

WAFER PROCESSING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a wafer processing method for dividing a wafer into individual device chips, the wafer having on a front surface thereof a device area formed with a plurality of devices partitioned by a plurality of intersecting streets and a peripheral marginal area surrounding the device area.

Description of the Related Art

A wafer having on a front surface thereof a device area formed with a plurality of devices such as integrated circuits (ICs) and large scale integrations (LSIs) partitioned by a plurality of intersecting streets and a peripheral marginal area surrounding the device is divided into individual device chips, and the divided device chips are used for electric apparatuses such as mobile phones and personal computers.

As a method for dividing the wafer into the individual device chips, a technology has been proposed in which a laser beam of such a wavelength as to be transmitted through the wafer is applied to the wafer, with a focal point of the laser beam positioned to an

inside of the wafer corresponding to the streets, to form modified layers along the streets, and thereafter an external force is applied to the wafer to divide the wafer into individual device chips (see, for example, Japanese Patent No. 3408805).

As a method for applying an external force to the wafer, a technique has been proposed in which a protective member is disposed on a front surface of the wafer, and a back surface of the wafer is ground to thin the wafer to a desired thickness, and to cause cracks to reach to the front surface, thereby dividing the wafer into the individual device chips (see, for example, Japanese Patent No. 4358762).

SUMMARY OF THE INVENTION

However, a peripheral surface of the peripheral marginal area of the wafer is chamfered, and it is difficult to form the modified layers in the chamfered area on extension lines of the streets. Therefore, when an external force is applied to the wafer after the modified layers are formed in the inside of the wafer along the streets, cracks may be generated at random in the chamfered area of the peripheral marginal area due to the absence of the modified layer formed in the chamfered

area, and, therefore, there is a problem that the devices adjacent to the peripheral marginal area may be damaged.

Accordingly, it is an object of the present invention to provide a wafer processing method capable of preventing devices adjacent to a peripheral marginal area of a wafer from being damaged.

In accordance with an aspect of the present invention, there is provided a wafer processing method for dividing a wafer into individual device chips, the wafer having on a front surface thereof a device area formed with a plurality of devices partitioned by a plurality of streets and a peripheral marginal area surrounding the device area, the wafer processing method including a protective member disposing step of disposing a protective member on the front surface of the wafer, a ring-shaped modified layer forming step of applying a laser beam of such a wavelength as to be transmitted through the wafer, with a focal point of the laser beam positioned from a back surface of the wafer to an inside of the wafer corresponding to the peripheral marginal area, to form a first ring-shaped modified layer and a second ring-shaped modified layer surrounding the first ring-shaped modified layer along the peripheral marginal area, a street modified layer forming step of applying a

laser beam of such a wavelength as to be transmitted through the wafer, with a focal point of the laser beam positioned from the back surface of the wafer to the inside of the wafer corresponding to the streets, to form street modified layers along the streets, and a dividing step of grinding the back surface of the wafer to form the wafer to a predetermined thickness and dividing the wafer into individual device chips by cracks extending from the street modified layers to the streets. In the street modified layer forming step, the focal point of the laser beam is positioned in such a manner that a start point and an end point of the street modified layer are positioned between the first ring-shaped modified layer and the second ring-shaped modified layer.

Preferably, spacing between the first ring-shaped modified layer and the second ring-shaped modified layer formed in the ring-shaped modified layer forming step is set to 300 to 1,000 μm .

According to the present invention, even if cracks extend at random from start points or end points of the street modified layers, the cracks are shielded by the first ring-shaped modified layer and the second ring-shaped modified layer, and, therefore, the cracks do not reach the devices. Therefore, according to the wafer

processing method of the present invention, the devices adjacent to the peripheral marginal area of the wafer can be prevented from being damaged.

The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view depicting a state in which a protective member disposing step is being carried out;

FIG. 2A is a perspective view depicting a state in which a wafer is held by a chuck table;

FIG. 2B is a perspective view depicting a state in which the wafer is held on the chuck table;

FIG. 3 is a perspective view depicting a state in which a ring-shaped modified layer forming step is being carried out;

FIG. 4A is a perspective view of a wafer formed with first and second ring-shaped modified layers;

FIG. 4B is a sectional view of the wafer depicted in FIG. 4A;

FIG. 5A is a perspective view depicting a state in which a street modified layer forming step is being carried out;

FIG. 5B is a plan view of the wafer depicted in FIG. 5A;

FIG. 5C is an enlarged view of part A of FIG. 5B;

FIG. 5D is an enlarged view of part B of FIG. 5B;

FIG. 6A is a perspective view depicting a state in which a dividing step is being carried out;

FIG. 6B is a perspective view of the divided wafer; and

FIG. 6C is a plan view of the wafer depicted in FIG. 6B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of a wafer processing method according to the present invention will be described below referring to the drawings. FIG. 1 depicts a wafer 2 to be processed by the wafer processing method of the present invention. The wafer 2 may be formed, for example, from silicon or the like. On a front surface 2a of the wafer 2 which is disk-like in shape, a device area

8 formed with a plurality of devices 4 such as ICs and LSIs partitioned by a plurality of streets 6 formed in a grid pattern and a peripheral marginal area 10 surrounding the device area 8 are formed. In FIG. 1, a boundary 12 between the device area 8 and the peripheral marginal area 10 is indicated by alternate long and two short dashes line for convenience, a line indicating the boundary 12 is not present in practice.

In the wafer processing method of the present invention, first, a protective member disposing step of disposing a protective member 14 on the front surface 2a of the wafer 2 is conducted, as depicted in FIG. 1. As the protective member 14, for example, a circular adhesive tape having the same diameter as the diameter of the wafer 2 may be used.

After the protective member disposing step is performed, a ring-shaped modified layer forming step is carried out in which a laser beam of such a wavelength as to be transmitted through the wafer 2 is applied to the wafer 2 with a focal point of the laser beam positioned from a back surface 2b of the wafer 2 to the inside of the wafer 2 corresponding to the peripheral marginal area 10, to form a first ring-shaped modified layer and a second ring-shaped modified layer surrounding the first

ring-shaped modified layer along the peripheral marginal area 10.

The ring-shaped modified layer forming step can be performed, for example, by use of a laser processing apparatus 16 a part of which is depicted in FIG. 3. The laser processing apparatus 16 includes a chuck table 18 which holds under suction the wafer 2, a beam condenser that applies a pulsed laser beam LB to the wafer 2 held under suction on the chuck table 18, and an imaging unit (not illustrated) that images the wafer 2 held under suction on the chuck table 18.

As illustrated in FIG. 2A, a porous circular suction chuck 22 connected to suction means (not illustrated) is disposed at an upper end of the chuck table 18. The chuck table 18 generates a suction force on an upper surface of the suction chuck 22 by the suction means and holds under suction the wafer 2 placed on the upper surface of the suction chuck 22.

The chuck table 18 is configured to be rotatable with an axis extending vertically while passing through the radial-directional center of the suction chuck 22 as a rotational center and is configured to be advanceable and retractable in an X-axis direction indicated by an arrow X in FIGS. 2A and 2B and a Y-axis direction (the

direction indicated by an arrow Y in FIGS. 2A and 2B) orthogonal to the X-axis direction. Note that an XY plane defined by the X-axis direction and the Y-axis direction is substantially horizontal.

The beam condenser 20 has a condenser lens (not illustrated) which condenses the pulsed laser beam LB emitted from a laser oscillator (not illustrated) of the laser processing apparatus 16. The imaging unit of the laser processing apparatus 16 includes an ordinary imaging element (charge-coupled device (CCD)) that images a workpiece by a visible beam, infrared ray applying means that applies infrared rays to the workpiece, an optical system that captures the infrared rays applied by the infrared ray applying means, and an imaging element (for example, infrared CCD) that outputs an electrical signal corresponding to the infrared rays captured by the optical system (none of these is illustrated).

In the ring-shaped modified layer forming step, as depicted in FIG. 2B, first, the wafer 2 is held under suction on the upper surface of the chuck table 18, with the back surface 2b of the wafer 2 directed upward. In this instance, the radial-directional center of the wafer 2 and the radial-directional center of the suction chuck 22 (the rotational center of the chuck table 18) are put

in register.

Next, the wafer 2 is imaged from above by the imaging unit (not illustrated) of the laser processing apparatus 16, and, based on an image of the wafer 2 imaged by the imaging unit, the focal point of the pulsed laser beam LB of such a wavelength as to be transmitted through the wafer 2 is positioned from the back surface 2b of the wafer 2 to the inside of the wafer 2 corresponding to the peripheral marginal area 10.

Note that, in the case where the wafer 2 is imaged by the imaging unit, the back surface 2b of the wafer 2 is directed upward, while the front surface 2a formed with the devices 4 and the streets 6 is directed downward; however, since the imaging unit includes the infrared ray applying means, the optical system that captures the infrared rays, and the imaging element (for example, infrared CCD) that outputs an electrical signal corresponding to the infrared rays, as described above, the devices 4 and the streets 6 on the front surface 2a can be imaged on a see-through basis from the back surface 2b of the wafer 2. As a result, the focal point of the pulsed laser beam LB can be positioned from the back surface 2b of the wafer 2 to the inside of the wafer 2 corresponding to the peripheral marginal area 10.

Subsequently, as depicted in FIG. 3, while moving the focal point of the pulsed laser beam LB relative to the wafer 2 along the peripheral marginal area 10 by rotating the chuck table 18 at a predetermined rotational speed, the pulsed laser beam LB is applied to the wafer 2 from the beam condenser 20. As a result, a first ring-shaped modified layer 24 weak in strength can be formed in the inside of the wafer 2 corresponding to the peripheral marginal area 10 along the peripheral marginal area 10.

Next, the chuck table 18 is moved, to position the focal point of the pulsed laser beam LB on the radially directionally outer side relative to the first ring-shaped modified layer 24. Subsequently, while moving the focal point of the pulsed laser beam LB along the peripheral marginal area 10 by rotating the chuck table 18 at a predetermined rotational speed, the pulsed laser beam LB is applied to the wafer 2 from the beam condenser 20. By this, a second ring-shaped modified layer 26 weak in strength can be formed in the inside of the wafer 2 corresponding to the peripheral marginal area 10 along the peripheral marginal area 10.

As is understood by referring to FIGS. 4A and 4B, the diameter of the second ring-shaped modified layer 26

is greater than the diameter of the first ring-shaped modified layer 24, and the second ring-shaped modified layer 26 surrounds the first ring-shaped modified layer 24. The spacing between the first ring-shaped modified layer 24 and the second ring-shaped modified layer 26 (the spacing in the radial direction of the wafer 2) may be set, for example, to 300 to 1,000 μm .

Such a ring-shaped modified layer forming step can be performed, for example, under the following conditions.

Diameter of wafer	: 200 mm
Diameter of device area	: 190 mm
Range of peripheral marginal area	: 190 to 200 mm
Diameter of first ring-shaped modified layer	: 193 mm
Diameter of second ring-shaped modified layer	: 194 mm
Wavelength of pulsed laser beam	: 1,342 nm
Repetition frequency	: 90 kHz
Average output	: 0.6 W
Rotational speed of chuck table	: 0.5 revolution/second

After the ring-shaped modified layer forming step is performed, a street modified layer forming step is

conducted in which the laser beam of such a wavelength as to be transmitted through the wafer 2 is applied to the wafer 2 with the focal point of the laser beam positioned from the back surface 2b of the wafer 2 to the inside of the wafer 2 corresponding to the streets 6, to form a street modified layers along the streets 6. The street modified layer forming step can also be conducted by use of the laser processing apparatus 16.

In the street modified layer forming step, first, in a state in which the wafer 2 is held under suction on the upper surface of the chuck table 18, based on the image of the wafer 2 imaged by the imaging unit of the laser processing apparatus 16, the street 6 is put in register with the X-axis direction, and the beam condenser 20 is positioned on the street 6 put in register with the X-axis direction. Next, the focal point of the pulsed laser beam LB of such a wavelength as to be transmitted through the wafer 2 is positioned from the back surface 2b of the wafer 2 to the inside of the wafer 2 corresponding to the street 6 between the first ring-shaped modified layer 24 and the second ring-shaped modified layer 26.

Subsequently, as depicted in FIG. 5A, while moving the focal point of the pulsed laser beam LB along the

street 6 relative to the wafer 2 by moving the chuck table 18 in the X-axis direction at a predetermined feeding speed, the pulsed laser beam LB is applied to the wafer 2 from the beam condenser 20. As a result, a street modified layer 28 weak in strength can be formed in the inside of the wafer 2 along the street 6. In the case of forming the street modified layer 28, the application of the pulsed laser beam LB is stopped when the focal point of the pulsed laser beam LB reaches a position between the first ring-shaped modified layer 24 and the second ring-shaped modified layer 26.

In the street modified layer forming step, as depicted in FIGS. 5B to 5D, it is important to position the focal point of the laser beam LB in such a manner that a start point 28a and an end point 28b of the street modified layer 28 are positioned between the first ring-shaped modified layer 24 and the second ring-shaped modified layer 26.

Next, the chuck table 18 is put into indexing feeding in the Y-axis direction relative to the beam condenser 20 by the interval in the Y-axis direction of the streets 6. Then, application of the laser beam LB and indexing feeding are alternately repeated, whereby the street modified layers 28 are formed along all the

streets 6 put in register with the X-axis direction. Subsequently, the chuck table 18 is rotated by 90 degrees, and the application of the laser beam LB and the indexing feeding are alternately repeated, whereby the street modified layers 28 are formed along all the streets 6 orthogonal to the streets 6 along which the street modified layers 28 have been formed previously.

Such a street modified layer forming step may be conducted, for example, under the following conditions.

Wavelength of pulsed laser beam	: 1,342 nm
Repetition frequency	: 90 kHz
Average output	: 0.6 W
Feeding speed of chuck table	: 500 mm/s

After the street modified layer forming step is performed, a dividing step is conducted in which the back surface 2b of the wafer 2 is ground to form the wafer 2 to a predetermined thickness and dividing the wafer 2 into individual device chips by cracks extending from the street modified layers 28 to the streets 6.

The dividing step can be conducted, for example, by use of a grinding apparatus 30 a part of which is depicted in FIG. 6. The grinding apparatus 30 includes a chuck table 32 that holds under suction the wafer 2, and a grinding unit 34 that grinds the wafer 2 held under

suction on the chuck table 32. The chuck table 32 that holds under suction the wafer 2 on an upper surface thereof is configured to be rotatable with an axis extending in the vertical direction as a center.

The grinding unit 34 includes a spindle 36 extending in the vertical direction, and a disk-shaped wheel mount 38 fixed to a lower end of the spindle 36. An annular grinding wheel 42 is fixed to a lower surface of the wheel mount 38 by bolts 40. To a peripheral edge part of the lower surface of the grinding wheel 42, a plurality of grindstones 44 arranged in an annular pattern at intervals in the circumferential direction are fixed.

Referring further to FIGS. 6A to 6C, in the dividing step, first, the wafer 2 is held under suction by the upper surface of the chuck table 32, with the back surface 2b of the wafer 2 directed upward. Next, the chuck table 32 is rotated counterclockwise as viewed from above at a predetermined rotational speed (for example, 300 rpm). In addition, the spindle 36 is rotated counterclockwise as viewed from above at a predetermined rotational speed (for example, 6,000 rpm). Next, the spindle 36 is lowered to bring the grindstones 44 into contact with the back surface 2b of the wafer 2, and the

spindle 36 is lowered at a predetermined grinding feeding speed (for example, $1.0 \mu\text{m/s}$). As a result, the back surface 2b of the wafer 2 can be ground to form the wafer 2 to a predetermined thickness.

At the time of grinding the wafer 2, a pressing force by the grinding feeding acts on the wafer 2, and, therefore, street cracks 28' extend in the thickness direction of the wafer 2 from the street modified layers 28 toward the streets 6. Accordingly, as depicted in FIGS. 6B and 6C, the wafer 2 is divided into individual device chips 46 by the street cracks 28'. Note that for enhancing die strength, it is preferable to remove the street modified layers 28 by grinding, leaving only the street cracks 28'.

In addition, at the time of grinding the wafer 2, it is possible that cracks extend at random from start points 28a or end points 28b of the street modified layers 28. In the present embodiment, however, the start points 28a and the end points 28b of the street modified layers 28 are located between the first ring-shaped modified layer 24 and the second ring-shaped modified layer 26, so that at the time of grinding the wafer 2, first and second ring-shaped cracks 24' and 26' extend in the thickness direction from the first and second ring-

shaped modified layers 24 and 26, so that the random cracks extending from the start points 28a and the end points 28b of the street modified layers 28 are shielded by the first and second ring-shaped modified layers 24 and 26 and the first and second ring-shaped cracks 24' and 26', and cannot reach the devices 4. Therefore, according to the present embodiment, the devices 4 adjacent to the peripheral marginal area 10 of the wafer 2 can be prevented from being damaged.

After the wafer 2 is divided into the individual device chips 46, the rectangular device chips 46 with peripheries thereof defined only by the street cracks 28' are conveyed to the next step, the part depicted in grey in FIG. 6C (the chips including the first ring-shaped crack 24' (arcuate part) in their peripheries and the part on the outer side relative to the first ring-shaped crack 24') is discarded.

In the wafer processing method of the present embodiment, the random cracks extending from the start points 28a and the end point 28b are shielded by the first and second ring-shaped modified layers 24 and 26 and the first and second ring-shaped cracks 24' and 26', and do not reach the devices 4, so that the devices 4 adjacent to the peripheral marginal area 10 of the wafer

2 can be prevented from being damaged.

Note that, in the case where only one ring-shaped modified layer is present, it is necessary, for preventing the devices 4 from being damaged by the random cracks extending from the start points 28a and the end points 28b, to position the start points 28a and the end points 28b precisely on the circumference of the ring-shaped modified layer. However, it is difficult to position the start points 28a and the end points 28b precisely on the circumference of the ring-shaped modified layer, and, therefore, where only one ring-shaped modified layer is present, it is possible that the devices 4 may be damaged by the random cracks. In this point, in the wafer processing method of the present embodiment, the first and second ring-shaped modified layers 24 and 26 are formed at an interval in the radial direction of the wafer 2, and, therefore, the start points 28a and the end points 28b can easily be positioned between the first ring-shaped modified layer 24 and the second ring-shaped modified layer 26, so that the random cracks can be shielded by the first and second ring-shaped modified layers 24 and 26 and the first and second ring-shaped cracks 24' and 26'; accordingly, the devices 4 can securely be prevented from being damaged.

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 into individual device chips, the wafer having on a front surface thereof a device area formed with a plurality of devices partitioned by a plurality of crossing streets and a peripheral marginal area surrounding the device area, the wafer processing method comprising:

a protective member disposing step of disposing a protective member on the front surface of the wafer;

a ring-shaped modified layer forming step of applying a laser beam of such a wavelength as to be transmitted through the wafer, with a focal point of the laser beam positioned from a back surface of the wafer to an inside of the wafer corresponding to the peripheral marginal area, to form a first ring-shaped modified layer and a second ring-shaped modified layer surrounding the first ring-shaped modified layer along the peripheral marginal area;

a street modified layer forming step of applying a laser beam of such a wavelength as to be transmitted through the wafer, with a focal point of the laser beam positioned from the back surface of the wafer to the inside of the wafer corresponding to the streets, to form street modified layers along the streets; and

a dividing step of grinding the back surface of the wafer to form the wafer to a predetermined thickness and dividing the wafer into individual device chips by cracks extending from the street modified layers to the streets,

wherein, in the street modified layer forming step, the focal point of the laser beam is positioned in such a manner that a start point and an end point of the street modified layer are positioned between the first ring-shaped modified layer and the second ring-shaped modified layer.

2. The wafer processing method according to claim 1,

wherein spacing between the first ring-shaped modified layer and the second ring-shaped modified layer formed in the ring-shaped modified layer forming step is set to 300 to 1,000 μm .