 to the pickup apparatus 18. As depicted in FIG. 9, the pickup apparatus 18 includes a cylindrical drum 20 and a frame holding unit 22 having a frame support table 26 provided around the cylindrical drum 20. The cylindrical drum 20 has an inner diameter larger than the diameter of the wafer 1 and an outer diameter smaller than the inner diameter of the ring frame 7 (the diameter of the inside opening 7a). The frame support table 26 of the frame holding unit 22 is an annular table having a circular inside opening larger in diameter than the drum 20. That is, the frame support table 26 has an inner diameter larger than the outer diameter of the drum 20. Further, the frame support table

26 has an outer diameter larger than the outer diameter of the ring frame 7. The inner diameter of the frame support table 26 is substantially equal to the inner diameter of the ring frame 7. The frame support table 26 has an upper surface as a supporting surface for supporting the ring frame 7 thereon through the polyester sheet 9. Initially, the height of the upper surface of the frame support table 26 is set equal to the height of the upper end of the drum 20 (see FIG. 10A). Further, the upper end portion of the drum 20 is surrounded by the inner circumference of the ring frame 7 in this initial stage.

A plurality of clamps 24 are provided on the outer circumference of the frame support table 26. Each clamp 24 functions to hold the ring frame 7 supported on the frame support table 26. That is, when the ring frame 7 of the frame unit 11 is placed through the polyester sheet 9 on the frame support table 26 and then held by each clamp 24, the frame unit 11 can be fixed to the frame support table 26. The frame support table 26 is supported by a plurality of rods 28 extending in a vertical direction. That is, each rod 28 is connected at its upper end to the lower surface of the frame support table 26. An air cylinder 30 for vertically moving each rod 28 is

connected to the lower end of each rod 28. More specifically, the lower end of each rod 28 is connected to a piston (not depicted) movably accommodated in the air cylinder 30. Each air cylinder 30 is supported to a disc-shaped base 32. That is, the lower end of each air cylinder 30 is connected to the upper surface of the disc-shaped base 32. Accordingly, when each air cylinder 30 is operated in the initial stage, the frame support table 26 is lowered with respect to the drum 20 fixed in position.

Further, a pushup mechanism 34 for pushing up each device chip supported to the polyester sheet 9 is provided inside the drum 20. The pushup mechanism 34 has, at an upper end thereof, a heating section 34a including therein a heating source such as a Peltier element or an electric heating wire. Further, a collet 36 (see FIG. 10B) capable of holding each device chip under suction is provided above the drum 20. Both the pushup mechanism 34 and the collet 36 are movable in a horizontal direction parallel to the upper surface of the frame support table 26. The collet 36 is connected through a selector 36b (see FIG. 10B) to a vacuum source 36a (see FIG. 10B).

In expanding the polyester sheet 9, each air cylinder 30 in the pickup apparatus 18 is first operated

to adjust the height of the frame support table 26 such that the height of the upper end of the drum 20 becomes equal to the height of the upper surface of the frame support table 26. Thereafter, the frame unit 11 transferred from the laser processing apparatus 12 is placed on the drum 20 and the frame support table 26 in the pickup apparatus 18 in a condition where the front side 1a of the wafer 1 of the frame unit 11 is oriented upward. Thereafter, each clamp 24 is operated to fix the ring frame 7 of the frame unit 11 to the upper surface of the frame support table 26. FIG. 10A is a schematic sectional view depicting a standby condition where the frame unit 11 is fixed to the frame support table 26 set at the initial position. At this time, the plural modified layers 3a have already been formed inside the wafer 1 along the division lines 3.

Thereafter, each air cylinder 30 is operated to lower the frame support table 26 of the frame holding unit 22 with respect to the drum 20. As a result, the polyester sheet 9 fixed to the frame holding unit 22 by each clamp 24 is expanded radially outward as depicted in FIG. 10B. FIG. 10B is a schematic sectional view depicting the expanded polyester sheet 9. When the polyester sheet 9 is expanded, a force toward a radially

outward direction is applied to the wafer 1, and the wafer 1 is divided with the modified layers 3a as a start point, thereby forming individual device chips 1c. When the polyester sheet 9 is further expanded, the spacing between any adjacent ones of the device chips 1c supported to the polyester sheet 9 is increased as depicted in FIG. 10B. Accordingly, each device chip 1c can be easily picked up.

In the wafer processing method according to the present embodiment, after the wafer 1 is divided into individual device chips 1c, a pickup step of picking up the device chips 1c from the polyester sheet 9 is performed. In the pickup step, a target one of the device chips 1c is decided, and the pushup mechanism 34 is next moved to a position directly below this target device chip 1c as depicted in FIG. 10B. Furthermore, the collet 36 is also moved to a position directly above this target device chip 1c as depicted in FIG. 10B. Thereafter, the heating section 34a is operated to increase a temperature thereof, and the pushup mechanism 34 causes the heating section 34a to come into contact with a region corresponding to the device chip 1c in the polyester sheet 9, thereby heating the region. Further, the pushup mechanism 34 is operated to push up the target device

chip 1c from the polyester sheet 9 side. Further, the selector 36b is operated to make the collet 36 communicate with the vacuum source 36a. As a result, the target device chip 1c is held under suction by the collet 36 and thereby picked up from the polyester sheet 9. Such a pickup operation is similarly performed for all the other device chips 1c. Thereafter, each device chip 1c picked up is mounted on a predetermined wiring substrate or the like for actual use. Note that, when the region in the polyester sheet 9 is heated by the heating section 34a, the region is heated to a temperature near the melting point of the polyester sheet 9, for example. Since the polyester sheet 9 reduces in its adhesion at a temperature near its melting point, a load applied to the device chip in peeling off from the polyester sheet 9 is reduced.

In the case of forming the frame unit 11 by using an adhesive tape, the leaked light of the laser beam 16 applied to the wafer 1 reaches the adhesive tape in the dividing step, so that the adhesive layer of the adhesive tape is melted and fixed to the back side of each device chip. Accordingly, in this case, there is a problem that the adherence of the adhesive layer to each device chip causes a degradation in quality. To the contrary, in the

wafer processing method according to this preferred embodiment, the frame unit 11 can be formed by using the polyester sheet 9 having no adhesive layer, in which the polyester sheet 9 is attached to the wafer 1 and the ring frame 7 by thermocompression bonding. That is, an adhesive tape having an adhesive layer is not required. As a result, it is possible to prevent a degradation in quality of each device chip due to the adherence of the adhesive layer to the back side of each device chip.

The present invention is not limited to the above preferred embodiment, but various modifications may be made within the scope of the present invention. For example, while the polyester sheet 9 is selected from a polyethylene terephthalate sheet and a polyethylene naphthalate sheet in the above preferred embodiment, this is merely illustrative. For example, the polyester sheet usable in the present invention may be formed of any other materials (polyesters) such as polytrimethylene terephthalate, polybutylene terephthalate, or polybutylene naphthalate.

The present invention is not limited to the details of the above described preferred embodiment. 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 wafer processing method for dividing a wafer along a plurality of division lines to obtain a plurality of individual device chips, the division lines being formed on a front side of the wafer to thereby define a plurality of separate regions where a plurality of devices are individually formed, the wafer processing method comprising:

a ring frame preparing step of preparing a ring frame having an inside opening for accommodating the wafer;

a polyester sheet providing step of positioning the wafer in the inside opening of the ring frame and providing a polyester sheet on a back side or the front side of the wafer and on a back side of the ring frame;

a uniting step of heating the polyester sheet as applying a pressure to the polyester sheet after performing the polyester sheet providing step, thereby uniting the wafer and the ring frame through the polyester sheet by thermocompression bonding to form a frame unit in a condition where the front side of the wafer and the front side of the ring frame are exposed upward;

a dividing step of positioning a focal point of a

laser beam inside the wafer, the laser beam having a transmission wavelength to the wafer, and applying the laser beam to the wafer along each division line, thereby forming a modified layer in the wafer along each division line to divide the wafer into the individual device chips, after performing the uniting step; and

a pickup step of heating the polyester sheet in each of the plurality of separate regions corresponding to each device chip, pushing up each device chip through the polyester sheet, then picking up each device chip from the polyester sheet after performing the dividing step.

2. The wafer processing method according to claim 1, wherein the uniting step includes a step of applying infrared light to the polyester sheet, thereby performing the thermocompression bonding.

3. The wafer processing method according to claim 1, wherein the polyester sheet is larger in size than the ring frame, and the uniting step includes an additional step of cutting the polyester sheet after heating the polyester sheet, thereby removing a part of the polyester sheet outside an outer circumference of the ring frame.

4. The wafer processing method according to claim 1, wherein the pickup step includes a step of expanding

the polyester sheet to thereby increase a spacing between any adjacent ones of the device chips.

5. The wafer processing method according to claim 1, wherein the polyester sheet is formed of a material selected from the group consisting of polyethylene terephthalate and polyethylene naphthalate.

6. The wafer processing method according to claim 5, wherein the polyester sheet is formed of polyethylene terephthalate, and the polyester sheet is heated in the range of 250°C to 270°C in the uniting step.

7. The wafer processing method according to claim 5, wherein the polyester sheet is formed of polyethylene naphthalate, and the polyester sheet is heated in the range of 160°C to 180°C in the uniting step.

8. The wafer processing method according to claim 1, wherein the wafer is formed of a material selected from the group consisting of silicon, gallium nitride, gallium arsenide, and glass.