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| United States Patent | 12394658 |
| Kind Code | B2 |
| Date of Patent | August 19, 2025 |
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## Method of processing plate-shaped workpiece

### Abstract

A method of processing a plate-shaped workpiece includes a workpiece supporting step of placing the plate-shaped workpiece on a thermocompression sheet whose area is larger than that of the plate-shaped workpiece, heating the thermocompression sheet to pressure-bond the thermocompression sheet to the plate-shaped workpiece, and supporting the plate-shaped workpiece on only the thermocompression sheet, a processing step of processing the plate-shaped workpiece to divide the plate-shaped workpiece into a plurality of chips, and a pick-up step of picking up the chips from the thermocompression sheet.

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**Appl. No.:** **17/931591**

**Filed:** **September 13, 2022**

### Prior Publication Data

| Document Identifier | Publication Date |
|---|---|
| US 20230099416 A1 | Mar. 30, 2023 |

### Foreign Application Priority Data

| | | |
|---|---|---|
| JP | 2021-156352 | Sep. 27, 2021 |

### Publication Classification

**Int. Cl.:** **H01L21/683** (20060101); **B23K26/38** (20140101); **H01L21/67** (20060101); **H01L21/78** (20060101)

**U.S. Cl.:**

CPC **H01L21/6836** (20130101); **B23K26/38** (20130101); **H01L21/67092** (20130101); **H01L21/78** (20130101); H01L2221/68336 (20130101); H01L2221/68386 (20130101)

## Field of Classification Search

**USPC:** None

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## Background/Summary

BACKGROUND OF THE INVENTION

Field of the Invention

(1) The present invention relates to a method of processing a plate-shaped workpiece.

Description of the Related Art

(2) Wafers having, on their face sides, a plurality of devices such as integrated circuits (ICs) or large-scale integration (LSI) circuits formed in respective areas demarcated by a plurality of projected dicing lines are divided into individual device chips by a cutting apparatus or a laser processing apparatus. The device chips will be used in electronic appliances such as mobile phones and personal computers.

(3) After such a wafer has been divided into individual device chips, a pick-up step is carried out on the device chips that are still kept together in a wafer configuration similar in shape to the wafer as a whole. Heretofore, as illustrated in FIG. **7** of the accompanying drawings, it has been the general practice to support a wafer **10** by an adhesive tape T on an annular frame F having an opening Fa that is defined centrally therein and that accommodates the wafer **10** therein and to deliver the wafer **10** thus supported to a cutting apparatus or a laser processing apparatus for processing the wafer **10** (see, for example, Japanese Patent Laid-open No. Hei 10-242083, Japanese Patent Laid-open No. 2002-222988, and Japanese Patent Laid-open No. 2004-188475). The wafer **10** illustrated in FIG. **7** is a circular, plate-shaped workpiece having devices **12** formed in respective areas demarcated on a face side **10***a* thereof by a grid of projected dicing lines **14**. The frame F has a pair of recesses Fb and Fc defined in an outer circumferential edge portion thereof for distinguishing between face and reverse sides of the frame F and defining a direction in which the frame F supports the wafer **10**.

SUMMARY OF THE INVENTION

(4) The processing apparatus disclosed in Japanese Patent Laid-open No. Hei 10-242083, Japanese Patent Laid-open No. 2002-222988, and Japanese Patent Laid-open No. 2004-188475 described

above repetitively uses the frame F for supporting the wafer **10**. Therefore, after the wafer **10** supported by the frame F has been processed, the adhesive tape T is removed from the frame F, and thereafter the frame F is retrieved. The retrieved frame F is serviced for maintenance, e.g., cleaned to remove debris, an adhesive, etc., deposited on the frame F and stored in a given place until it will be used to support a wafer. However, since the maintenance process is tedious and time-consuming, the overall process for processing wafers is low in productivity.

(5) It is therefore an object of the present invention to provide a method of processing a plate-shaped workpiece with higher productivity without the need for a maintenance process for a frame that supports the plate-shaped workpiece.

(6) In accordance with an aspect of the present invention, there is provided a method of processing a plate-shaped workpiece, including a workpiece supporting step of placing the plate-shaped workpiece on a thermocompression sheet whose area is larger than that of the plate-shaped workpiece, heating the thermocompression sheet to pressure-bond the thermocompression sheet to the plate-shaped workpiece, and supporting the plate-shaped workpiece on only the thermocompression sheet, a processing step of processing the plate-shaped workpiece to divide the plate-shaped workpiece into a plurality of chips, and a pick-up step of picking up the chips from the thermocompression sheet.

(7) Preferably, the method further includes an expanding step of expanding the thermocompression sheet to widen distances between the chips. Preferably, the method further includes after the pick-up step, a discarding step of discarding the thermocompression sheet.

(8) Preferably, the plate-shaped workpiece includes a wafer including a face side having a plurality of devices formed in respective areas demarcated thereon by a plurality of projected dicing lines, the face side of the wafer or a reverse side thereof being placed on the thermocompression sheet. Preferably, the thermocompression sheet is either one of a polyolefin-based sheet and a polyester-based material.

(9) The polyolefin-based sheet may be either one of a polyethylene sheet, a polypropylene sheet, and a polystyrene sheet. Preferably, if the polyethylene sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 120° C. to 140° C., if the polypropylene sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 160° C. to 180° C., and if the polystyrene sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 220° C. to 240° C.

(10) The polyester-based sheet is either one of a polyethylene terephthalate sheet and a polyethylene naphthalate sheet. Preferably, if the polyethylene terephthalate sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 250° C. to 270° C., and if the polyethylene naphthalate sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 160° C. to 180° C.

(11) Since the method of processing a plate-shaped workpiece according to the aspect of the present invention includes a workpiece supporting step of placing the plate-shaped workpiece on an upper surface of a thermocompression sheet whose area is larger than that of the plate-shaped workpiece, heating the thermocompression sheet to pressure-bond the thermocompression sheet to the plate-shaped workpiece, and supporting the plate-shaped workpiece on only the thermocompression sheet, a processing step of processing the plate-shaped workpiece to divide the plate-shaped workpiece into a plurality of chips, and a pick-up step of picking up the chips from the thermocompression sheet, a frame that has heretofore been used is not required and no tedious and time-consuming work has to be performed for maintenance to make such a frame reusable, so that the method of processing a plate-shaped workpiece is of increased productivity.

(12) 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 an appended claim with reference to the attached drawings showing a preferred embodiment of the invention.

## Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view of a cutting apparatus for use in a method of processing a plate-shaped workpiece according to an embodiment of the present invention;

(2) FIG. **2**A is a perspective view of a thermocompression sheet according to the present embodiment;

(3) FIG. **2**B is a perspective view of a thermocompression sheet according to a modification;

(4) FIG. **2**C is a perspective view of a thermocompression sheet according to another modification;

(5) FIG. **2**D is a perspective view of a thermocompression sheet according to still another modification;

(6) FIGS. **3**A and **3**B are perspective views illustrating the manner in which a thermocompression sheet is placed on a wafer in a workpiece supporting step;

(7) FIGS. **4**A and **4**B are perspective views illustrating the manner in which the thermocompression sheet is pressure-bonded to the wafer by a thermocompression roller in the workpiece supporting step;

(8) FIGS. **5**A and **5**B are perspective views illustrating the manner in which a cutting step according to the present embodiment is performed as a processing step;

(9) FIG. **6**A is a cross-sectional view, partly in side elevation, illustrating the manner in which an expanding step is carried out;

(10) FIG. **6**B is a cross-sectional view, partly in side elevation, illustrating the manner in which a pick-up step is carried out; and

(11) FIG. **7** is a perspective view illustrating the manner in which a wafer is supported on an annular frame by an adhesive tape.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

(12) A preferred embodiment of the present invention will be described hereinbelow with reference to the accompanying drawings.

(13) FIG. **1** illustrates a cutting apparatus **1** in its entirety in perspective that is suitable for use in a method of processing a plate-shaped workpiece according to an embodiment of the present invention. As illustrated in FIG. **1**, the cutting apparatus **1** is an apparatus for cutting a circular wafer **10** as the plate-shaped workpiece. The wafer **10** is similar to the wafer **10** described above with reference to FIG. **7**, and is a semiconductor wafer made of silicon (Si), for example, having a plurality of devices **12** (see FIG. **4**A) formed in respective areas demarcated on a face side **10***a* by a plurality of projected dicing lines **14**.

(14) The cutting apparatus **1** includes an apparatus housing **2**. The wafer **10**, which is the plate-shaped workpiece according to the present embodiment, has been pressure-bonded to a thermocompression sheet S in a workpiece supporting step, to be described later, and is supported on only the thermocompression sheet S. A plurality of wafers **10** each supported on the thermocompression sheet S are stored in a cassette **3**, indicated by the two-dot-and-dash lines, that is delivered to the apparatus housing **2**. The cassette **3** is placed on a vertically movable cassette table **3***a* disposed in the apparatus housing **2**. One, at a time, of the wafers **10** stored in the cassette **3** is taken out of the cassette **3** and delivered onto a temporary rest table **5** on the apparatus housing **2** when a loading/unloading mechanism **4** grips the thermocompression sheet S and moves in a Y-axis direction to bring the wafer **10** on the thermocompression sheet S onto the temporary rest table

**5**.

(15) The wafer **10** delivered to the temporary rest table **5** is attracted under suction by a delivery mechanism **6**, which is then turned to deliver the wafer **10** to a chuck table **7** positioned in a loading/unloading area where the wafer **10** is to be loaded and unloaded. The wafer **10** delivered to the chuck table **7** is placed, with its reverse side **10***b* (see FIG. **4**A) facing downwardly, on a suction chuck **7***a* of the chuck table **7** and held under suction thereon. Four clamps **7***b* that are angularly spaced at equal intervals around an outer circumferential surface of the chuck table **7** grip and secure the thermocompression sheet S in position.

(16) The cutting apparatus **1** includes an alignment unit **8** and a cutting unit **9** that are disposed over an alignment area next to the loading/unloading area along the X-axis direction. The apparatus housing **2** houses therein an X-axis moving mechanism, not illustrated, for moving the chuck table **7** in the X-axis direction from the loading/unloading area to the alignment area next to it and also for processing-feeding the chuck table **7** in a processing area next to the alignment area, a Y-axis moving mechanism, not illustrated, for indexing-feeding a cutting blade **9***a* of the cutting unit **9** in a Y-axis direction perpendicular to the X-axis direction, and a Z-axis moving mechanism, not illustrated, for lifting and lowering the cutting blade **9***a* and incising-feeding the cutting blade **9***a* in the processing area. When the chuck table **7** and hence the wafer **10** placed thereon are moved in the X-axis direction by the X-axis moving mechanism to the alignment area, the alignment unit **8** with a camera function captures an image of the wafer **10** to detect a region of the wafer **10** to be cut by the cutting unit **9**. The cutting unit **9** carries out a cutting step as follows.

(17) The alignment unit **8** detects one of the projected dicing lines **14** as the region to be cut. The detected projected dicing line **14** is aligned with the X-axis direction and hence oriented in alignment with the cutting blade **9***a* in the alignment area. The chuck table **7** is then moved from the alignment area in the X-axis direction by the X-axis moving mechanism to position the aligned projected dicing line **14** in the processing area that is directly below the cutting blade **9***a* of the cutting unit **9**. Then, the cutting blade **9***a* is rotated about its central axis, and lowered or incising-fed by the Z-axis moving mechanism while, at the same time, the chuck table **7** is processing-fed by the X-axis moving mechanism, thereby cutting the wafer **10** along the projected dicing line **14** to form a straight cut groove in the wafer **10** along the projected dicing line **14**. After the straight cut groove has been formed in the wafer **10**, the Z-axis moving mechanism lifts the cutting blade **9***a*, and the wafer **10** is indexing-fed a distance in the Y-axis direction up to an adjacent projected dicing line **14** by the Y-axis moving mechanism. Then, in the same manner as described above, the cutting blade **9***a* is incising-fed by the Z-axis moving mechanism and processing-fed in the X-axis direction by the X-axis moving mechanism while, at the same time, the chuck table **7** is processing-fed by the X-axis moving mechanism, thereby cutting the wafer **10** along the projected dicing line **14** to form a straight cut groove in the wafer **10** along the adjacent projected dicing line **14**. The above process is repeated until straight cut grooves are formed in the wafer **10** along all the projected dicing lines **14** that extend in a predetermined direction. Thereafter, the chuck table **7** is turned 90 degrees about its central axis to align one of the projected dicing lines **14** that extend in a direction perpendicular to the straight cut grooves already formed in the wafer **10** with the X-axis direction. Then, the above cutting process is carried out again on the wafer **10** until straight cut grooves are formed in the wafer **10** along all the projected dicing lines **14** that extend in the direction perpendicular to the straight cut grooves. In this manner, straight cut grooves are formed in the wafer **10** along all the projected dicing lines **14** on the wafer **10**. When the above cutting step has been performed on the wafer **10**, the wafer **10** is divided along the cut grooves into individual device chips. At this time, since the individual device chips remain supported on the thermocompression sheet S, the device chips are still kept together in a wafer configuration similar in shape to the wafer **10** as a whole. The device chips that are divided but remain in the wafer configuration will also be referred to as the "wafer **10**." The components described above of the cutting apparatus **1** are controlled in operation by a control unit, not illustrated.

(18) The wafer **10** divided into the individual device chips in the cutting step described above is attracted under suction by a delivery mechanism **11** from the chuck table **7** that has been moved from the processing area to the loading/unloading area. Then, the wafer **10** is delivered to a cleaning device **13**, details of which are omitted from illustration, by the delivery mechanism **11**. The wafer **10** is then cleaned and dried by the cleaning device **13**, and thereafter delivered to the temporary rest table **5** by the delivery mechanism **6**. The wafer **10** is then placed back into a position in the cassette **3** by the loading/unloading mechanism **4**. The cassette **3** on the cassette table **3***a* is vertically movable by the cassette table **3***a* to allow the wafer **10** to be stored in a desired one of storage positions arranged in a vertical array in the cassette **3**.
(19) The cutting apparatus **1** according to the present embodiment is of the above structure and operates as described above. The method of processing a plate-shaped workpiece according to the present embodiment is carried out as follows.
(20) For performing the method of processing a plate-shaped workpiece according to the present embodiment, either one of a first thermocompression sheet S**1** (see FIG. **2**A) whose area is larger than that of the wafer **10**, i.e., the face side **10***a* or the reverse side **10***b* thereof, and second through fourth thermocompression sheets S**2**, S**3**, and S**4** (see FIGS. **2**B, **2**C, and **2**D) according to modifications thereof is prepared as the thermocompression sheet S referred to above. Each of the first through fourth thermocompression sheets S**1**, S**2**, S**3**, and S**4** is a thermocompression sheet that softens to produce adhesive power when heated, and may be either a polyolefin-based sheet or a polyester-based sheet, for example.
(21) If a polyolefin-based sheet is selected as the thermocompression sheet S, then either one of a polyethylene (PE) sheet, a polypropylene (PP) sheet, and a polystyrene (PS) thermocompression sheet should preferably be selected as the thermocompression sheet S.
(22) If a polyester-based sheet is selected as the thermocompression sheet S, then either one of a polyethylene terephthalate (PET) sheet and a polyethylene naphthalate (PEN) thermocompression sheet should preferably be selected as the thermocompression sheet S.
(23) The first thermocompression sheet S**1** illustrated in FIG. **2**A is a regular octagonal sheet, and the second thermocompression sheet S**2** illustrated in FIG. **2**B is a square sheet. The third thermocompression sheet S**3** illustrated in FIG. **2**C is a circular sheet, and the fourth thermocompression sheet S**4** illustrated in FIG. **2**D is a thermocompression sheet similar in shape to the contour of the frame F illustrated in FIG. **7** that has heretofore been in use. The fourth thermocompression sheet S**4** has recesses S**4***b* and S**4***c* similar in shape to the recesses Fb and Fc defined in the frame F illustrated in FIG. **7**. Though the first through third thermocompression sheets S**1**, S**2**, and S**3** illustrated in FIGS. **2**A through **2**C are free of such recesses, they may have similar recesses. The thermocompression sheet used in the method according to the present invention is not limited to the first through fourth thermocompression sheets S**1**, S**2**, S**3**, and S**4** illustrated in FIGS. **2**A through **2**D, may have an area larger than that of the wafer **10**, and may be of any shape as long as it can be held on the chuck table **7** referred to above. In the description that follows, the first thermocompression sheet S**1** illustrated in FIG. **2**A that is made of polyethylene will be described and illustrated as the thermocompression sheet S according to the present embodiment, the thermocompression sheet S supporting the wafer **10** as illustrated in FIG. **7** while the wafer **10** is being processed.
(24) After the wafer **10** and the first thermocompression sheet S**1** have been prepared, in order to place the wafer **10** on a face side Sla of the first thermocompression sheet S**1**, which will be an upper surface when the wafer **10** is to be processed, the face side Sla of the first thermocompression sheet S**1** is directed toward a reverse side **10***b* of the wafer **10**, and the wafer **10** is placed centrally on the first thermocompression sheet S**1**, as illustrated in FIG. **3**A. Then, in order to pressure-bond the face side Sla of the first thermocompression sheet S**1** to the reverse side **10***b* of the wafer **10**, a thermocompression roller **20** that includes a heating unit disposed therein and has a temperature control unit for controlling the temperature of the surface of the

thermocompression roller **20** to reach a predetermined heating temperature is positioned over the wafer **10**, as illustrated in FIG. **4**A. According to the present embodiment, since a polyethylene sheet is used as the first thermocompression sheet S**1**, the temperature of the surface of the thermocompression roller **20** is controlled to reach a heating temperature in the range of 120° C. to 140° C. close to the melting temperature of the polyethylene sheet. The surface of the thermocompression roller **20** is coated with a layer of fluororesin to prevent the first thermocompression sheet S**1** from sticking to the surface of the thermocompression roller **20** even when the first thermocompression sheet S**1** produces adhesive power. At the same time at which the temperature of the surface of the thermocompression roller **20** reaches the heating temperature, the thermocompression roller **20** is rotated about its central axis in the direction indicated by an arrow R**1** and is moved in the direction indicated by an arrow R**2**, pressure-bonding the first thermocompression sheet S**1** to the entire reverse side **10***b* of the wafer **10**. The first thermocompression sheet S**1** and the wafer **10** are thereby integrally combined with each other, making up an integral assembly (workpiece supporting step). FIG. **4**B illustrates in perspective the manner in which the first thermocompression sheet S**1** combined with the wafer **10** is turned upside down and placed on an unillustrated table after the workpiece supporting step has been carried out. When the first thermocompression sheet S**1** is placed on the table, the wafer **10** combined with the first thermocompression sheet S**1** has the face side **10***a* exposed upwardly. However, the present invention is not limited to such a wafer orientation. Instead, as illustrated in FIG. **3**B, the face side **10***a* of the wafer **10** may be directed toward the face side S**1***a* of the first thermocompression sheet S**1**, and the face side Sla of the first thermocompression sheet S**1** may be pressure-bonded to and integrally combined with the face side **10***a* of the wafer **10**.

(25) After the workpiece supporting step has been carried out, the temperature of the first thermocompression sheet S**1** drops, causing the first thermocompression sheet S**1** to harden. The wafer **10** is now supported on only the first thermocompression sheet S**1** thus hardened. The integral assembly, formed in the workpiece supporting step, of the first thermocompression sheet S**1** and the wafer **10** supported on only the first thermocompression sheet S**1** has a predetermined degree of rigidity. The predetermined degree of rigidity of the integral assembly is such that the first thermocompression sheet S**1** will be kept flat when the first thermocompression sheet S**1** is supported at two diametrically opposite points on its outer circumferential edge portion.

(26) A plurality of wafers **10** supported on respective first thermocompression sheets S**1** in the workpiece supporting step described above are stored in the cassette **3** illustrated in FIG. **1**, and introduced into the cutting apparatus **1**.

(27) For carrying out the above cutting step as a processing step according to the present invention, one of the wafers **10** introduced into the cutting apparatus **1** is taken out of the cassette **3** by the loading/unloading mechanism **4** and temporarily placed on the temporary rest table **5**. Then, the wafer **10** is delivered by the delivery mechanism **6** to the suction chuck **7***a* of the chuck table **7** positioned in the loading/unloading area illustrated in FIG. **1**, and held under suction on the suction chuck **7***a*. The clamps **7***b* grip and secure the outer circumferential edge portion of the first thermocompression sheet S**1**. The wafer **10** held on the chuck table **7** is moved by the X-axis moving mechanism from the loading/unloading area to the alignment area directly below the alignment unit **8**. The alignment unit **8** detects one of the projected dicing lines **14** as the region to be cut, and aligns the detected projected dicing line **14** with the X-axis direction and also with the cutting blade **9***a*. Then, as illustrated in FIG. **5**A, the wafer **10** is moved in the X-axis direction by the X-axis moving mechanism to the processing area where the wafer **10** is positioned directly below the cutting unit **9** by the X-axis moving mechanism.

(28) As illustrated in FIG. **5**A, the cutting unit **9** includes a rotational shaft, or a spindle, **9***b* that extends in the Y-axis direction and that is rotatably supported for rotation about its central axis parallel to the Y-axis direction and an annular cutting blade **9***a* mounted on a distal end of the rotational shaft **9***b*. The cutting blade **9***a* is movable by the Y-axis moving mechanism so as to be

indexing-fed in the Y-axis direction, as described above. The rotational shaft **9***b* is rotatable about its central axis by a spindle motor, not illustrated.

(29) After the wafer **10** has been positioned directly below the cutting unit **9**, the cutting blade **9***a* that is being rotated at a high speed in the direction indicated by an arrow R**3** is positioned on the projected dicing line **14** aligned with the X-axis direction. The cutting blade **9***a* is then lowered or incising-fed by the Z-axis moving mechanism to cut into the wafer **10** from the face side **10***a* thereof while the chuck table **7** is being processing-fed in the X-axis direction, thereby forming a cut groove **100** as illustrated in FIG. **5**A. The cutting step is repeated until cut grooves **100** are formed in the wafer **10** along all the projected dicing lines **14** established on the wafer **10**, as illustrated in FIG. **5**B. The cutting step is carried out as described above to divide the wafer **10** along the projected dicing lines **14** into individual device chips **12**′. The division of the wafer **10** is now completed.

(30) Even after the wafer **10** has been divided into the individual device chips **12**′ in the cutting step, the device chips **12**′ are still kept together in a wafer configuration similar in shape to the wafer **10** as a whole because the device chips **12**′ are supported on the first thermocompression sheet S**1**.

(31) After the cutting step has been carried out as described above, an expanding step and a pick-up step are carried out to pick up the device chips **12**′ from the first thermocompression sheet S**1** as described below. The expanding step and the pick-up step are carried out using a pick-up apparatus **40** illustrated in FIGS. **6**A and **6**B. The pick-up apparatus **40** includes an expanding mechanism **42** for carrying out the expanding step of expanding the first thermocompression sheet S**1** in its plane to expand the distances between adjacent ones of the device chips **12**′.

(32) As illustrated in FIGS. **6**A and **6**B, the expanding mechanism **42** includes a hollow cylindrical expansion drum **42***a*, a plurality of upwardly extending air cylinders **42***b* disposed adjacent to and around the expansion drum **42***a* and angularly spaced circumferentially around the expansion drum **42***a*, an annular holder **42***c* joined to each of upper ends of piston rods of the air cylinders **42***b*, and a plurality of clamps **42***d* mounted on an outer circumferential surface of the holder **42***c* and angularly spaced circumferentially around the holder **42***c*. In FIGS. **6**A and **6**B, some components are illustrated in cross section for illustrative purposes. According to the present embodiment, the expansion drum **42***a* has an inside diameter equal to or larger than the diameter of the wafer **10**, and has an outside diameter smaller than the diameter of the first thermocompression sheet S**1**. The holder **42***c* has an outside diameter commensurate with the diameter of the first thermocompression sheet S**1**, so that the first thermocompression sheet S**1** is placed on the holder **42***c*, and the first thermocompression sheet S**1** has an outer circumferential edge portion placed on a flat upper surface of the holder **42***c*.

(33) As illustrated in FIGS. **6**A and **6**B, the air cylinders **42***b* lift and lower the holder **42***c* between a reference position where the upper surface of the holder **42***c* lies substantially at the same height as the upper end of the expansion drum **42***a* indicated by the solid lines and an expanding position where the upper surface of the holder **42***c* is lower than the upper end of the expansion drum **42***a* indicated by the two-dot-and-dash lines. In FIGS. **6**A and **6**B, the expansion drum **42***a* is illustrated as being lifted and lowered with respect to the holder **42***c* for illustrative purposes. In practice, however, the holder **42***c* is lifted and lowered with respect to the expansion drum **42***a*.

(34) As illustrated in FIG. **6**B, the pick-up apparatus **40** further includes a pick-up unit **44** in addition to the expanding mechanism **42**. The pick-up unit **44** includes a pick-up collet **44***a* for sucking one device chip **12**′ at a time and a pusher mechanism **44***b* that is disposed in the expansion drum **42***a* and that pushes a device chip **12**′ upwardly. The pusher mechanism **44***b* is movable horizontally in the directions indicated by an arrow R**6**, and includes a push rod **44***c* that can be protruded and retracted in the vertical directions indicated by an arrow R**7**.

(35) As illustrated in FIG. **6**B, the pick-up collet **44***a* is movable horizontally and vertically. The pick-up collet **44***a* is fluidly connected to a suction source, not illustrated, that draws air in the

direction indicated by an arrow R**9**, thereby creating a negative pressure in a suction nose **44***d* mounted on a distal end of the pick-up collet **44***a* to attract a device chip **12**′ under suction on a lower end surface of the suction nose **44***d*.

(36) In the expanding step, as illustrated in FIG. **6**A, the first thermocompression sheet S**1** with the wafer **10** as divided into the individual device chips **12**′ facing upwardly is placed on the upper surface of the holder **42***c* that is disposed in the reference position. Then, the clamps **42***d* are actuated to secure the outer circumferential edge portion of the first thermocompression sheet S**1** to the upper surface of the holder **42***c*. Then, the holder **42***c* is lowered in the direction indicated by an arrow R**4** toward the expanding position, exerting tensile forces on the wafer **10** supported centrally on the first compression thermocompression sheet S**1**, in radially outward directions indicated by an arrow R**5**. At this time, the heating unit, not illustrated, is energized to heat the first thermocompression sheet S**1** to a temperature close to the melting point of the material thereof, thereby softening the first thermocompression sheet S**1**. As indicated by the two-dot-and-dash lines in FIG. **6**A, an area, of the first thermocompression sheet S**1**, that supports the wafer **10** thereon is expanded in its plane, widening the distances between adjacent ones of the device chips **12**′. In a case where the cut grooves **100** formed in the wafer **10** along the projected dicing lines **14** in the cutting step are wide enough, the expanding step may be omitted.

(37) After the expanding step has been carried out as described above, as illustrated in FIG. **6**B, the suction nose **44***d* of the pick-up collet **44***a* is positioned above one of the device chips **12**′ that is to be picked up, and the pusher mechanism **44***b* is moved horizontally in a direction indicated by the arrow R**6**, to a position below the device chip **12**′ to be picked up. Then, the push rod **44***c* of the pusher mechanism **44***b* is extended in an upward direction indicated by the arrow R**7**, pushing up the device chip **12**′ from below. Concurrently, the pick-up collet **44***a* is lowered in a direction indicated by an arrow R**8**, and attracts the device chip **12**′ under suction on the lower end surface thereof. Then, the pick-up collet **44***a* is lifted to peel the device chip **12**′ off from the first thermocompression sheet S**1**, thereby picking up the device chip **12**′. Then, the device chip **12**′ that has been picked up is delivered to a container, not illustrated, such as a tray, or to a predetermined position for a next step. The above pick-up process is carried out successively on all the device chips **12**′ on the first thermocompression sheet S**1** (pick-up step).

(38) After the pick-up step has been carried out as described above, the first thermocompression sheet S**1** is discarded into a dustbin and disposed of (discarding step). The first thermocompression sheet S**1** is much less costly than the frame F (see FIG. **7**) that has heretofore been used, only the first thermocompression sheet S**1** is required, and the first thermocompression sheet S**1** is rigid enough to hold the wafer **10** thereon. Therefore, the frame F is not required, and no tedious and time-consuming work has to be performed for maintenance to make the frame F reusable, so that the method of processing a plate-shaped workpiece is of increased productivity.

(39) The present invention is not limited to the embodiment described above. According to the above embodiment, the processing step of processing the wafer **10** to divide the wafer **10** into a plurality of device chips **12**′ is the cutting step of positioning the cutting blade **9***a* in alignment with the projected dicing lines **14** on the wafer **10** and cutting the wafer **10** with the cutting blade **9***a* along the projected dicing lines **14** to form the cut grooves **100** in the wafer **10** along the projected dicing lines **14**. However, the processing step may instead be a laser ablation step of applying a laser beam having a wavelength absorbable by the wafer **10** to a region to be divided of the wafer **10** along the projected dicing lines **14** to form grooves in the wafer **10** along the projected dicing lines **14** by way of laser ablation. Alternatively, the cutting step described above may be replaced with a modified layer forming step of applying a laser beam having a wavelength transmittable through the wafer **10**, to a region to be divided of the wafer **10** while positioning a focused spot of the laser beam within the wafer **10** to form modified layers in the wafer **10** along the projected dicing lines **14**. In a case where the grooves are formed in the wafer **10** along the projected dicing lines **14** in the laser ablation step or the modified layers are formed in the wafer **10** along the

projected dicing lines **14** in the modified layer forming step, the wafer **10** can more reliably be divided into individual device chips **12**′ by external forces imposed thereon in the expanding step.
(40) According to the embodiment described above, a polyethylene sheet is illustrated as the thermocompression sheet S**1**. However, the thermocompression sheet S**1** may be a polyolefin-based sheet other than a polyethylene sheet or a polyester-based sheet. A polyolefin-based sheet other than a polyethylene sheet may be either a polypropylene sheet or a polystyrene sheet, and a polyester-based sheet may be either a polyethylene terephthalate sheet or a polyethylene naphthalate sheet.
(41) If a polypropylene sheet is selected as the thermocompression sheet S, then the heating temperature in the workpiece supporting step should preferably be in the range of 160° C. to 180° C. If a polystyrene sheet is selected as the thermocompression sheet S, then the heating temperature in the workpiece supporting step should preferably be in the range of 220° C. to 240° C. Further, if a polyethylene terephthalate sheet is selected as the thermocompression sheet S, then the heating temperature in the workpiece supporting step should preferably be in the range of 250° C. to 270° C. If a polyethylene naphthalate sheet is selected as the thermocompression sheet S, then the heating temperature in the workpiece supporting step should preferably be in the range of 160° C. to 180° C. At any rate, the above temperature ranges are close to the melting temperatures of the respective materials of the thermocompression sheet S. When heated as described above, the thermocompression sheet S softens to produce adhesive power and is pressure-bonded to the wafer **10**. Since the thermocompression sheet S is used to support the wafer **10** thereon, when the device chips **12**′ are picked up from the thermocompression sheet S in the pick-up step, no adhesive sticks to and remains on the device chips **12**′.
(42) 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 claim and all changes and modifications as fall within the equivalence of the scope of the claim are therefore to be embraced by the invention.

## Claims

1. A method of processing a plate-shaped workpiece, comprising: a workpiece supporting step of placing the plate-shaped workpiece on a thermocompression sheet whose area is larger than that of the plate-shaped workpiece, heating the thermocompression sheet to pressure-bond the thermocompression sheet to the plate-shaped workpiece, and supporting the plate-shaped workpiece on the thermocompression sheet without using an annular frame; a step of gripping and securing an outer circumferential edge portion of the thermocompression sheet by means of a plurality of clamps which directly contact the outer circumferential edge portion; a processing step of processing the plate-shaped workpiece to divide the plate-shaped workpiece into a plurality of chips; and a pick-up step of picking up the chips from the thermocompression sheet.
2. The method of processing a plate-shaped workpiece according to claim 1, further comprising: an expanding step of expanding the thermocompression sheet to widen distances between the chips including heating the thermocompression sheet.
3. The method of processing a plate-shaped workpiece according to claim 1, further comprising: after the pick-up step, a discarding step of discarding the thermocompression sheet.
4. The method of processing a plate-shaped workpiece according to claim 1, wherein the processing step includes a cutting step of positioning a cutting blade on a region to be divided of the plate-shaped workpiece and cutting the plate-shaped workpiece with the cutting blade.
5. The method of processing a plate-shaped workpiece according to claim 1, wherein the processing step includes a laser ablation step of applying a laser beam having a wavelength absorbable by the plate-shaped workpiece to a region to be divided of the plate-shaped workpiece to form grooves in the plate-shaped workpiece by way of laser ablation.

6. The method of processing a plate-shaped workpiece according to claim 1, wherein the processing step includes a modified layer forming step of applying a laser beam having a wavelength transmittable through the plate-shaped workpiece to a region to be divided of the plate-shaped workpiece while positioning a focused spot of the laser beam within the plate-shaped workpiece, to form modified layers in the plate-shaped workpiece.
7. The method of processing a plate-shaped workpiece according to claim 1, wherein the plate-shaped workpiece is a wafer including a face side having a plurality of devices formed in respective areas demarcated thereon by a plurality of projected dicing lines, the face side of the wafer or a reverse side thereof being placed on the thermocompression sheet.
8. The method of processing a plate-shaped workpiece according to claim 1, wherein the thermocompression sheet is either one of a polyolefin-based sheet and a polyester-based material.
9. The method of processing a plate-shaped workpiece according to claim 8, wherein the polyolefin-based sheet is selected and is either one of a polyethylene sheet, a polypropylene sheet, and a polystyrene sheet.
10. The method of processing a plate-shaped workpiece according to claim 9, wherein, if the polyethylene sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 120° C. to 140° C., if the polypropylene sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 160° C. to 180° C., and if the polystyrene sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 220° C. to 240° C.
11. The method of processing a plate-shaped workpiece according to claim 8, wherein the polyester-based sheet is selected and is either one of a polyethylene terephthalate sheet and a polyethylene naphthalate sheet.
12. The method of processing a plate-shaped workpiece according to claim 11, wherein, if the polyethylene terephthalate sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 250° C. to 270° C., and if the polyethylene naphthalate sheet is selected as the thermocompression sheet, a heating temperature to which the thermocompression sheet is heated in the workpiece supporting step ranges from 160° C. to 180° C.