

CHIP FABRICATION METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a chip fabrication method.

Description of the Related Art

A wafer such as an optical device wafer having an optical device layer laminated on a front surface of a sapphire (Al_2O_3) substrate, a silicon carbide (SiC) substrate, or a gallium nitride (GaN) substrate or a surface acoustic wave (SAW) wafer having SAW devices formed on a front surface of a lithium tantalate (LiTaO_3) substrate, a lithium niobate (LiNbO_3) substrate, a silicon carbide (SiC) substrate, a diamond substrate, or a quartz substrate is cut along a plurality of crossing planned division lines to be divided into individual devices, thereby fabricating chips.

As a method for dividing the wafer described above, there is known a laser processing method for irradiating the wafer with a pulsed laser beam having a wavelength that is transmittable through the wafer, with a focal point of the pulsed laser beam positioned inside the wafer at a position corresponding to a region to be

divided, to form a modified layer to be used as a division initiating point, and applying an external force to divide the wafer from the modified layer (refer to Japanese Patent No. 3408805, for example).

The method disclosed in Japanese Patent No. 3408805 is applicable also to a wafer having a metal film or a distributed Bragg reflector (DBR) film laminated on a reverse surface of a wafer, and in this case, the laminated film is also divided from cracks that are developed from the modified layer at the time of processing the wafer.

In recent years, however, films tend to be made thick for the purpose of enhancing luminance or the like, and hence, it is difficult for cracks to be developed inside such films. This can lead to division failure or chipping.

To cope with this problem, there is proposed a method for carrying out laser processing after removing a laminated film with use of a cutting blade or by etching (refer to Japanese Patent Laid-open No. 2016-164924, for example).

SUMMARY OF THE INVENTION

Although the processing method disclosed in

Japanese Patent Laid-open No. 2016-164924 can solve the above problem, there is a demand for further enhancement in productivity.

It is therefore an object of the present invention to provide a chip fabrication method that can enhance productivity while securely dividing a wafer formed with a film.

In accordance with an aspect of the present invention, there is provided a chip fabrication method for fabricating chips by dividing a wafer having a film formed on a front surface or a reverse surface thereof, along a plurality of crossing planned division lines into individual chips. The chip fabrication method includes a laser beam irradiation step of irradiating the wafer with a laser beam along the planned division lines set on the wafer, to form ablation marks in the film formed on the front surface or the reverse surface and to form modified regions inside the wafer, and a division step of applying an external force to the wafer after the laser beam irradiation step has been carried out, to divide the wafer along the ablation marks formed in the laser beam irradiation step.

Preferably, in the laser beam irradiation step, the wafer may be irradiated with a laser beam along the

planned division lines set on the wafer, the laser beam having a wavelength that is transmittable through the wafer and is absorbable to the film, with a condensing region of the laser beam positioned within a range from a position inside the wafer to a front surface of the film or to a position shifted outward from the front surface of the film, to thereby simultaneously form the modified regions inside the wafer and the ablation marks in the film.

Preferably, the laser beam irradiation step may include a modified region forming step of irradiating the wafer with a laser beam having a wavelength transmittable through the wafer, with a condensing region of the laser beam positioned inside the wafer, to form the modified regions, and after the modified region forming step has been carried out, an ablation mark forming step of irradiating the wafer with a laser beam having a wavelength absorbable to the film, with a condensing region of the laser beam positioned in a vicinity of the film, to form the ablation marks.

Preferably, in the laser beam irradiation step, each of the modified regions formed inside the wafer may have a pore and an amorphous part surrounding the pore.

The present invention offers an advantageous effect

that productivity is enhanced while a wafer formed with a film is securely divided.

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 some preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view schematically illustrating a wafer to be processed by a chip fabrication method according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional view schematically illustrating the wafer illustrated in FIG. 1;

FIG. 3 is a flowchart illustrating a sequence of the chip fabrication method according to the first embodiment;

FIG. 4 is a perspective view schematically illustrating a laser beam irradiation step of the chip fabrication method illustrated in FIG. 3;

FIG. 5 is a cross-sectional view schematically

illustrating an essential part of the wafer irradiated with a laser beam in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 3;

FIG. 6 is a cross-sectional view schematically illustrating, in another state, the essential part of the wafer illustrated in FIG. 5;

FIG. 7 is a perspective view schematically illustrating the essential part of the wafer for which the laser beam irradiation step of the chip fabrication method illustrated in FIG. 3 has been carried out;

FIG. 8 is a cross-sectional view schematically illustrating the essential part of the wafer for which the laser beam irradiation step of the chip fabrication method illustrated in FIG. 3 has been carried out;

FIG. 9 is a perspective view schematically illustrating one of modified regions formed in the wafer illustrated in FIG. 8;

FIG. 10 is a side view schematically illustrating, partly in cross section, a state in which the wafer is held by a division apparatus in a division step of the chip fabrication method illustrated in FIG. 3;

FIG. 11 is a side view schematically illustrating, partly in cross section, a state in which the wafer has been divided into chips by the division apparatus in the

division step of the chip fabrication method illustrated in FIG. 3;

FIG. 12 is a plan view schematically illustrating one of the chips obtained as a result of the division in the division step of the chip fabrication method illustrated in FIG. 3;

FIG. 13 is a flowchart illustrating a sequence of a chip fabrication method according to a second embodiment of the present invention;

FIG. 14 is a cross-sectional view schematically illustrating the essential part of the wafer irradiated with a laser beam in a modified region forming step included in a laser beam irradiation step of the chip fabrication method illustrated in FIG. 13;

FIG. 15 is a cross-sectional view schematically illustrating the essential part of the wafer for which the modified region forming step included in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 13 has been carried out;

FIG. 16 is a cross-sectional view schematically illustrating the essential part of the wafer irradiated with a laser beam in an ablation mark forming step included in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 13; and

FIG. 17 is a cross-sectional view schematically illustrating the essential part of the wafer for which the ablation mark forming step included in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 13 has been carried out.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described in detail hereinbelow with reference to the accompanying drawings. The present invention is not limited to the details of the embodiments described below. Components described below cover those which could easily be anticipated by those skilled in the art and those which are essentially identical to those described below. Furthermore, arrangements described below can be combined in appropriate manners. Various omissions, replacements, or changes of the arrangements may be made without departing from the scope of the present invention.

FIRST EMBODIMENT

A chip fabrication method according to a first embodiment of the present invention will be described below with reference to the accompanying drawings. FIG. 1 is a perspective view schematically illustrating a wafer

to be processed by the chip fabrication method according to the first embodiment. FIG. 2 is a cross-sectional view schematically illustrating the wafer illustrated in FIG. 1. FIG. 3 is a flowchart illustrating a sequence of the chip fabrication method according to the first embodiment.

The chip fabrication method according to the first embodiment is a method for processing the wafer, denoted by 1, illustrated in FIG. 1. The wafer 1 to be processed by the chip fabrication method according to the first embodiment is a disk-shaped wafer, such as an optical device wafer or a SAW wafer, including a substrate 2 and a film 4 such as a metal film or a DBR film of a uniform thickness formed on a reverse surface 3 of the substrate 2, as illustrated in FIG. 1 and FIG. 2.

An optical device wafer is formed by laminating an optical device layer on a front surface of a sapphire (Al_2O_3) substrate, a silicon carbide (SiC) substrate, or a gallium nitride (GaN) substrate. A SAW wafer is formed by forming SAW devices on a front surface of a lithium tantalate (LiTaO_3) substrate, a lithium niobate (LiNbO_3) substrate, a silicon carbide (SiC) substrate, a diamond substrate, or a quartz substrate.

The substrate 2 of the wafer 1 has a front surface

5 which is demarcated into regions by first planned division lines 6 extending in parallel to each other and second planned division lines 7 extending in parallel to each other and which has devices 8 formed thereon in the respective regions, and the reverse surface 3 formed with the film 4. It is to be noted that, in the first embodiment, the first planned division lines 6 are orthogonal to the second planned division lines 7.

In the first embodiment, the substrate 2 of the wafer 1 is a c-plane sapphire substrate, and the devices 8 formed on the front surface 5 of the substrate 2 are light-emitting diodes (LEDs) including an epitaxial film formed through GaN-based epitaxial growth. It is to be noted that, in the first embodiment, the wafer 1 has at an interface between the devices 8, i.e., LEDs, and the substrate 2 a patterned sapphire substrate (PSS) structure for enhancing luminance.

Further, in the first embodiment, the film 4 formed on the reverse surface 3 of the substrate 2 of the wafer 1 is a DBR film (multilayered dielectric film). In the first embodiment, the wafer 1 has an outer diameter of six inches and a thickness of 150 μm , and the devices 8 each have a dimension of 200 μm $\times$ 200 μm . The wafer 1 thus configured is divided along the planned division

lines 6 and 7 into chips 10. It is to be noted that each chip 10 includes part of the substrate 2, the device 8, and part of the film 4.

The chip fabrication method according to the first embodiment is a method for dividing the wafer 1, which has the film 4 formed on the reverse surface 3 of the substrate 2, along the planned division lines 6 and 7 to fabricate the chips 10. As illustrated in FIG. 3, the chip fabrication method according to the first embodiment includes a laser beam irradiation step 101 and a division step 102.

(Laser beam irradiation step)

FIG. 4 is a perspective view schematically illustrating the laser beam irradiation step of the chip fabrication method illustrated in FIG. 3. FIG. 5 is a cross-sectional view schematically illustrating an essential part of the wafer irradiated with a laser beam in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 3. FIG. 6 is a cross-sectional view schematically illustrating, in another state, the essential part of the wafer illustrated in FIG. 5. FIG. 7 is a perspective view schematically illustrating the essential part of the wafer for which the laser beam irradiation step of the

chip fabrication method illustrated in FIG. 3 has been carried out. FIG. 8 is a cross-sectional view schematically illustrating the essential part of the wafer for which the laser beam irradiation step of the chip fabrication method illustrated in FIG. 3 has been carried out. FIG. 9 is a perspective view schematically illustrating one of modified regions formed in the wafer illustrated in FIG. 8.

The laser beam irradiation step 101 is a step of irradiating the wafer 1 with a laser beam 21 (illustrated in FIG. 4, FIG. 5, and FIG. 6) along the planned division lines 6 and 7 set on the wafer 1, to form ablation marks 11 (illustrated in FIG. 7 and FIG. 8) in the film 4 formed on the reverse surface 3, and to form modified regions 12 (illustrated in FIG. 7, FIG. 8, and FIG. 9) inside the substrate 2 of the wafer 1. It is to be noted that, since the wafer 1 has at the interface between the devices 8, i.e., LEDs, and the substrate 2 the PSS structure for enhancing luminance, the laser beam 21 applied thereto is scattered. Hence, it is difficult to irradiate the wafer 1 with the laser beam 21 from the front surface 5 side.

In the laser beam irradiation step 101, as illustrated in FIG. 4, a laser processing apparatus 20

holds the front surface 5 of the wafer 1 under suction on a holding surface 23 of a holding table 22. It is to be noted that, in the first embodiment, a disk-shaped tape 13 (illustrated in FIG. 10) having a diameter larger than that of the wafer 1 is attached to the front surface 5 of the wafer 1, and an annular frame 14 (illustrated in FIG. 10) is attached to an outer edge portion of the tape 13. Therefore, the front surface 5 of the wafer 1 is held under suction on the holding surface 23 with an intermediary of the tape 13. It is to be noted that, in FIG. 4, the tape 13 and the annular frame 14 are omitted from the illustration.

According to the first embodiment, in the laser beam irradiation step 101, the laser processing apparatus 20 causes an infrared camera 24 or the like to image the reverse surface 3 of the wafer 1 held under suction on the holding table 22, to detect the planned division lines 6 and 7, and carries out alignment between a laser beam irradiation unit 25 of the laser processing apparatus 20 and each of the planned division lines 6 and 7. According to the first embodiment, in the laser beam irradiation step 101, as illustrated in FIG. 4, the laser processing apparatus 20 then causes the laser beam irradiation unit 25 to irradiate the wafer 1 with the

laser beam 21 having a wavelength that is transmittable through the substrate 2 of the wafer 1 and is absorbable to the film 4, while moving the laser beam irradiation unit 25 and the wafer 1 relative to each other along each of the planned division lines 6 and 7, on the basis of processing conditions.

According to the first embodiment, in the laser beam irradiation step 101, the laser processing apparatus 20 causes the laser beam irradiation unit 25 to irradiate the wafer 1 with the laser beam 21 having been applied with an aberration (especially, longitudinal aberration) by an optical system in the laser beam irradiation unit 25, with a focal point of the laser beam 21 positioned inside the wafer 1, as illustrated in FIG. 5. More specifically, according to the first embodiment, in the laser beam irradiation step 101, the laser processing apparatus 20 causes the laser beam irradiation unit 25 to irradiate the wafer 1 with the laser beam 21 along the planned division lines 6 and 7 set on the wafer 1, with a condensing region 211 of the laser beam 21 (a region in which the laser beam 21 having been applied with the aberration, especially, longitudinal aberration, is condensed) positioned in a range from a position inside the substrate 2 of the wafer 1 to a front surface 9 of

the film 4, as illustrated in FIG. 5. It is to be noted that, according to the present invention, in the laser beam irradiation step 101, the laser processing apparatus 20 may cause the laser beam irradiation unit 25 to irradiate the wafer 1 with the laser beam 21 along the planned division lines 6 and 7 set on the wafer 1, with the condensing region 211 of the laser beam 21 positioned in a range from a position inside the substrate 2 of the wafer 1 to a position which is shifted outward from the front surface 9 of the film 4 and is closer to the laser beam irradiation unit 25 than the front surface 9, as illustrated in FIG. 6.

According to the first embodiment, in the laser beam irradiation step 101, since the laser beam 21 has a wavelength that is transmittable through the substrate 2 of the wafer 1 and is absorbable to the film 4, and has been applied with an aberration (especially, longitudinal aberration), the laser processing apparatus 20 simultaneously forms modified regions 12 at intervals inside the substrate 2 of the wafer 1 and ablation marks 11 at intervals in the front surface 9 of the film 4 along the planned division lines 6 and 7 as illustrated in FIG. 7 and FIG. 8. It is to be noted that, according to the first embodiment, since the laser beam 21 has been

applied with an aberration, the modified regions 12 are each formed into a linear shape extending along a thickness direction of the wafer 1 as illustrated in FIG. 7 and FIG. 8.

According to the first embodiment, as illustrated in FIG. 9, each modified region 12 includes a pore 121 which is circular in plan and an amorphous part 122 which is cylindrical and surrounds the pore 121. The pore 121 is a hole (space) defined inside the substrate 2, and in the first embodiment, has a diameter of approximately 1 μm . The amorphous part 122 represents a region in which a density, a refractive index, a mechanical strength, or another physical characteristic is varied from that of surrounding regions, and examples of the amorphous part 122 include a melting treatment region, a crack region, a dielectric breakdown region, a refractive-index change region, and a region including any of these regions in a mixed manner. In the first embodiment, the amorphous part 122 has an outer diameter of approximately 5 μm . The mechanical strength in the modified region 12 is lower than that of other regions in the substrate 2.

Each ablation mark 11 is a mark formed through ablation carried out on the film 4, and in the first embodiment, is a recess defined in the front surface 9 of

the film 4. Further, in the first embodiment, each ablation mark 11 is circular in plan.

According to the first embodiment, in the laser beam irradiation step 101, the wafer 1 is irradiated with the laser beam 21 having a wavelength of 1064 nm, an energy of 40 μ J, and a repetition frequency of 40 kHz, while the holding table 22 is being moved at a speed of 800 m/s. It is to be noted that the energy and repetition frequency of the laser beam 21 and the moving speed of the holding table 22 are set as the processing conditions in the laser beam irradiation step 101. That is, according to the first embodiment, in the laser beam irradiation step 101, the laser processing apparatus 20 carries out the irradiation with the laser beam 21 along the first planned division lines 6 under the processing conditions same as the processing conditions under which the irradiation with the laser beam 21 along the second planned division lines 7 is carried out. According to the first embodiment, in the laser beam irradiation step 101, the irradiation with the laser beam 21 is carried out along all the planned division lines 6 and 7 set on the wafer 1, so that the formation of the modified regions 12 and the ablation marks 11 is carried out along all the planned division lines 6 and 7 set on the wafer 1.

(Division step)

FIG. 10 is a side view schematically illustrating, partly in cross section, a state in which the wafer is held by a division apparatus in the division step of the chip fabrication method illustrated in FIG. 3. FIG. 11 is a side view schematically illustrating, partly in cross section, a state in which the wafer has been divided into chips by the division apparatus in the division step of the chip fabrication method illustrated in FIG. 3. FIG. 12 is a plan view schematically illustrating one of the chips obtained as a result of the division in the division step of the chip fabrication method illustrated in FIG. 3. It is to be noted that, in FIG. 10 and FIG. 11, the devices 8 are omitted from the illustration.

The division step 102 is a step of applying an external force to the wafer 1 for which the laser beam irradiation step 101 has been carried out, to divide the wafer 1 into the individual chips 10 along the modified regions 12 and the ablation marks 11 formed in the laser beam irradiation step 101. In the division step 102, as illustrated in FIG. 10, the division apparatus, denoted by 30, holds the wafer 1 by causing a frame clamping section 31 to clamp the annular frame 14 supporting therein the wafer 1 and the outer edge portion of the

tape 13, and causes roller members 33 provided at an upper end of a cylindrical expansion drum 32 to abut against the tape 13.

In the division step 102, as illustrated in FIG. 10, the division apparatus 30 thus causes the frame clamping section 31 to hold the annular frame 14 supporting the wafer 1 and the like, in a state in which the tape 13 lies flat over a range from the outer edge portion to a central portion thereof. In the division step 102, the division apparatus 30 moves the annular frame 14 and the wafer 1 relative to each other in a direction crossing (in the first embodiment, orthogonal to) the front surface 5 of the wafer 1. According to the first embodiment, in the division step 102, the division apparatus 30 raises the expansion drum 32 to move the annular frame 14 and the wafer 1 relative to each other in the direction crossing (in the first embodiment, orthogonal to) the front surface 5 of the wafer 1 as illustrated in FIG. 11.

As a result, the roller members 33 push the tape 13 upward from below at a position between an outer edge of the wafer 1 and an inner edge of the annular frame 14, thereby expanding the tape 13 in a plane direction. This expansion of the tape 13 causes a tensile force to

radially act on the tape 13. With the tensile force radially acting on the tape 13 attached to the front surface 5 of the wafer 1, in the wafer 1 formed with the modified regions 12 and the ablation marks 11 along the planned division lines 6 and 7, the substrate 2 is divided from the modified regions 12, and the film 4 is divided from the ablation marks 11. Accordingly, the wafer 1 is divided into the individual chips 10, one of which is illustrated in FIG. 12, along the planned division lines 6 and 7. The individual chips 10 thus divided are picked up from the tape 13. It is to be noted that, according to the first embodiment, each of the divided individual chips 10 has a plurality of semicircular recesses 15 formed at an outer edge thereof as illustrated in FIG. 12 since the wafer 1 has been formed with the ablation marks 11 and the modified regions 12.

With the above-described chip fabrication method according to the first embodiment, in the laser beam irradiation step 101, the wafer 1 is irradiated with the laser beam 21 along the planned division lines 6 and 7 to form the ablation marks 11 in the laminated film 4 through ablation and to form the modified regions 12 inside the substrate 2 of the wafer 1. In this manner,

with the chip fabrication method according to the first embodiment, since the ablation marks 11 are formed in the film 4 laminated on the substrate 2 of the wafer 1, even if cracks are not successfully developed from the modified regions 12 to the film 4 in the division step 102, it is possible to securely divide the wafer 1 into the individual chips 10 with use of the ablation marks 11 as division initiating points, while suppressing meandering or chipping.

Moreover, with the chip fabrication method according to the first embodiment, in the laser beam irradiation step 101, since the wafer 1 is irradiated with the laser beam 21 along the planned division lines 6 and 7 to form the ablation marks 11 in the laminated film 4 through ablation and to form the modified regions 12 inside the substrate 2 of the wafer 1, man-hours required to remove the film 4 on the planned division lines 6 and 7 in advance can be reduced, which contributes to enhancement in productivity.

Accordingly, the chip fabrication method according to the first embodiment offers an advantageous effect that productivity is enhanced while the wafer 1 formed with the film 4 is securely divided into the individual chips 10.

SECOND EMBODIMENT

A chip fabrication method according to a second embodiment of the present invention will be described below with reference to the drawings. FIG. 13 is a flowchart illustrating a sequence of the chip fabrication method according to the second embodiment. FIG. 14 is a cross-sectional view schematically illustrating the essential part of the wafer irradiated with a laser beam in a modified region forming step included in a laser beam irradiation step of the chip fabrication method illustrated in FIG. 13. FIG. 15 is a cross-sectional view schematically illustrating the essential part of the wafer for which the modified region forming step included in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 13 has been carried out. FIG. 16 is a cross-sectional view schematically illustrating the essential part of the wafer irradiated with a laser beam in an ablation mark forming step included in the laser beam irradiation step of the chip fabrication method illustrated in FIG. 13. FIG. 17 is a cross-sectional view schematically illustrating the essential part of the wafer for which the ablation mark forming step included in the laser beam irradiation step of the chip fabrication method

illustrated in FIG. 13 has been carried out. In FIG. 13, FIG. 14, FIG. 15, FIG. 16, and FIG. 17, components identical to those in the first embodiment are denoted by identical reference signs, and redundant description is omitted.

The chip fabrication method according to the second embodiment is the same as that of the first embodiment except that a laser beam irradiation step 101 in the second embodiment includes a modified region forming step 101-1 and an ablation mark forming step 101-2.

According to the second embodiment, the modified region forming step 101-1 is a step of forming a modified layer 12-2 (illustrated in FIG. 14) as a modified region by irradiating the wafer 1 with the laser beam 21 having a wavelength that is transmittable through the substrate 2 of the wafer 1, with a focal point 211-2 (illustrated in FIG. 14) as a condensing region of the laser beam 21 positioned inside the substrate 2 of the wafer 1.

According to the second embodiment, in the modified region forming step 101-1, as in the first embodiment, the laser processing apparatus 20 holds the front surface 5 of the wafer 1 under suction on the holding surface 23 of the holding table 22, carries out alignment, and causes the laser beam irradiation unit 25 to irradiate

the wafer 1 with the laser beam 21 having a wavelength that is transmittable through the substrate 2 of the wafer 1 and is absorbable to the film 4, while the laser beam irradiation unit 25 and the wafer 1 are being moved relative to each other along the planned division lines 6 and 7, on the basis of processing conditions.

According to the second embodiment, in the modified region forming step 101-1, the laser processing apparatus 20 causes the laser beam irradiation unit 25 to irradiate the wafer 1 with the laser beam 21 having not been applied with an aberration (especially, longitudinal aberration) by the optical system in the laser beam irradiation unit 25, with the focal point 211-2 of the laser beam 21 positioned inside the substrate 2 of the wafer 1 as illustrated in FIG. 14. According to the second embodiment, in the modified region forming step 101-1, since the laser beam 21 has a wavelength transmittable through the substrate 2 of the wafer 1, the laser processing apparatus 20 forms the modified layers 12-2 at intervals inside the substrate 2 of the wafer 1 along the planned division lines 6 and 7 as illustrated in FIG. 15.

According to the second embodiment, the modified layers 12-2 each represent a region in which a density, a

refractive index, a mechanical strength, or another physical characteristic is varied from that of surrounding regions, and examples of the modified layer 12-2 include a melting treatment region, a crack region, a dielectric breakdown region, a refractive-index change region, and a region including any of these regions in a mixed manner. The mechanical strength in the modified layers 12-2 is lower than that of other regions in the substrate 2. In the modified region forming step 101-1, the irradiation with the laser beam 21 is carried out along all the planned division lines 6 and 7 set on the wafer 1, so that the formation of the modified layers 12-2 is carried out along all the planned division lines 6 and 7 set on the wafer 1.

According to the second embodiment, the ablation mark forming step 101-2 is a step of forming, after the modified region forming step 101-1 has been carried out, ablation marks 11 by irradiating the wafer 1 with the laser beam 21 having a wavelength absorbable to the film 4, with the focal point 211-2 as the condensing region of the laser beam 21 positioned in the vicinity of the front surface 9 of the film 4. According to the second embodiment, in the ablation mark forming step 101-2, the laser processing apparatus 20 causes the laser beam

irradiation unit 25 to irradiate the wafer 1 with the laser beam 21 having a wavelength that is transmittable through the substrate 2 of the wafer 1 and is absorbable to the film 4, while the laser beam irradiation unit 25 and the wafer 1 are being moved relative to each other along the planned division lines 6 and 7, on the basis of processing conditions.

According to the second embodiment, in the ablation mark forming step 101-2, the laser processing apparatus 20 causes the laser beam irradiation unit 25 to irradiate the wafer 1 with the laser beam 21 having not been applied with an aberration (especially, longitudinal aberration) by the optical system in the laser beam irradiation unit 25, with the focal point 211-2 of the laser beam 21 positioned on the front surface 9 of the film 4 as illustrated in FIG. 16. According to the second embodiment, in the ablation mark forming step 101-2, since the laser beam 21 has a wavelength absorbable to the film 4, the laser processing apparatus 20 forms the ablation marks 11 at intervals in the front surface 9 of the film 4 of the wafer 1 along the planned division lines 6 and 7 as illustrated in FIG. 17. In the ablation mark forming step 101-2, the irradiation with the laser beam 21 is carried out along all the planned division

lines 6 and 7 set on the wafer 1, so that the formation of the ablation marks 11 is carried out along all the planned division lines 6 and 7 set on the wafer 1.

It is to be noted that, according to the second embodiment, the modified region forming step 101-1 and the ablation mark forming step 101-2 use the laser beams 21 of the same wavelength (1064 nm in the second embodiment) for irradiation to form the modified layers 12-2 and the ablation marks 11. However, according to the present invention, the modified region forming step 101-1 and the ablation mark forming step 101-2 may use the laser beams 21 of different wavelengths for irradiation to form the modified layers 12-2 and the ablation marks 11. In this case, it is preferable that irradiation be carried out with the laser beam 21 having a wavelength of 1064 nm in the modified region forming step 101-1 and that irradiation be carried out with the laser beam 21 having a wavelength of 355 nm in the ablation mark forming step 101-2.

Moreover, according to the present invention, especially in the modified region forming step 101-1, as in the first embodiment, the wafer 1 may be irradiated with the laser beam 21 having been applied with an aberration (especially, longitudinal aberration), to form

the modified regions 12 inside the substrate 2 of the wafer 1. Further, according to the present invention, in the modified region forming step 101-1, the focal point 211-2 of the laser beam 21 may be positioned inside the substrate 2 rather than in the front surface 9 of the film 4 or may be positioned at a position closer to the laser beam irradiation unit 25 than the front surface 9 of the film 4, so that the focal point 211-2 is positioned in the vicinity of the front surface 9 of the film 4. It is to be noted that positioning the focal point 211-2 in the vicinity of the front surface 9 of the film 4 means that the focal point 211-2 is separated from the front surface 9 of the film 4 to such an extent that the ablation marks 11 can be formed in the front surface 9 of the film 4 at the time of irradiation with the laser beam 21.

The chip fabrication method according to the second embodiment, in the laser beam irradiation step 101, irradiates the wafer 1 with the laser beam 21 along the planned division lines 6 and 7 set on the wafer 1, to form the ablation marks 11 in the laminated film 4 through ablation while forming the modified layers 12-2 inside the substrate 2 of the wafer 1. Consequently, the chip fabrication method according to the second

embodiment offers an advantageous effect that productivity is enhanced while the wafer 1 formed with the film 4 is securely divided into the individual chips 10, as in the first embodiment.

The present invention is not limited to the above embodiments. Various changes and modifications may be made therein without departing from the scope of the invention. For example, in the present invention, the processing conditions under which the irradiation with the laser beam 21 along the first planned division lines 6 is carried out may be the same as or different from the processing conditions under which the irradiation with the laser beam 21 along the second planned division lines 7 is carried out. In addition, while the film 4 is formed on the reverse surface 3 of the wafer 1 in the embodiments described above, the film 4 may be formed on the front surface 5 of the wafer 1 in the present invention.

The present invention is not limited to the details of the above described preferred embodiments. 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 chip fabrication method for fabricating chips by dividing a wafer having a film formed on a front surface or a reverse surface thereof, along a plurality of crossing planned division lines into individual chips, the chip fabrication method comprising:

a laser beam irradiation step of irradiating the wafer with a laser beam along the planned division lines set on the wafer, to form ablation marks in the film formed on the front surface or the reverse surface and to form modified regions inside the wafer; and

a division step of applying an external force to the wafer after the laser beam irradiation step has been carried out, to divide the wafer along the ablation marks formed in the laser beam irradiation step.

2. The chip fabrication method according to claim 1, wherein,

in the laser beam irradiation step, the wafer is irradiated with a laser beam along the planned division lines set on the wafer, the laser beam having a wavelength that is transmittable through the wafer and is absorbable to the film, with a condensing region of the laser beam positioned within a range from a position inside the wafer to a front surface of the film or to a

position shifted outward from the front surface of the film, to thereby simultaneously form the modified regions inside the wafer and the ablation marks in the film.

3. The chip fabrication method according to claim 1, wherein

the laser beam irradiation step includes
a modified region forming step of
irradiating the wafer with a laser beam having a wavelength transmittable through the wafer, with a condensing region of the laser beam positioned inside the wafer, to form the modified regions, and

after the modified region forming step has been carried out, an ablation mark forming step of
irradiating the wafer with a laser beam having a wavelength absorbable to the film, with a condensing region of the laser beam positioned in a vicinity of the film, to form the ablation marks.

4. The chip fabrication method according to any one of claims 1 to 3, wherein,

in the laser beam irradiation step, each of the modified regions formed inside the wafer has a pore and an amorphous part surrounding the pore.