

PROCESSING METHOD FOR WAFER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a processing method for a wafer.

Description of the Related Art

As methods for manufacturing semiconductor device chips, various methods are known in which a wafer with a function layer forming devices and stacked on a front surface of a substrate is divided by a cutting blade or a laser beam. A method that divides a wafer through formation of modified layers as fracture starting points inside a substrate by a laser beam has an advantageous effect in that compared with its division by a cutting blade, scribe lines (hereinafter called "streets") can be made narrower and the formation of cutting debris can be suppressed as much as possible (see, for example, JP 2013-008831A).

In a method that divides a wafer by a laser beam, there is a need to allow the laser beam to transmit into a substrate. The laser beam is therefore irradiated from a back surface of the wafer, where there is not any function layer which interferes the transmission of the

laser beam. If a nitride film or oxide film having a predetermined reflectance or higher is formed on the back surface of the wafer, however, the film on the back surface needs to be removed beforehand by grinding it away.

SUMMARY OF THE INVENTION

In the grinding of the film on the back surface, however, the stock removal is reduced to leave at least a certain thickness such that the wafer is prevented from cracking or breaking during its transfer to a laser processing step as a next step. As a consequence, the film accounts for a large proportion of the ground debris volume, and grinding stones hence become more prone to clogging. Accordingly, the grinding stones require periodical dressing, thereby causing problems, that is, the occurrence of an increase in dressing man-hour and an increase in the wear amount of the grinding stones.

An object of the present invention is to provide a processing method for a wafer, which can suppress clogging of grinding stones when a film on a back surface of the wafer is ground away before laser processing.

In accordance with an aspect of the present invention, there is provided a processing method for a

wafer having a substrate, a plurality of devices formed by a function layer stacked on a front surface of the substrate, and a film formed on a back surface of the substrate, including dividing the wafer along a plurality of intersecting streets sectioning the devices. The processing method includes a protective member arrangement step of arranging a protective member on a front surface of the wafer; a laser processed groove forming step of, after the protective member arrangement step, irradiating a laser beam of a wavelength, which has absorption in the film or the substrate, to a back surface of the wafer, so that laser processed grooves are formed in the back surface of the wafer to remove the film in parts; a provisional grinding step of grinding the back surface of the wafer, in which the laser processed grooves have been formed, by grinding stones to remove remaining parts of the film and the laser processed grooves, so that the wafer is formed to a predetermined thickness greater than a finish thickness; a modified layer forming step of, after the provisional grinding step, irradiating a laser beam of a wavelength, which has transmissivity through the substrate, from a side of the back surface of the wafer, from which the film has been removed, with a condensing point of the

laser beam positioned inside the substrate, so that modified layers are formed along the streets inside the substrate; and a grinding step of grinding the wafer, in which the modified layers have been formed, by grinding stones from the side of the back surface of the wafer, so that the wafer is thinned to the finish thickness and the wafer is divided into individual chips along the modified layers.

According to the present invention, the clogging of the grinding stones can be suppressed when the film on the back surface of the wafer is ground before laser processing.

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.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view depicting an example of a wafer as an object of processing by a processing method according to an embodiment of the present

invention for the wafer;

FIG. 2 is a flow chart illustrating a flow of the processing method according to the embodiment for the wafer;

FIG. 3 is a perspective view depicting an example of a protective member arrangement step illustrated in FIG. 2;

FIG. 4 is a perspective view depicting the wafer after the protective member arrangement step;

FIG. 5 is a side view depicting, partly in section, an example of a laser processed groove forming step illustrated in FIG. 2;

FIG. 6 is a perspective view depicting the wafer after the laser processed groove forming step;

FIG. 7 is a side view depicting, partly in section, an example of a provisional grinding step illustrated in FIG. 2;

FIG. 8 is a side view depicting, partly in section, an example of a modified layer forming step illustrated in FIG. 2;

FIG. 9 is a side view depicting, partly in section, an example of a grinding step illustrated in FIG. 2; and

FIG. 10 is a perspective view depicting the wafer after the grinding step.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the drawings, a description will hereinafter be made in detail about an embodiment of the present invention. However, the present invention shall not be limited by details that will be described in the subsequent embodiment. The constituents of configurations that will hereinafter be described include those readily conceivable to persons skilled in the art and substantially the same ones. Further, the configurations that will hereinafter be described can be combined appropriately. Furthermore, various omissions, replacements, and modifications of configurations can be made without departing from the spirit of the present invention.

A processing method according to the embodiment of the present invention for a wafer 10 will be described based on the drawings. A description will first be made about the configuration of the wafer 10 as an object of processing in the embodiment. FIG. 1 is a perspective view depicting an example of the wafer 10 as the object of processing by the processing method according to the embodiment for the wafer 10.

As depicted in FIG. 1, the wafer 10 is a wafer,

such as a disc-shaped semiconductor wafer or a disc-shaped optical device wafer, in which silicon (Si), sapphire (Al_2O_3), gallium arsenide (GaAs), silicon carbide (SiC) or the like is used as a substrate 11. The wafer 10 has a plurality of streets 13 formed intersecting in a grid pattern on a front surface 12 of the substrate 11, and devices 14 formed in individual regions defined by the streets 13. The other surface of the wafer 10, which is located on a side opposite to the front surface 12 having the devices 14 formed thereon, will be referred to as a "back surface 15." On a side of the back surface 15 of the substrate 11, a film 17 having a predetermined reflectance or higher, such as a nitride film or an oxide film, is formed.

The devices 14 are, for example, integrated circuits such as integrated circuits (ICs) or large-scale integration (LSI) circuits, image sensors such as charge coupled devices (CCDs) or complementary metal oxide semiconductors (CMOSs), micro electro mechanical systems (MEMSs), or the like.

On the side of the front surface 12 of the substrate 11, a function layer 16 is stacked. The function layer 16 includes a plurality of low dielectric constant insulating films (hereinafter called "low-k

films") formed of films based on inorganic material such as SiOF or BSG (SiOB) or films based on organic material, that is, polymer films such as polyimide-based films or parylene-based films, and a plurality of conductor films formed with a conductive metal. The conductor films and low-k films are stacked alternately to form the devices 14. The conductor film makes up circuits of the devices 14. Therefore, the devices 14 are formed with the low-k films stacked each other and the conductor film stacked between the low-k films. It is to be noted that at the streets 13, the function layer 16 is formed with the low-k films and does not include the conductor film.

A description will next be made of the processing method of the embodiment for the wafer 10. FIG. 2 is a flow chart illustrating a flow of the processing method according to the embodiment for the wafer 10. The processing method for the wafer 10 has a protective member arrangement step 1, a laser processed groove forming step 2, a provisional grinding step 3, a modified layer forming step 4, and a grinding step 5.

(Protective Member Arrangement Step 1)

FIG. 3 is a perspective view depicting an example of the protective member arrangement step 1 illustrated in FIG. 2. FIG. 4 is a perspective view depicting the

wafer 10 after the protective member arrangement step 1. In the protective member arrangement step 1, a protective member 20 is arranged on the front surface 12 of the wafer 10 as will hereinafter be described in detail.

The protective member 20 serves to protect the devices 14 on the side of the front surface 12 of the wafer 10, which is to be held on a chuck table 50 or 80 of a laser processing machine 40 (see FIG. 5) or a grinding machine 70 (see FIG. 7) to be described subsequently herein, from adhesion of foreign matter or contact damage. In the embodiment, the protective member 20 is a disc-shaped tape having a larger diameter than the wafer 10. The protective member 20 includes, for example, a base material layer formed with a synthetic resin, and an adhesive layer having adhesiveness and laminated on at least one of a front surface and a back surface of the base material layer.

In the protective member arrangement step 1, the protective member 20 is first bonded to a side of a back surface of a frame 21 as depicted in FIG. 3. The frame 21 has an opening greater than an outer diameter of the wafer 10. The wafer 10 is next positioned at a predetermined location in the opening of the frame 21, and is bonded at the front surface 12 thereof to the

protective member 20. As a consequence, the wafer 10 is fixed on the protective member 20 and the frame 21 as depicted in FIG. 3.

(Laser Processed Groove Forming Step 2)

FIG. 5 is a side view depicting, partly in section, an example of the laser processed groove forming step 2 illustrated in FIG. 2. FIG. 6 is a perspective view depicting the wafer 10 after the laser processed groove forming step 2. In the laser processed groove forming step 2, a pulsed laser beam 30, as will hereinafter be described in detail, is irradiated to the back surface 15 of the wafer 10, so that laser processed grooves 18 are formed in the back surface 15 of the wafer 10 to remove the film 17 in parts.

In the laser processed groove forming step 2, the laser processed grooves 18 are formed on the side of the back surface 15 of the wafer 10 through ablation processing by the laser processing machine 40. The laser beam 30 is of a wavelength having absorption in the film 17 or the substrate 11. The laser processing machine 40 includes the chuck table 50, a laser beam irradiation unit 60, an undepicted moving unit that relatively moves the chuck table 50 and the laser beam irradiation unit 60, and an undepicted imaging unit that images the wafer

10.

In the laser processed groove forming step 2, the wafer 10 is first held under suction on the side of the front surface 12 thereof on a holding surface 51 of the chuck table 50 via the protective member 20, and the frame 21 is fixed at an outer peripheral edge thereof by clamp portions 52. Here, the frame 21 is fixed in a state that the frame 21 is pushed downward beyond the front surface 12 of the wafer 10, whereby the front surface 12 of the wafer 10 is fixed on the holding surface 51 of the chuck table 50.

In the laser processed groove forming step 2, the chuck table 50 is next moved to a processing position by the undepicted moving unit, the wafer 10 is imaged by the undepicted imaging unit, followed by alignment, whereby an irradiation section 61 of the laser beam irradiation unit 60 is aligned to a position where desired one of the laser processed grooves 18 is to be formed in the wafer 10.

If desired to form the laser processed grooves 18 along the streets 13, the wafer 10 is imaged by the undepicted imaging unit, and alignment is performed to determine the streets 13. If it does not matter where the laser processed grooves 18 are to be formed, alignment

may be performed to determine the position of the wafer 10, for example, by detecting three or more positions on an outer peripheral edge of the wafer 10 and calculating ordinates of the outer peripheral edge. If wafers 10 can be always positioned at the same location when transferring them onto the chuck table 50, the above-described alignment may be omitted.

In the laser processed groove forming step 2, the laser beam 30 is next irradiated toward the wafer 10 held on the holding surface 51 of the chuck table 50 while moving the chuck table 50 relative to the laser beam irradiation unit 60. Here, the laser beam 30 is irradiated from the side of the back surface 15 of the wafer 10 with a condensing point 31 positioned at the film 17. By irradiating the laser beam 30 along the back surface 15 of the wafer 10 with the condensing point 31 positioned at the film 17, the laser processed grooves 18 are formed in the back surface 15 of the wafer 10.

It is to be noted that insofar as the laser beam 30 is of a wavelength having absorption in the substrate 11 in the present invention, the wavelength may have or may not have absorption in the film 17. Even if the laser beam 30 is of a wavelength having absorption in only the substrate 11, the film 17 can be still removed by the

laser beam 30.

No particular limitation is imposed on where and how many the laser processed grooves 18 are to be formed, but the laser processed grooves 18 may preferably be formed, for example, in a grid pattern. No particular limitation is imposed either on how deep the laser processed grooves 18 are to be formed, but the laser processed grooves 18 may preferably extend in a height direction through the film 17. If the film 17 allows easy transmission of the laser beam 30 therethrough, laser processing may be performed after coating a surface of the film 17 with a water-soluble liquid resin containing a light absorbing material such as an oxide or nitride that promotes absorption of the laser beam 30. As a consequence, the removal of the film 17 by the laser processing can be promoted even if the film 17 allows easy transmission of the laser beam 30 therethrough. When the laser processed grooves 18 have been formed over the entire area on the side of the back surface 15 of the wafer 10 in the laser processed groove forming step 2, the irradiation of the laser beam 30 and the holding under suction by the chuck table 50 are stopped, and the processing proceeds to the provisional grinding step 3. (Provisional Grinding Step 3)

FIG. 7 is a side view depicting, partly in section, an example of the provisional grinding step 3 illustrated in FIG. 2. In the provisional grinding step 3, the back surface 15 of the wafer 10 with the laser processed grooves 18 formed therein is ground by grinding stones 93 to remove remaining parts of the film 17 and the laser processed grooves 18, so that the wafer 10 is formed to a predetermined thickness greater than a finish thickness.

In the provisional grinding step 3, the remaining parts of the film 17 and the laser processed grooves 18, both on the side of the back surface 15 of the wafer 10, are removed through grinding processing by the grinding machine 70, so that the wafer 10 is formed to the predetermined thickness greater than the finish thickness. The grinding machine 70 includes the chuck table 80 and a grinding unit 90. The grinding unit 90 includes a spindle 91 as a rotating shaft member, a wheel base 92 attached to a lower end of the spindle 91, the grinding stones 93 mounted on a lower surface of the wheel base 92, and a grinding water supply nozzle 94. The wheel base 92 rotates about an axis of rotation, which is parallel to the center of a rotating shaft of the chuck table 80.

In the provisional grinding step 3, the wafer 10 is

first held on the side of the front surface 12 thereof under suction on a holding surface 81 of the chuck table 80 via the protective member 20, and the frame 21 is fixed at the outer peripheral edge thereof by clamp portions 82. Here, the frame 21 is fixed in a state that the frame 21 is pushed downward beyond the front surface 12 of the wafer 10, whereby the front surface 12 of the wafer 10 is fixed on the holding surface 81 of the chuck table 80.

In the provisional grinding step 3, the wheel base 92 is next rotated about the axis of rotation with the chuck table 80 maintained rotating about an axis of rotation. Grinding water 95 is supplied from the grinding water supply nozzle 94, and at the same time the grinding stones 93 mounted on the lower surface of the wheel base 92 are brought close at a predetermined speed to the chuck table 80, whereby the wafer 10 is ground from the side of the back surface 15 thereof by the grinding stones 93.

In the provisional grinding step 3, the remaining parts of the film 17 and the laser processed grooves 18, both on the side of the back surface 15 of the wafer 10, are removed. In other words, the substrate 11 is ground beyond the depth of the laser processed grooves 18. Here,

the wafer 10 is ensured to have a remaining thickness greater than the finish thickness so that the wafer 10 is formed to the predetermined thickness greater than the finish thickness. The thickness to be ground away in the provisional grinding step 3 is, for example, 100 μm or less.

When the remaining parts of the film 17 on the side of the back surface 15 of the wafer 10 are ground away in the provisional grinding step 3, the volume of the film 17 relative to the total volume to be ground away decreases compared with the case without the laser processed grooves 18 owing to the formation of the laser processed grooves 18. Further, depressions and elevations are formed on the side of the back surface 15 of the wafer 10 by the laser processed grooves 18, and impacts are hence produced when the grinding stones 93 strike the elevations. These impacts can be expected to bring about dressing effect for the grinding stones 93. When the wafer 10 has been formed to the predetermined thickness greater than the finish thickness in the provisional grinding step 3, the rotations of the chuck table 80 and the grinding unit 90 are stopped, the holding under suction by the chuck table 80 is released, and the processing proceeds to the modified layer forming step 4.

(Modified Layer Forming Step 4)

FIG. 8 is a side view depicting, partly in section, an example of the modified layer forming step 4 illustrated in FIG. 2. The modified layer forming step 4 is performed after the provisional grinding step 3. In the modified layer forming step 4, a pulsed laser beam 30 is irradiated from the side of the back surface 15 of the wafer 10 from which the film 17 has been removed, so that modified layers 19 are formed along the streets 13 inside the substrate 11.

The modified layer 19 means a region changed into a state in which the region is different in density, refractive index, mechanical strength and/or other physical characteristics from a surrounding region. The modified layer 19 is, for example, a fusion-processed region, a cracked region, a dielectric breakdown region, a refractive index changed region, a region where two or more of such regions are mixed, or the like. The modified layers 19 are lower in mechanical strength or the like than the other parts of the wafer 10.

In the modified layer forming step 4, the modified layers 19 are formed inside the substrate 11 of the wafer 10 through stealth dicing by a laser processing machine 40. The laser beam 30 is of a wavelength having

transmissivity through the substrate 11. The laser processing machine 40 may be the same machine as that used in the laser processed groove forming step 2.

In the modified layer forming step 4, as in the laser processed groove forming step 2, the wafer 10 is first held under suction on the side of the front surface 12 thereof on a holding surface 51 of a chuck table 50 via the protective member 20, and the frame 21 is held at the outer peripheral edge thereof by clamp portions 52. The chuck table 50 is next moved to a processing position by an undepicted moving unit, the wafer 10 is imaged by an undepicted imaging unit, followed by alignment, whereby an irradiation section 61 of a laser beam irradiation unit 60 is aligned to desired one of the streets 13 of the wafer 10.

In the modified layer forming step 4, while moving the chuck table 50 relative to the laser beam irradiation unit 60, the laser beam 30 is next irradiated from the side of the back surface 15 of the wafer 10 with a condensing point 31 positioned inside the substrate 11. By irradiating the laser beam 30 along the individual streets 13 with the condensing point 31 positioned inside the substrate 11, the modified layers 19 are formed along the streets 13 inside the substrate 11. When the modified

layers 19 have been formed along all the streets 13 in the modified layer forming step 4, the irradiation of the laser beam 30 and the holding under suction by the chuck table 50 are stopped, and the processing proceeds to the grinding step 5.

(Grinding Step 5)

FIG. 9 is a side view depicting, partly in section, an example of the grinding step 5 illustrated in FIG. 2. FIG. 10 is a perspective view depicting the wafer 10 after the grinding step 5. In the grinding step 5, the wafer 10 with the modified layers 19 formed therein is ground from the side of the back surface 15 thereof by grinding stones 93, so that the wafer 10 is thinned to the finish thickness and is also divided along the modified layers.

In the grinding step 5, the wafer 10 is ground from the side of the back surface 15 thereof through grinding processing by a grinding machine 70, so that the wafer 10 is thinned to the finish thickness. The grinding machine 70 may be the same machine as that used in the provisional grinding step 3.

In the grinding step 5, as in the provisional grinding step 3, the wafer 10 is first held on the side of the front surface 12 thereof under suction on a

holding surface 81 of a chuck table 80 via the protective member 20, and the frame 21 is fixed at the outer peripheral edge thereof by clamp portions 82. With the chuck table 80 maintained rotating about an axis of rotation, a wheel base 92 is next rotated about an axis of rotation. Grinding water 95 is supplied from a grinding water supply nozzle 94, and at the same time grinding stones 93 mounted on a lower surface of a wheel base 92 are brought close at a predetermined speed to the chuck table 80, whereby the wafer 10 is ground from the side of the back surface 15 thereof by the grinding stones 93.

In the grinding step 5, the wafer 10 is ground from the side of the back surface 15 thereof until the wafer 10 is thinned to the finish thickness. In the grinding step 5, the wafer 10 is also divided into individual chips from the modified layers 19 as fracture starting points along the streets 13 by grinding stress acting from the wheel base 92 of the grinding unit 90. When the wafer 10 has been ground to the finish thickness, the processing method of the wafer 10 in the embodiment ends all the steps.

As described above, the processing method according to the embodiment for the wafer 10 forms the laser

processed grooves 18 in the back surface 15 of the wafer 10, and, before the provisional grinding step 3, the film 17 is beforehand removed in parts. When grinding away the remaining parts of the film 17 on the side of the back surface 15 of the wafer 10 in the provisional grinding step 3, the volume of the film 17 relative to the total volume to be ground decreases compared with the case without the laser processed grooves 18 owing to the formation of the laser processed grooves 18. As a consequence, the clogging of the grinding stones 93 in the provisional grinding step 3 can be suppressed. In addition, the depressions and elevations are formed on the side of the back surface 15 of the wafer 10 by the laser processed grooves 18, and impacts are hence produced when the grinding stones 93 strike the elevations. These impacts can be expected to bring about the dressing effect for the grinding stones 93.

It is to be noted that the present invention should not be limited to or by the above-described embodiment. In other words, the present invention can be practiced with various modifications within the scope not departing from the spirit of the present invention. For example, the wafer 10 is fixed on the frame 21 in the laser processed groove forming step 2, the provisional grinding

step 3, the modified layer forming step 4 and the grinding step 5 in the embodiment, but without using the frame 21, these steps may each be performed in the present invention by bonding the wafer 10 to the protective member 20 having substantially the same diameter as the wafer 10. In other words, in the laser processed groove forming step 2, the provisional grinding step 3, the modified layer forming step 4, and the grinding step 5, the wafer 10 is only required to be bonded to the protective member 20, but is not absolutely required to be fixed on the frame 21 via the protective member 20.

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.

WHAT IS CLAIMED IS:

1. A processing method for a wafer having a substrate, a plurality of devices formed by a function layer stacked on a front surface of the substrate, and a film formed on a back surface of the substrate, the method including dividing the wafer along a plurality of intersecting streets sectioning the devices, the method comprising:

a protective member arrangement step of arranging a protective member on a front surface of the wafer;

a laser processed groove forming step of, after the protective member arrangement step, irradiating a laser beam of a wavelength, which has absorption in the film or the substrate, to a back surface of the wafer, so that laser processed grooves are formed in the back surface of the wafer to remove the film in parts;

a provisional grinding step of grinding the back surface of the wafer, in which the laser processed grooves have been formed, by grinding stones to remove remaining parts of the film and the laser processed grooves, so that the wafer is formed to a predetermined thickness greater than a finish thickness;

a modified layer forming step of, after the provisional grinding step, irradiating a laser beam of a

wavelength, which has transmissivity through the substrate, from a side of the back surface of the wafer, from which the film has been removed, with a condensing point of the laser beam positioned inside the substrate, so that modified layers are formed along the streets inside the substrate; and

a grinding step of grinding the wafer, in which the modified layers have been formed, by grinding stones from the side of the back surface of the wafer, so that the wafer is thinned to the finish thickness and the wafer is divided into individual chips along the modified layers.