CHIP MANUFACTURING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a chip manufacturing method for manufacturing a plurality of chips by dividing a wafer.

Description of the Related Art

In a fabrication process for semiconductor device chips, a semiconductor wafer having a plurality of devices such as integrated circuits (ICs) and large-scale integrated circuits (LSIs) is used, in which a plurality of division lines (streets) are formed on the front side of the semiconductor wafer to define a plurality of separate regions where the plural devices are respectively formed. By dividing the semiconductor wafer along the division lines, a plurality of semiconductor device chips respectively including the plural devices are obtained. Similarly, by dividing an optical device wafer having a plurality of optical devices such as light emitting diodes (LEDs), a plurality of optical device chips respectively including the plural optical devices are fabricated.

In dividing a wafer typically including such a

semiconductor wafer and an optical device wafer, a cutting apparatus is used, for example, in which the cutting apparatus includes a chuck table holding the wafer and an annular cutting blade cutting the wafer, the cutting blade being mounted on a spindle. In operation, the wafer is held on the chuck table, and the cutting blade is rotated to cut the wafer along each division line.

There is a case that a part of a metal layer constituting wiring and electrodes in each device is formed on each division line of the wafer. When the wafer is cut by using the cutting blade in this case, the cutting blade being rotated comes into contact with the metal layer formed on each division line, so that the metal layer is drawn by the cutting blade to cause the production of whisker-shaped burrs. The burrs may cause a short circuit of wiring and electrodes in each chip obtained by dividing the wafer and may further cause defective bonding of each chip. To cope with this problem, there has been proposed a technique of applying a laser beam to the wafer along each division line before cutting the wafer by using the cutting blade, thereby forming a laser processed groove on the wafer along each division line(see Japanese Patent Laid-Open No. 2006-190779, for

example). According to this technique, the metal layer formed on each division line can be removed by the application of the laser beam, thereby suppressing the production of burrs in subsequently cutting the wafer by using the cutting blade.

However, when the metal layer is removed by applying the laser beam to the wafer, debris containing metal is sometimes generated to adhere to the inside surface of each laser processed groove. In the case that this debris contains copper (Cu) and the wafer contains silicon (Si), it is confirmed that the debris coming into contact with the wafer is grown and enlarged in size with the elapse of time. Further, when the enlarged debris comes into contact with the metal layer included in each chip, there is a case that a short circuit of wiring and electrodes in each chip may be caused. It is therefore desirable to remove the debris. For example, Japanese Patent Laid-Open No. 2017-92363 discloses a technique of performing dry etching to remove the debris generated by the application of the laser beam. By removing the debris, it is possible to prevent a reduction in quality of each chip due to a short circuit of wiring and electrodes.

SUMMARY OF THE INVENTION

As described above, it is preferable to remove the debris generated by the application of the laser beam to the wafer, because the debris causes a reduction in quality of each chip. However, in the case of performing dry etching to remove the debris, it is necessary to use an apparatus performing dry etching, causing an increase in manufacturing cost for the chips.

It is therefore an object of the present invention to provide a chip manufacturing method which can suppress an increase in manufacturing cost for the chips and prevent a reduction in quality of each chip.

In accordance with an aspect of the present invention, there is provided a chip manufacturing method for manufacturing a plurality of chips by dividing a wafer containing Si, the wafer having a front side on which a plurality of division lines are formed to define a plurality of separate regions where a plurality of devices are respectively formed, a metal layer containing Cu being formed on each division line, the chip manufacturing method including a protective film forming step of forming a protective film on the front side of the wafer; a laser processed groove forming step of applying a laser beam to the front side of the wafer along each division line after performing the protective

film forming step, the laser beam having an absorption wavelength to the wafer, thereby removing the metal layer and forming a laser processed groove on the front side of the wafer along each division line; an enlargement promoting step of promoting the enlargement of debris generated by the formation of the laser processed groove and adhering to the inside surface of the laser processed groove, after performing the laser processed groove forming step; and a dividing step of dividing the wafer along the laser processed groove after performing the enlargement promoting step.

Preferably, the chip manufacturing method further includes a removing step of removing the protective film after performing the enlargement promoting step. Preferably, the dividing step is performed by using a cutting blade to cut the wafer along the laser processed groove, the cutting blade having a thickness smaller than the width of the laser processed groove, thereby dividing the wafer along the laser processed groove. Preferably, the enlargement promoting step is performed by placing the wafer in the environment where the temperature is in the range of 50°C to 200°C, thereby promoting the enlargement of the debris. Preferably, the enlargement promoting step is performed by placing the wafer in the

environment where the humidity is 75% or higher, thereby promoting the enlargement of the debris.

In the chip manufacturing method according to the present invention, a laser beam is applied to the wafer to thereby form a laser processed groove along each division line. Thereafter, the enlargement promoting step is performed to intentionally enlarge the debris adhering to the inside surface of each laser processed groove. By enlarging the debris, the debris can be easily removed in performing the subsequent step (e.g., the step of cutting the wafer by using a cutting blade). Accordingly, the debris can be easily removed without the need for performing any large-scale step. That is, an increase in manufacturing cost for the chips can be suppressed and a reduction in quality of each chip can be prevented.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view depicting a wafer;

FIG. 2 is a sectional view of the wafer depicted in FIG. 1;

FIG. 3 is a perspective view depicting a frame unit formed by supporting the wafer through an adhesive tape to an annular frame;

FIG. 4 is a sectional view depicting the wafer (the frame unit) in the condition where a protective film is formed on the wafer;

FIG. 5 is a perspective view depicting a laser processing apparatus;

FIG. 6A is a sectional view depicting the wafer (the frame unit) in the condition where a laser processed groove is formed on the wafer and debris is generated;

FIG. 6B is a sectional view depicting the wafer (the frame unit) in the condition where the debris has been enlarged;

FIG. 7 is a perspective view depicting a cutting apparatus; and

FIG. 8 is a sectional view depicting a dividing step using a cutting blade in the cutting apparatus depicted in FIG. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to the attached drawings. There will first be described a wafer that can be used in a chip manufacturing method according to this preferred embodiment.

FIG. 1 is a perspective view depicting a wafer 11. As depicted in FIG. 1, the wafer 11 is a disk-shaped member and has a front side 11a and aback side 11b. A plurality of crossing division lines (streets) 13 are formed on the front side 11a of the wafer 11 to thereby define a plurality of separate regions. A plurality of devices 15 such as ICs and LSIs are respectively formed in these plural separate regions. The wafer 11 is formed of a material containing Si. For example, the wafer 11 may be formed of Si, SiC, or SiGe. The wafer 11 is not limited in shape, size, etc. The devices 15 are not limited in kind, number, shape, structure, size, layout, etc.

FIG. 2 is a sectional view of the wafer 11 depicted in FIG. 1. As depicted in FIG. 2, a multilayer film 17 is formed on the front side 11a of the wafer 11. The multilayer film 17 includes metal layers and insulating layers constituting each device 15. A metal layer 19 containing Cu is formed between any adjacent ones of the

devices 15 so as to cover each division line 13. The metal layer 19 corresponds to wiring layers and electrodes constituting each device 15, for example. In FIG. 2, the multilayer film 17 and the metal layer 19 are separately depicted for convenience of illustration. However, the metal layer 19 may be a part of the multiple layers constituting the multilayer film 17, and a part of the metal layer 19 may be formed on each division line 13. That is, the multilayer film 17 may be connected to the metal layer 19 in an integral manner. However, the configuration of the metal layer 19 is not limited to the above. For example, the metal layer 19 may be a metal layer constituting a test element group (TEG) evaluating the operation of each device 15.

The wafer 11 is supported to an annular frame to thereby form a frame unit. FIG. 3 is a perspective view depicting a frame unit 25. As depicted in FIG. 3, the back side 11b of the wafer 11 is attached to a circular adhesive tape 21 at its central portion. The circular adhesive tape 21 is formed of resin, for example. The circular adhesive tape 21 has a diameter larger than that of the wafer 11. Further, a peripheral portion of the circular adhesive tape 21 is attached to an annular frame 23 having a circular inside opening 23a. That is, the

wafer 11 is supported through the adhesive tape 21 to the annular frame 23 in the condition where the wafer 11 is located in the inside opening 23a of the annular frame 23, thus forming the frame unit 25. Accordingly, the wafer 11 is supported to the adhesive tape 21 in the condition where the front side 11a of the wafer 11 is exposed upward.

By dividing the wafer 11 along the division lines 13, a plurality of chips respectively including the devices 15 can be obtained. For example, the wafer 11 may be divided by using an annular cutting blade to cut the wafer 11 along each division line 13. However, since the metal layer 19 is formed on each division line 13 as depicted in FIG. 2, there is a possibility that the metal contained in the metal layer 19 may come into contact with the cutting blade in cutting the wafer 11 along each division line 13, so that the metal may be drawn by the cutting blade being rotated, causing the production of whisker-shaped burrs. To cope with this problem, in this preferred embodiment, a laser beam is applied to the wafer 11 along each division line 13 to thereby remove the metal layer 19, before cutting the wafer 11 by using the cutting blade. Accordingly, it is possible to avoid the contact between the cutting blade and the metal layer

19 in dividing the wafer 11, thereby preventing the production of burrs. There will now be described a chip manufacturing method according to this preferred embodiment.

First, a protective film protecting the devices 15 is formed so as to cover the multilayer film 17 and the metal layer 19 on the front side 11a of the wafer 11 (protective film forming step). FIG. 4 is a sectional view depicting the wafer 11 in the condition where a protective film 27 is formed so as to cover the multilayer film 17 and the metal layer 19 on the front side 11a of the wafer 11. That is, the multilayer film 17 and the metal layer 19 are fully covered with the protective film 27 as depicted in FIG. 4. The protective film 27 is preferably formed of a water-soluble resin such as polyvinyl alcohol (PVA) and polyethylene glycol (PEG). By using such a water-soluble resin for the material of the protective film 27, the protective film 27 can be easily removed in a subsequent step.

Thereafter, a laser beam is applied to the wafer 11 along each division line 13 to thereby form a laser processed groove along each division line 13 as removing the metal layer 19 (laser processed groove forming step). That is, a laser processing apparatus is used to apply a

laser beam to the wafer 11. FIG. 5 is a perspective view depicting a laser processing apparatus 2. As depicted in FIG. 5, the laser processing apparatus 2 includes a chuck table 4 holding the wafer 11 and a laser processing unit 6 applying a laser beam to the wafer 11 held on the chuck table 4.

The wafer 11 is adapted to be held on the chuck table 4 under suction in the condition where the adhesive tape 21 attached to the wafer 11 is in contact with the upper surface of the chuck table 4. That is, the upper surface of the chuck table 4 functions as a holding surface holding the wafer 11. The holding surface of the chuck table 4 is connected through a suction passage (not depicted) to a vacuum source (not depicted) producing a vacuum, in which the suction passage is formed inside the chuck table 4. A plurality of clamps (not depicted) clamping the annular frame 23 are provided on the outer circumference of the chuck table 4. That is, the annular frame 23 supporting the wafer 11 held on the upper surface of the chuck table 4 is adapted to be fixed by the plural clamps. The chuck table 4 is connected to a moving mechanism (not depicted) and a rotating mechanism(not depicted) both provided below the chuck table 4. By operating the moving mechanism, the chuck

table 4 is movable both in the X direction (feeding direction) depicted by an arrow X in FIG. 5 and in the Y direction (indexing direction) depicted by an arrow Y in FIG. 5. Further, by operating the rotating mechanism, the chuck table 4 is rotatable about its axis substantially parallel to the Z direction (vertical direction) depicted by an arrow Z in FIG. 5. In operation, the wafer 11 is placed through the adhesive tape 21 on the holding surface of the chuck table 4 in the condition where the front side 11a of the wafer 11 is exposed upward (i.e., the protective film 27 is exposed upward). Further, by operating the clamps provided on the outer circumference of the chuck table 4, the annular frame 23 is fixed. Further, by operating the vacuum source to apply a vacuum to the holding surface of the chuck table 4, the wafer 11 is held through the adhesive tape 21 on the chuck table 4 under suction.

The laser processing unit 6 is located above the chuck table 4 in its working position as depicted in FIG. 5. The laser processing unit 6 is so configured as to focus a laser beam at a predetermined position, in which the laser beam has a wavelength at which at least a part of the laser beam is absorbed in the wafer 11 (i.e., the laser beam has an absorption wavelength to the wafer 11).

For example, the laser processing unit 6 includes a laser oscillator (not depicted) such as yttrium aluminum garnet (YAG) laser and yttrium vanadium tetra oxide (YVO_4) laser generating a pulsed laser beam and focusing means (not depicted) focusing the pulsed laser beam generated from the laser oscillator. Further, an imaging unit 8 imaging the wafer 11 held on the chuck table 4 is provided so as to be united with the laser processing unit 6. According to an image obtained by the imaging unit 8, the chuck table 4 and the laser processing unit 6 are controlled in position to thereby adjust the position of the laser beam to be applied to the wafer 11. In applying the laser beam to the wafer 11, the chuck table 4 is moved to the working position below the laser processing unit 6. Thereafter, the laser processing unit 6 is operated to apply the laser beam having an absorption wavelength to the wafer 11. At the same time, the chuck table 4 is moved in the feeding direction (the X direction). Accordingly, the laser beam is applied along a predetermined one of the division lines 13 to thereby form a linear laser processed groove in the wafer 11 along the predetermined division line 13. This laser processing operation is similarly performed along all of the other division lines 13 by further moving the chuck

table 4 in the indexing direction (the Y direction) and rotating the chuck table 4 about its vertical axis by 90 degrees.

FIG. 6A is a sectional view depicting the wafer 11 in the condition where a laser processed groove 11c is formed along each division line 13. When the laser beam is applied to the wafer 11, the front side 11a of the wafer 11 is subjected to ablation. More specifically, all of the protective film 27, the metal layer 19, and the front side 11a along each division line 13 are subjected to ablation. As a result, the laser processed groove 11c having a depth larger than the thickness of the metal layer 19 is formed along each division line 13 as depicted in FIG. 6A. The laser processed groove 11c extending along each division line 13 is formed by a pair of side walls 11d and 11e opposed to each other and a bottom surface 11f as depicted in FIG. 6A. Accordingly, the metal layer 19 formed along each division line 13 is removed by the laser processed groove 11c. A part of the metal layer 19 formed along each division line 13 may be left along the side walls 11d and 11e of the laser processed groove 11c as depicted in FIG. 6A.

When the metal layer 19 containing Cu is subjected to ablation as mentioned above, debris 29 containing Cu

is sometimes generated to adhere to the side walls 11d and 11e and the bottom surface 11f of each laser processed groove 11c as depicted in FIG. 6A. With the elapse of time in the condition where the debris 29 is left in each laser processed groove 11c, the debris 29 is grown to become larger in size. This enlargement of the debris 29 is considered to be due to there action of Cu contained in the debris 29, Si contained in the wafer 11, and water contained in the air. More specifically, the debris 29 generated by the application of the laser beam comes into contact with the side walls 11d and 11e or the bottom surface 11f of each laser processed groove 11c. As a result, Cu contained in the debris 29 reacts with Si contained in the wafer 11 to form Cu_3Si as the seeds for the growth of the debris 29. This Cu_3Si then reacts with water contained in the air to form a layer containing Cu_2O and Cu on the surface of Cu_3Si. Thus, it is estimated that the enlargement of the debris 29 may be caused by the above process. With the advance of the enlargement of the debris 29 adhering to the inside surface of each laser processed groove 11c, there is a possibility that the enlarged debris 29 may come into contact with the metal layer 19 to cause a short circuit and accordingly invite a reduction in quality of the chips obtained by

dividing the wafer 11. It is therefore preferable to remove the debris 29.

In this preferred embodiment, after forming each laser processed groove 11c on the wafer 11 by the application of the laser beam, a step of promoting the enlargement of the debris 29 adhering to the inside surface of each laser processed groove 11c is performed (enlargement promoting step). By promoting the enlargement of the debris 29, the enlarged debris 29 can be easily removed in performing a subsequent step (e.g., a step of cutting the wafer 11 by using a cutting blade). Accordingly, the debris 29 can be easily removed without the need for adding any large-scale step such as dry etching. As a result, an increase in manufacturing cost for the chips can be suppressed and are duction in quality of the chips can be prevented.

As described above, the enlargement of the debris 29 is assumed to be due to the reaction of Cu contained in the debris 29, Si contained in the wafer 11, and water contained in the air (this reaction will be hereinafter referred to as “enlargement reaction”). Accordingly, it is considered that promoting the enlargement reaction may result in promotion of the enlargement of the debris 29.

The enlargement reaction can be promoted by placing

the wafer 11 in the environment of high temperature or high humidity. For example, the wafer 11 is placed in the environment where the humidity is 75% or higher or the temperature is in the range of 50°C to 200°C, thereby promoting the enlargement reaction. Alternatively, the wafer 11 may be placed in the environment where these conditions (high temperature and high humidity) are both satisfied. As described above, the enlargement reaction includes the reaction of Cu_3Si and water. Accordingly, to promote the enlargement of the debris 29, it is preferable to place the wafer 11 in the high-humidity environment where the humidity is 75% or higher.

The step of promoting the enlargement reaction is not limited to the above. For example, the wafer 11 may be placed in the high-pressure environment where the pressure is higher than atmospheric pressure. Further, the wafer 11 may be placed in the environment where the temperature alternately changes between high temperature and low temperature. In this case, the high temperature may be set to a temperature (e.g., approximately 150°C) higher than room temperature, and the low temperature may be set to a temperature (e.g., approximately -65°C) lower than room temperature. Further, the adhesive tape 21 is preferably formed of a material having heat resistance to

such a degree that the supported condition of the wafer 11 by the adhesive tape 21 is not affected by the environment in performing the enlargement promoting step. In this case, it is unnecessary to peel the adhesive tape 21 from the wafer 11 before performing the enlargement promoting step, so that the manufacturing method can be simplified.

By performing the enlargement promoting step as mentioned above, the debris 29 adhering to the inside surface of each laser processed groove 11c is enlarged in size. FIG. 6B is a sectional view depicting the wafer 11 in the condition where the debris 29 has been enlarged by performing the enlargement promoting step. At the time the debris 29 is generated, the diameter of the debris 29 is approximately 1 μm or less, For example. In contrast, by promoting the enlargement reaction, the diameter of the debris 29 is increased to approximately 10 μm, for example.

After performing the enlargement promoting step, the wafer 11 is divided along each laser processed groove 11c (dividing step). In this preferred embodiment, the division of the wafer 11 is performed by using a cutting apparatus including an annular cutting blade to cut the wafer 11. FIG. 7 is a perspective view depicting a

cutting apparatus 10. As depicted in FIG. 7, the cutting apparatus 10 includes a chuck table 12 holding the wafer 11 and a cutting unit 14 having an annular cutting blade 18 cutting the wafer 11 held on the chuck table 12.

The wafer 11 is adapted to be held on the chuck table 12 under suction in the condition where the adhesive tape 21 attached to the wafer 11 is in contact with the upper surface of the chuck table 12. That is, the upper surface of the chuck table 12 functions as a holding surface holding the wafer 11. The holding surface of the chuck table 12 is connected through a suction passage (not depicted) to a vacuum source (not depicted) producing a vacuum, in which the suction passage is formed inside the chuck table 12. A plurality of clamps (not depicted) clamping the annular frame 23 are provided on the outer circumference of the chuck table 12. That is, the annular frame 23 supporting the wafer 11 held on the upper surface of the chuck table 12 is adapted to be fixed by the plural clamps. The chuck table 12 is connected to a moving mechanism (not depicted) and a rotating mechanism(not depicted) both provided below the chuck table 12. By operating the moving mechanism, the chuck table 12 is movable both in the X direction (feeding direction) depicted by an arrow X in FIG. 7 and

in the Y direction (indexing direction) depicted by an arrow Y in FIG. 7. Further, by operating the rotating mechanism, the chuck table 12 is rotatable about its axis substantially parallel to the Z direction (vertical direction) depicted by an arrow Z in FIG. 7. In operation, the wafer 11 is placed through the adhesive tape 21 on the holding surface of the chuck table 12 in the condition where the front side 11a of the wafer 11 is exposed upward (i.e., each laser processed groove 11c is exposed upward). Further, by operating the clamps provided on the outer circumference of the chuck table 12, the annular frame 23 is fixed. Further, by operating the vacuum source to apply a vacuum to the holding surface of the chuck table 12, the wafer 11 is held through the adhesive tape 21 on the chuck table 12 under suction.

The cutting unit 14 is located above the chuck table 12 in its working position as depicted in FIG. 7. The cutting unit 14 includes a spindle housing 16 and a spindle (not depicted) rotatably supported in the spindle housing 16, in which the spindle is connected to a rotational drive source (not depicted) such as a motor provided in the spindle housing 16. The spindle has a front end portion projecting outward from the spindle housing 16, and the annular cutting blade 18 is mounted

on this front end portion of the spindle. The cutting blade 18 is formed by binding abrasive grains such as diamond abrasive grains with a bond such as a metal bond, resin bond, and vitrified bond. By rotating the spindle, the cutting blade 18 is rotated about the axis of the spindle. Further, the wafer 11 held on the chuck table 12 is cut by the cutting blade 18 being rotated. Further, an imaging unit 20 imaging the wafer 11 held on the chuck table 12 is provided so as to be united with the cutting unit 14. According to an image obtained by the imaging unit 20, the chuck table 12 and the cutting unit 14 are controlled in position.

FIG. 8 is a sectional view depicting a condition that the wafer 11 is being cut by the cutting blade 18 in the dividing step. In cutting the wafer 11 by using the cutting blade 18, the cutting unit 14 is positioned in such a manner that the lower end 18a of the cutting blade 18 as viewed in FIG. 8 is lower in level than the back side 11b of the wafer 11. Further, the cutting blade 18 is aligned with a predetermined one of the plural laser processed grooves 11c (i.e., the plural division lines 13) extending in the X direction. In this condition, the chuck table 12 is moved in the feeding direction (the X direction), so that the cutting blade 18 and the wafer 11

are relatively moved along the division lines 13. Accordingly, the wafer 11 is cut along the predetermined laser processed groove 11c by the cutting blade 18. This cutting operation is similarly performed along all of the other laser processed grooves11c by further moving the chuck table 12 in the indexing direction (the Y direction) and rotating the chuck table 12 about its vertical axis by 90 degrees.

The width of the cutting blade 18 is smaller than the width of each laser processed groove 11c. Accordingly, the wafer 11 is cut along each laser processed groove 11c by the cutting blade 18 in such a manner that the cutting blade 18 does not come into contact with the side walls 11d and 11e of each laser processed groove 11c, that is, a spacing is defined between one side surface 18b of the cutting blade 18 and the side wall 11d of each laser processed groove 11c and an other spacing is defined between the other side surface 18c of the cutting blade 18 and the side wall 11e of each laser processed groove 11c. As described above, the metal layer 19 has already been removed from each laser processed groove 11c. Accordingly, the production of burrs due to the contact between the cutting blade 18 and the metal layer 19 can be avoided. At the same time, the cutting blade 18 comes

into contact with the enlarged debris 29 (see FIG. 6B) adhering to the inside surface of each laser processed groove 11c in cutting the wafer 11, so that the enlarged debris 29 can be removed by the cutting blade 18. As described above, the debris 29 present in each laser processed groove 11c has already been enlarged by performing the enlargement promoting step, so that the cutting blade 18 easily comes into contact into the enlarged debris 29 present in each laser processed groove 11c. Accordingly, the debris 29 present in each laser processed groove 11ccan be easily removed by the cutting blade 18 in cutting the wafer 11.

The specific thickness and position of the cutting blade 18 are suitably set according to the size of the debris 29. For example, the thickness and position of the cutting blade 18 are set in such a manner that in cutting the wafer 11 along each laser processed groove 11c, the spacing between the side surface 18b of the cutting blade 18 and the side wall 11d of each laser processed groove 11c is smaller than the diameter (e.g., approximately 10 μm) of the enlarged debris 29 and the spacing between the side surface 18c of the cutting blade 18 and the side wall 11e of each laser processed groove 11c is also smaller than the diameter of the enlarged debris 29. As a

modification, the cutting operation using the cutting blade 18 may be performed twice along each laser processed groove 11c to thereby separately effect the removal of the debris 29 adhering to the side wall 11d and the removal of the debris 29 adhering to the side surface 11e.

In the dividing step mentioned above, the division of the wafer 11 and the removal of the debris 29 can be effected simultaneously. Accordingly, the debris 29 can be removed without the need for performing any additional step. In cutting the wafer 11 by using the cutting blade 18, a cutting water such as pure water is supplied to the cutting blade 18 and the wafer 11. By supplying the cutting water, the cutting blade 18 and the wafer 11 are cooled and any dust (cutting dust) generated in the cutting operation is washed away by the cutting water. At this time, the debris 29 removed by the cutting blade 18 can also be washed away together with the cutting dust by the cutting water. Accordingly, it is possible to prevent that the debris 29 may be left on the wafer 11.

Further, in the case that the protective film 27 is formed of a water-soluble resin, the protective film 27 can be removed by the cutting water supplied to the wafer 11 in the dividing step. Thus, the removal of the

protective film 27 can also be effected in performing the dividing step, so that it is unnecessary to perform any additional step removing the protective film 27. That is, the manufacturing method can be simplified. However, in the case hat the protective film 27 is still left on the wafer 11 after performing the dividing step, a cleaning water such as pure water may be supplied to the wafer 11, thereby removing the protective film 27. That is, a removing step of removing the protective film 27 may be performed after performing the dividing step. The removal of the protective film 27 may be effected by spraying a mixed fluid to the wafer 11, in which this mixed fluid is composed of pure water and gas (e.g., air).

When the wafer 11 is cut along all of the division lines 13, the dividing step is finished to obtain the plural chips. That is, the wafer 11 is divided into the plural chips respectively including the plural devices 15. In this preferred embodiment, the debris 29 is removed in the dividing step as described above, so that the adherence of the debris 29 to each chip can be avoided to thereby prevent a reduction in quality of each chip.

While the dividing step is performed by using the cutting blade 18 to cut the wafer 11 in this preferred embodiment, the method dividing the wafer 11 is not

limited to the above. For example, the dividing step may be performed by using a laser processing apparatus or a plasma etching apparatus. In the case of using a laser processing apparatus in the dividing step, a laser beam is applied along each laser processed groove 11c to thereby form a modified layer inside the wafer 11 along each division line 13 (along each laser processed groove 11c). In an area where the modified layer is formed, the strength of the wafer 11 is smaller than that in the other area of the wafer 11. That is, the area including the modified layer is more brittle than the other area of the wafer 11. Accordingly, by applying an external force to the wafer 11 having the modified layer, the wafer 11 is divided along each division line 13 where the modified layer is formed as a division start point. The external force may be applied by expanding the adhesive tape 21 attached to the wafer 11. In the case of using a plasma etching apparatus, a mask is formed so as to cover any are other than each laser processed groove 11c of the wafer 11. Thereafter, the wafer 11 is processed by plasma etching. Accordingly, the wafer 11 is etched along each laser processed groove 11c and accordingly divided into the plural chips.

In the case of dividing the wafer 11 by performing

any method other than the above cutting method using the cutting blade 18, a removing step of removing the protective film 27 is performed after performing the enlargement promoting step. In this removing step, a cleaning water such as pure water is supplied to the wafer 11 to remove the protective film 27 formed of a water-soluble resin. For example, the cleaning water such as pure water is sprayed from a nozzle to ward the wafer 11 in the removing step. By spraying the cleaning water toward the wafer 11, the protective film 27 can be removed and the enlarged debris 29 adhering to the inside surface of each laser processed groove 11c can also be washed away by the cleaning water.

In the chip manufacturing method according to this preferred embodiment described above, a laser beam is applied to the wafer 11 to thereby form the laser processed groove 11c along each division line 13. Thereafter, the enlargement promoting step is performed to intentionally enlarge the debris 29 adhering to the inside surface of each laser processed groove 11c. By enlarging the debris 29, the debris 29 can be easily removed in performing the subsequent step(e.g., the step of cutting the wafer 11 by using the cutting blade 18). Accordingly, the debris 29 can be easily removed without

the need for adding any large-scale step. That is, an increase in manufacturing cost for the chips can be suppressed and a reduction in quality of each chip can be prevented.

Note that the structure, method, etc. according to this preferred embodiment may be suitably modified without departing from the scope of the object of the present invention.

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 chip manufacturing method for manufacturing a plurality of chips by dividing a wafer containing silicon, the wafer having a front side on which a plurality of division lines are formed to define a plurality of separate regions where a plurality of devices are respectively formed, a metal layer containing copper being formed on each division line, the chip manufacturing method comprising:

a protective film forming step of forming a protective film on the front side of the wafer;

a laser processed groove forming step of applying a laser beam to the front side of the wafer along each division line after performing the protective film forming step, the laser beam having an absorption wavelength to the wafer, thereby removing the metal layer and forming a laser processed groove on the front side of the wafer along each division line;

an enlargement promoting step of promoting the enlargement of debris generated by the formation of the laser processed groove and adhering to the inside surface of the laser processed groove, after performing the laser processed groove forming step; and

a dividing step of dividing the wafer along the

laser processed groove after performing the enlargement promoting step.

2. The chip manufacturing method according to claim 1, further comprising:

a removing step of removing the protective film after performing the enlargement promoting step.

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

the dividing step is performed by using a cutting blade to cut the wafer along the laser processed groove, the cutting blade having a thickness smaller than the width of the laser processed groove, thereby dividing the wafer along the laser processed groove.

4. The chip manufacturing method according to claim 1, wherein

the enlargement promoting step is performed by placing the wafer in the environment where the temperature is in the range of 50°C to 200°C, thereby promoting the enlargement of the debris.

5. The chip manufacturing method according to claim 1, wherein

the enlargement promoting step is performed by placing the wafer in the environment where the humidity is 75% or higher, thereby promoting the enlargement of

the debris.