

INSPECTION SUBSTRATE AND INSPECTING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an inspection substrate for use in inspecting a laser beam for leakage light possibly produced in processing a workpiece with the laser beam, and also relates to an inspecting method for inspecting the laser beam for leakage light by using this inspection substrate.

Description of the Related Art

Conventionally known is a disk-shaped wafer having a plurality of semiconductor devices, in which a plurality of crossing division lines (streets) are set on the front side of the wafer to thereby define a plurality of separate regions where the plural semiconductor devices are respectively formed. For example, a laser processing apparatus is used to divide the wafer along the streets and to thereby manufacture a plurality of semiconductor chips respectively including the plural semiconductor devices. In processing the wafer by using the laser processing apparatus, a pulsed laser beam having a transmission wavelength to the wafer is applied to the back side of the wafer along each street in the

condition where the focal point of the laser beam is set inside the wafer. As a result, multiphoton absorption occurs in the vicinity of the focal point of the laser beam applied, so that a modified layer reduced in mechanical strength is formed inside the wafer along each street. Thereafter, an external force is applied to the wafer to thereby divide the wafer along each street where the modified layer has been formed to function as a break start point.

Usually, plural modified layers are formed at different depths inside the wafer along each street. For example, the focal point is first positioned at a predetermined depth from the back side of the wafer (i.e., the upper surface to which the laser beam is to be applied), and the laser beam is applied to the back side of the wafer along any one street. The laser beam is thus applied once along this street (i.e., the laser beam is applied as a first pass along this street), thereby forming a first modified layer at this predetermined depth along this street. Thereafter, the focal point is shifted upward toward the back side of the wafer by a predetermined distance, and the laser beam is then applied once again along this street (the same street) (i.e., the laser beam is applied as a second pass along

this street), thereby forming a second modified layer just above the first modified layer previously formed. The operation of upward shifting the focal point toward the back side of the wafer by the predetermined distance and the operation of next applying the laser beam along the same street are repeated to thereby form plural (e.g., two to five) modified layers inside the wafer along the same street.

In forming the plural modified layers along the same street as mentioned above, the laser beam is absorbed in the wafer mainly at the focal point set at the predetermined depth. However, there is a case in which a part of the laser beam may be refracted or reflected by the modified layer previously formed at the depth lower than the predetermined depth or by a crack extending from this modified layer. There is a possibility for this refracted or reflected part of the laser beam to become leakage light (i.e., the light deflected beyond the target area (street) to reach the semiconductor device adjacent to this street). Specifically, the leakage light may reach the semiconductor device formed in each separate region on the front side of the wafer as defined by the streets. In this case, there is a possibility for the semiconductor

device to be damaged by the leakage light. To eliminate this possibility of the leakage light reaching the semiconductor device, the conditions of application of the laser beam (i.e., laser processing conditions) must suitably be selected. To cope with this problem, there has been proposed a technique including the steps of forming a coating layer of tin (Sn) or oil-based ink, for example, on the front side of a wafer, next applying a laser beam to the back side of the wafer, and next checking for leakage light reaching the front side of the wafer (see Japanese Patent Laid-open No. 2017-216413, for example).

SUMMARY OF THE INVENTION

However, in the above technique described in Japanese Patent Laid-open No. 2017-216413, the coating layer is partially modified in an area by the leakage light, and this modified area is merely observed. That is, there is no technique of quantitatively evaluating the modified area generated by the leakage light. It is therefore an object of the present invention to provide an inspection substrate for use in inspecting a laser beam for leakage light, so as to quantitatively evaluate such a modified area generated by the leakage light.

It is another object of the present invention to provide an inspecting method for inspecting a laser beam for leakage light by using this inspection substrate.

In accordance with an aspect of the present invention, there is provided an inspection substrate for use in inspecting a laser beam for leakage light, the laser beam having a transmission wavelength to the inspection substrate, the inspection substrate including a first surface to which the laser beam is to be applied, a second surface opposite to the first surface, a street set on the second surface; a plurality of first inspection wires provided on the second surface so as to extend along the street, the plurality of first inspection wires being located at different distances from the street, and a plurality of first electrode pads provided on each of the plurality of first inspection wires so as to be spaced from each other in a direction along the street.

Preferably, the inspection substrate further includes a plurality of second inspection wires provided on the second surface so as to extend along the street, the plurality of second inspection wires being spaced from the plurality of first inspection wires along the street, the plurality of second inspection wires being

located at different distances from the street.

In accordance with another aspect of the present invention, there is provided an inspecting method for inspecting a laser beam for leakage light by using an inspection substrate, the laser beam having a transmission wavelength to the inspection substrate, the inspection substrate including a first surface to which the laser beam is to be applied; a second surface opposite to the first surface, a street set on the second surface, a plurality of first inspection wires provided on the second surface so as to extend along the street, the plurality of first inspection wires being located at different distances from the street, and a plurality of first electrode pads provided on each of the plurality of first inspection wires so as to be spaced from each other in a direction along the street; the inspecting method including a holding step of holding the second surface side of the inspection substrate on a chuck table; a laser processing step of applying the laser beam to the first surface of the inspection substrate along the street after performing the holding step, thereby forming a modified layer inside the inspection substrate along the street; and a leakage light checking step of bringing a probe into contact with each of the first electrode

pads after performing the laser processing step, thereby determining whether or not each first inspection wire has been broken by the leakage light and checking for the leakage light.

The inspection substrate according to the present invention has the plural first inspection wires and the plural first electrode pads on the second surface opposite to the first surface to which the laser beam is to be applied. The plural first inspection wires extend along the street and they are located at different distances from the street. The plural first electrode pads are provided on each of the plural first inspection wires, and these electrode pads are spaced from each other in a direction along the street. In performing a continuity test on the first inspection wires, the laser beam is applied to the first surface of the inspection substrate along the street. Thereafter, a probe is brought into contact with one of the two adjacent first electrode pads, for example, and another probe is brought into contact with the other first electrode pad. Thereafter, a current is passed between the two probes to thereby check each first inspection wire for any break caused by the leakage light. Accordingly, by identifying the position (the distance from the street) of the first

inspection wire broken due to the leakage light, the influence of the leakage light can be evaluated quantitatively.

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 of a frame unit including an inspection substrate according to the present invention;

FIG. 2 is an enlarged plan view of an essential part of a device area according to a first preferred embodiment;

FIG. 3 is a partially sectional side view of the frame unit and a laser processing apparatus;

FIG. 4 is an enlarged view of an enclosed area C depicted in FIG. 3;

FIG. 5A is an enlarged plan view of an essential part of the device area similar to FIG. 2, depicting an

example of the result of a laser processing operation;

FIG. 5B is a view similar to FIG. 5A, depicting another example;

FIG. 6 is a flowchart depicting an inspecting method according to the present invention;

FIG. 7 is a view similar to FIG. 2, depicting a second preferred embodiment; and

FIG. 8 is a view similar to FIG. 2, depicting a third preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described with reference to the attached drawings. FIG. 1 is a perspective view of a frame unit 1. The frame unit 1 has an inspection substrate 11 for use in inspecting a laser beam for leakage light. The inspection substrate 11 is a disk-shaped member having a circular front surface (second surface) 11a and a circular back surface (first surface) 11b opposite to the front surface 11a. The inspection substrate 11 has a thickness of approximately 500 μm to 1000 μm . The inspection substrate 11 is a wafer formed from a silicon (Si) substrate. However, the material of the inspection substrate 11 is not limited to silicon, and various other materials may

be adopted. Other examples of the material of the inspection substrate 11 include other semiconductors, sapphire, and various kinds of glass. Examples of the other semiconductors include gallium arsenide (GaAs), silicon carbide (SiC), and gallium nitride (GaN).

A plurality of crossing streets 13 are set on the front surface 11a of the inspection substrate 11. The plurality of crossing streets 13 are composed of a plurality of parallel streets 13 extending in a first direction depicted by an arrow A in FIG. 1 and a plurality of parallel streets 13 extending in a second direction depicted by an arrow B in FIG. 1, the second direction B being perpendicular to the first direction A. The first direction A is composed of a positive direction pointed by the head of the arrow A and a negative direction opposite to the positive direction. This positive direction will hereinafter be referred to as +A direction, and this negative direction will hereinafter be referred to as -A direction. Similarly, the second direction B is composed of a +B direction pointed by the head of the arrow B and a -B direction opposite to the +B direction. A plurality of rectangular separate regions are defined by these plural crossing streets 13, and a plurality of devices 15a and a plurality of inspection

areas 15b are provided in these plural separate regions. In the following description, the area where the plural devices 15a and the plural inspection areas 15b are provided will be referred to as a device area 15A. For example, some of all the devices 15a are arranged in a line along the first direction A, and some of all the inspection areas 15b are arranged in a line along the first direction A so as to be adjacent to this line of the devices 15a in the second direction B. The other devices 15a and the other inspection areas 15b are similarly arranged so as to be arrayed alternately in the second direction B. In this manner, a plurality of lines of the devices 15a and a plurality of lines of the inspection areas 15b are alternately arrayed in the second direction B from one end to the other end of the device area 15A.

However, the arrangement of the devices 15a and the inspection areas 15b is not limited to the above example. As a modification, the plural devices 15a may be arranged linearly in the second direction B and the plural inspection areas 15b may be arranged linearly in the second direction B. In such case, the plural lines of the devices 15a and the plural lines of the inspection areas 15b may be arrayed alternately in the first direction A

from one end to the other end of the device area 15A. As another modification, the plural devices 15a and the plural inspection areas 15b may be arranged alternately both in the first direction A and in the second direction B (i.e., in a checker-like manner). As another modification, the devices 15a may not be provided in the device area 15A. In this case, all of the separate regions defined by the plural crossing streets 13 are used for the inspection areas 15b.

The inspection areas 15b will now be described in more detail. FIG. 2 is an enlarged plan view of an essential part of the device area 15A according to a first preferred embodiment. In FIG. 2, for convenience of illustration, the streets 13 extending in the first direction A are illustrated as streets 13-1, and the streets 13 extending in the second direction B are illustrated as streets 13-2. In FIG. 2, there are depicted two devices 15a arranged in the first direction A, two inspection areas 15b arranged in the first direction A so as to be juxtaposed to these two devices 15a in the second direction B, and other two devices 15a arranged in the first direction A so as to be juxtaposed to these two inspection areas 15b in the second direction B.

Each inspection area 15b has plural first inspection wires 23a (23a-1, 23a-2, 23a-3, 23a-4, and 23a-5) provided on the front surface (second surface) 11a side. Each of the first inspection wires 23a extends along the street 13-2 interposed between the adjacent inspection areas 15b. Each of the first inspection wires 23a is a thin-film conductor layer formed of a conductive material such as tin (Sn). Each of the first inspection wires 23a has a width and thickness such that the conductor layer is broken by a laser beam having a predetermined level of energy. Accordingly, each of the first inspection wires 23a can be broken by the leakage light of the laser beam having a predetermined level of energy. For example, each of the first inspection wires 23a has a width of 10 nm to 5 μm and a thickness corresponding to the thickness of one of stacked conductor layers provided in each device 15a (e.g., a thickness of 10 nm to 1 μm).

The first inspection wires 23a-1 to 23a-5 are located at different distances from the street 13-2. The first inspection wire 23a-1 is adjacent to the street 13-2. The other first inspection wires 23a-2, 23a-3, 23a-4, and 23a-5 are farther in this order from the first inspection wire 23a-1. In other words, the first

inspection wire 23a-2 is nearest to the first inspection wire 23a-1, and the first inspection wire 23a-5 is farthest from the first inspection wire 23a-1.

Any adjacent ones of the plural first inspection wires 23a are spaced a predetermined distance. For example, this predetermined distance between any adjacent ones of the plural first inspection wires 23a is almost equal to the length of one side of a substantially square first electrode pad 25a to be described below. The plural first inspection wires 23a have different lengths along the second direction B. That is, the larger the distance from the street 13-2, the shorter the length of each of the first inspection wires 23a. In other words, the first inspection wire 23a-1 is longest and the first inspection wire 23a-5 is shortest among the first inspection wires 23a.

The centers of the first inspection wires 23a-1 to 23a-5 in the second direction B are aligned in the first direction A. That is, the center positions of the first inspection wires 23a-1 to 23a-5 in the second direction B are the same position. Accordingly, both ends of the first inspection wire 23a-1 are positioned outside both ends of the first inspection wire 23a-2 in the second direction B. Both ends of the first inspection wire 23a-2

are positioned outside both ends of the first inspection wire 23a-3 in the second direction B. Both ends of the first inspection wire 23a-3 are positioned outside both ends of the first inspection wire 23a-4 in the second direction B. Both ends of the first inspection wire 23a-4 are positioned outside both ends of the first inspection wire 23a-5 in the second direction B.

Each of the first inspection wires 23a is provided with a pair of first electrode pads 25a at two distance positions spaced from each other in the second direction B along the street 13-2 (more specifically, at both ends of each of the first inspection wires 23a). That is, the pair of first electrode pads 25a is connected to both ends of each of the first inspection wires 23a. For example, each first electrode pad 25a has a substantially square shape, and each side has a length of tens of micrometers. One side of the square first electrode pad 25a is positioned at one end of each first inspection wire 23a. Each first electrode pad 25a is a conductor layer formed of tin, for example, and has the same thickness as that of each first inspection wire 23a. However, one side of each first electrode pad 25a has a length larger than the width of each first inspection wire 23a.

Plural second inspection wires 23b (23b-1, 23b-2, 23b-3, 23b-4, and 23b-5) are provided adjacent to the first inspection wires 23a along the street 13-2 at a given distance from the first inspection wires 23a. Similarly to the first inspection wires 23a, the second inspection wires 23b are located at different distances from the street 13-2. The second inspection wire 23b-1 is adjacent to the street 13-2. The other second inspection wires 23b-2, 23b-3, 23b-4, and 23b-5 are farther in this order from the second inspection wire 23b-1. In other words, the second inspection wire 23b-2 is nearest to the second inspection wire 23b-1, and the second inspection wire 23b-5 is farthest from the second inspection wire 23b-1. Further, any adjacent ones of the plural second inspection wires 23b are spaced a predetermined distance.

Similarly to the first inspection wires 23a, the second inspection wires 23b have different lengths along the second direction B. That is, the larger the distance from the street 13-2, the shorter the length of each of the second inspection wires 23b. Further, the centers of the second inspection wires 23b-1 to 23b-5 in the second direction B are aligned in the first direction A. Further, a pair of second electrode pads 25b is connected to both ends of each of the second inspection wires 23b. Each

second electrode pad 25b has the same shape and size as those of each first electrode pad 25a, and each second electrode pad 25b is formed of tin. One side of the square second electrode pad 25b is positioned at one end of each second inspection wire 23b.

Assuming that the plural first inspection wires 23a-1 to 23a-5 constitute a first set 23A and the plural second inspection wires 23b-1 to 23b-5 constitute a second set 23B, plural first sets 23A and plural second sets 23B are alternately arranged along the street 13-2 so as to be spaced a given distance in the second direction B. To minimize this given distance between the first set 23A and the second set 23B adjacent to each other, the distance between the first electrode pad 25a and the second electrode pad 25b adjacent to each other in the second direction B is set smaller than the length of one side of each first electrode pad 25a. More specifically, the distance between the first electrode pad 25a and the second electrode pad 25b adjacent to each other in the second direction B is set equal to the spot diameter of the laser beam to be applied. In this manner, the plural first sets 23A and the plural second sets 23B are provided in the vicinity of the street 13-2 in one inspection area 15b so as to be arranged alternately and

closely in the second direction B from one end to the other thereof (i.e., from the front end of the +B direction to the front end of the -B direction).

Similarly, another plural first sets 23A and another plural second sets 23B are also provided in the vicinity of the street 13-2 in another inspection area 15b adjacent to the above inspection area 15b with the street 13-2 interposed therebetween in the first direction A so as to be arranged alternately and closely in the second direction B from one end to the other end thereof. Further, in the same inspection area 15b, another plural first sets 23A and another plural second sets 23B are also provided in the vicinity of the street 13-1 along one side of the inspection area 15b in the +B direction so as to be arranged alternately and closely in the first direction A from one end to the other end thereof.

Further, in the same inspection area 15b, another plural first sets 23A and another plural second sets 23B are also provided in the vicinity of the street 13-1 along the other side of the inspection area 15b in the -B direction so as to be arranged alternately and closely in the first direction A from one end to the other end thereof. In FIG. 2, for convenience of illustration, some

of the plural first inspection wires 23a and some of the plural second inspection wires 23b are simply depicted as inspection wires 23. Similarly, some of the plural first electrode pads 25a and some of the plural second electrode pads 25b are simply depicted as electrode pads 25.

Referring back to FIG. 1, the frame unit 1 will now be described in more detail. A peripheral marginal area 15B is present around the device area 15A on the front surface 11a side of the inspection substrate 11. That is, the devices 15a and the inspection areas 15b are not provided in this peripheral marginal area 15B. A notch 11c indicating the crystal orientation of the wafer is formed on the outer circumference of the inspection substrate 11. As a modification, the notch 11c may be replaced by any other mark such as an orientation flat.

The inspection substrate 11 is supported through a circular dicing tape 17 to a ring frame 19 having a circular inside opening. The ring frame 19 is formed of metal. The dicing tape 17 is an expandable film formed of resin. The dicing tape 17 has a laminated structure composed of an adhesive resin layer (not depicted) having adhesion and a base resin layer (not depicted) having no adhesion. The adhesive resin layer is formed of

ultraviolet light curable resin, for example. The adhesive resin layer is formed on the whole of one side of the base resin layer. When ultraviolet light is applied to the adhesive resin layer, the adhesion of the adhesive resin layer is decreased, so that the dicing tape 17 can easily be peeled off from the inspection substrate 11. The inside opening of the ring frame 19 has a diameter larger than that of the inspection substrate 11 and smaller than that of the dicing tape 17. In supporting the inspection substrate 11 through the dicing tape 17 to the ring frame 19, the inspection substrate 11 is disposed in the inside opening of the ring frame 19, and the adhesive resin layer (upper surface as viewed in FIG. 1) of the dicing tape 17 is attached to the front surface 11a side (lower surface side as viewed in FIG. 1) of the inspection substrate 11 and is also attached to one side (lower surface as viewed in FIG. 1) of the ring frame 19. That is, the central portion of the dicing tape 17 is attached to the front surface 11a side of the inspection substrate 11, and the peripheral portion of the dicing tape 17 is attached to the ring frame 19, thus forming the frame unit 1.

There will now be described an inspecting method for inspecting the laser beam for leakage light with

reference to FIGS. 3, 4, 5A, 5B, and 6. FIG. 6 is a flowchart depicting the inspecting method. In the inspecting method according to the first preferred embodiment, the frame unit 1 is first held on a chuck table 12 included in a laser processing apparatus 10 depicted in FIG. 3 (holding step S10). FIG. 3 is a partially sectional side view of the frame unit 1 and the laser processing apparatus 10. The laser processing apparatus 10 has the chuck table 12 for holding the frame unit 1. A disk-shaped porous plate (not depicted) is provided on the upper surface of the chuck table 12. The porous plate is formed of porous ceramic, for example. A suction passage (not depicted) is formed inside the chuck table 12. The porous plate is connected through this suction passage to a vacuum source (not depicted) such as an ejector for producing a vacuum. Accordingly, a suction force can be generated on the upper surface (i.e., holding surface 12a) of the porous plate by the vacuum produced from the vacuum source.

A plurality of clamp units 14 are fixed to the outer circumferential surface of the chuck table 12. For example, four clamp units 14 are arranged at equal intervals in the circumferential direction of the chuck table 12. The clamp units 14 function to fix the ring

frame 19 of the frame unit 1 held on the chuck table 12. An X moving unit (not depicted) and a Y moving unit (not depicted) are provided below the chuck table 12. The X moving unit has a ball screw mechanism for moving the chuck table 12 in the X direction depicted by an arrow X in FIG. 3. Similarly, the Y moving unit has a ball screw mechanism for moving the chuck table 12 in the Y direction depicted by an arrow Y in FIG. 3, the head of the arrow Y being pointed to the front side of the sheet plane of FIG. 3. That is, the Y direction is perpendicular to the X direction in a horizontal plane. The X direction is composed of a +X direction pointed by the head of the arrow X and a -X direction opposite to the +X direction. Similarly, the Y direction is composed of a +Y direction pointed by the head of the arrow Y and a -Y direction opposite to the +Y direction. The chuck table 12 is connected to a rotational drive source (not depicted) such as a motor. Accordingly, the chuck table 12 is rotatable by the rotational drive source about a vertical axis (the center axis of the chuck table 12) substantially parallel to the Z direction (vertical direction) depicted by an arrow Z in FIG. 3. The Z direction is composed of a +Z direction pointed by the head of the arrow Z and a -Z direction opposite to the +Z

direction. A processing head 16 constituting a laser beam applying unit (not depicted) included in the laser processing apparatus 10 is provided above the chuck table 12. The processing head 16 functions to apply a pulsed laser beam L toward the holding surface 12a in a direction substantially perpendicular thereto. The pulsed laser beam L has a transmission wavelength to the inspection substrate 11.

In the holding step S10, the frame unit 1 is first placed on the holding surface 12a of the chuck table 12 in the condition where the back surface 11b of the inspection substrate 11 is oriented upward. Thereafter, the vacuum source is operated to apply a vacuum to the holding surface 12a. Further, the clamp units 14 are operated to fix the ring frame 19 in position. Accordingly, the front surface (second surface) 11a side of the inspection substrate 11 opposite to the back surface (first surface) 11b is held under suction through the dicing tape 17 on the chuck table 12.

Thereafter, the laser beam L is applied to the back surface (first surface) 11b of the inspection substrate 11 along the streets 13 by using the laser processing apparatus 10 (laser processing step S20). In the laser processing step S20, the rotational drive source

connected to the chuck table 12 is operated to rotate the chuck table 12 so that the streets 13-2 extending in the second direction B become parallel to the X direction. Thereafter, the X moving unit is operated to adjust the position of the chuck table 12 so that the lower end of the processing head 16 is positioned above an extension of a predetermined one of the streets 13-2 while extending in the +X direction. Thereafter, the vertical position of the processing head 16 is adjusted so that the focal point of the laser beam L is positioned inside the inspection substrate 11. Thereafter, the laser beam L is applied from the processing head 16 to the back surface 11b of the inspection substrate 11.

Thereafter, the X moving unit is operated in the condition where the laser beam L applied to the back surface 11b of the inspection substrate 11 is focused inside the inspection substrate 11, thereby moving the chuck table 12 in the +X direction. That is, the processing head 16 is relatively moved in the -X direction with respect to the chuck table 12, and the laser beam L is applied along this predetermined street 13-2 (first pass). As a result, a first modified layer 11d as a lowest layer near the front surface 11a is formed inside the inspection substrate 11 along the

predetermined street 13-2.

After performing the first pass, the processing head 16 is raised in the +Z direction to upward shift the vertical position of the focal point toward the back surface 11b by a predetermined distance. Thereafter, the chuck table 12 is moved in the -X direction along the same predetermined street 13-2 while the laser beam L is applied (second pass). As a result, a second modified layer 11d as a second lowest layer is formed just above the first modified layer 11d along the same predetermined street 13-2. After performing the second pass, the processing head 16 is further raised in the +Z direction to upward shift the vertical position of the focal point toward the back surface 11b by the predetermined distance. Thereafter, the chuck table 12 is moved in the +X direction along the same predetermined street 13-2 while the laser beam L is applied (third pass). As a result, a third modified layer 11d as a third lowest layer is formed just above the second modified layer 11d along the same predetermined street 13-2.

Thereafter, a similar operation is repeated to apply the laser beam L as a fourth pass and the laser beam L as a fifth pass along the same predetermined street 13-2, thereby forming a fourth modified layer 11d

and a fifth modified layer 11d inside the inspection substrate 11 along the same predetermined street 13-2. Thereafter, the application of the laser beam L is once stopped. For example, the laser processing conditions in applying the laser beam L are set as follows:

Wavelength of the laser beam L: 1342 nm

Repetition frequency of the pulses: 90 kHz

Average power: 1.9 W

Spot diameter: 10 μm to 20 μm

Feed speed: 700 mm/s

Thereafter, the chuck table 12 is moved (indexed) in the Y direction (e.g., +Y direction) by a predetermined index amount, thereby positioning the lower end of the processing head 16 above the next street 13-2 adjacent to the above predetermined street 13-2 in the Y direction (e.g., -Y direction). Thereafter, a similar operation is repeated to apply the laser beams L as a first pass to a fifth pass. This operation is repeated along all of the other streets 13-2 extending in the second direction B, thereby forming similar five modified layers 11d inside the inspection substrate 11 along each street 13-2. Thereafter, the chuck table 12 is rotated 90 degrees to make the first direction A of the streets 13-1 parallel to the X direction. Thereafter, a similar

operation is repeated to apply the laser beams L as a first pass to a fifth pass along each street 13-1. As a result, similar five modified layers 11d are formed inside the inspection substrate 11 along each street 13-1. Thus, the five modified layers 11d are formed inside the inspection substrate 11 along each of all the crossing streets 13. The number of the modified layers 11d along each street 13 is not limited to five, and may be set to two or more.

In applying the laser beam L, there is a case in which a part of the laser beam L may be refracted or reflected to produce leakage light D (see FIG. 4) (i.e., the light being deflected beyond the target area (the street 13) to reach the adjacent device 15a). For example, in forming the second modified layer 11d, a crack 11e is formed so as to extend from the first modified layer 11d to the second modified layer 11d as depicted in FIG. 4, so that a part of the laser beam L may be refracted or reflected by the crack 11e to produce the leakage light D.

FIG. 4 is an enlarged view of an enclosed area C in FIG. 3. FIG. 4 depicts the leakage light D produced in forming the second modified layer 11d. When the leakage light D having a predetermined level of energy is deflected beyond the street 13-2 to reach any one of the

first inspection wires 23a, in the inspection area 15b, the first inspection wire 23a is damaged by the leakage light D to cause a break, for example. After performing the laser processing step S20, each inspection wire 23 is thus checked for any break caused by the leakage light D (leakage light checking step S30). Before performing the leakage light checking step S30, another tape (not depicted) is attached to the back surface (first surface) 11b side of the inspection substrate 11, and ultraviolet light is next applied to the dicing tape 17 to reduce the adhesion of the adhesive resin layer of the dicing tape 17. Thereafter, the dicing tape 17 is peeled off from the inspection substrate 11 by using a peeling apparatus (not depicted).

Thereafter, the leakage light checking step S30 is performed. In the leakage light checking step S30, an inspection jig (not depicted) such as a wafer prober is used to check each inspection wire 23 for any break caused by the leakage light D. The inspection jig has a plurality of probes adapted to come into contact with the electrode pads 25. More specifically, a first probe of the inspection jig is brought into contact with the first electrode pad 25a located at one end of the first inspection wire 23a-1, and a second probe of the

inspection jig is brought into contact with the first electrode pad 25a located at the other end of the first inspection wire 23a-1. In this condition, current is applied between the first probe and the second probe.

In the case where a part of the first inspection wire 23a-1 is modified by the leakage light D to cause a remarkable decrease in the conductivity of the first inspection wire 23a-1, a current measurable in a predetermined measurement range does not flow between the first probe and the second probe. Therefore, it can be determined that the first inspection wire 23a-1 has been broken by the leakage light D. In contrast thereto, in the case where a current of a predetermined value or more measurable in the predetermined measurement range flows between the first probe and the second probe through the first inspection wire 23a-1, it can be determined that the first inspection wire 23a-1 is not broken.

In this manner, it can be checked whether or not the first inspection wire 23a-1 has been broken, by using the inspection jig. Similarly, it can be checked whether or not the other first inspection wires 23a-2 to 23a-5 and the second inspection wires 23b have been broken. Thus, such a continuity test is performed for each inspection wire 23 to thereby check each inspection wire

23 for any break caused by the leakage light D, so that the position of each inspection wire 23 broken by the leakage light D can be identified. Accordingly, it is possible to quantitatively evaluate the distance from the street 13 where the influence of the leakage light D is exerted.

FIG. 5A is an enlarged plan view of an essential part of the device area 15A, depicting an example of the result obtained by performing the leakage light checking step S30. In FIG. 5A, an arrow E denotes the direction of relative movement of the laser beam L with respect to the chuck table 12. For example, the direction depicted by the arrow E is parallel to the X direction in the laser processing apparatus 10 depicted in FIG. 3. In the example depicted in FIG. 5A, modified areas 27 generated by the leakage light D are formed only in the inspection area 15b on one side of the street 13-2 in the +A direction. That is, the inspection wires 23 having the modified areas 27 are broken. In the inspection area 15b on the other side of the street 13-2 in the -A direction, the modified areas 27 are not formed.

There is a case in which the energy distribution of the laser beam L may be deviated due to a deviation in position between the center of the laser beam L and the

optical axis of a lens in an optical system for applying the laser beam L or the center of a slit in this optical system. In this case, the leakage light D reaches an area different from that depicted in FIG. 5A. FIG. 5B is an enlarged plan view of an essential part of the device area 15A, depicting another example of the result obtained by performing the leakage light checking step S30. In the example depicted in FIG. 5B, modified areas 27 generated by the leakage light D are formed in the inspection areas 15b on both sides of the street 13-2 in the first direction A (one side in the +A direction and the other side in the -A direction). That is, the inspection wires 23 having the modified areas 27 are broken, and the other inspection wires 23 having no modified areas 27 are not broken.

In this manner, a continuity test is performed by using the inspection wires 23 provided in each inspection area 15b, thereby identifying the position of each inspection wire 23 broken by the leakage light D. Accordingly, it is possible to quantitatively evaluate the distance from the street 13 where the influence of the leakage light D is exerted and the frequency of production of the leakage light D. Further, the conditions of application of the laser beam L can be

corrected on the basis of this quantitative evaluation.

There will now be described an inspection substrate 11 according to a second preferred embodiment with reference to FIG. 7. FIG. 7 is an enlarged plan view of an essential part of a device area 15A according to the second preferred embodiment. In the device area 15A of the inspection substrate 11 according to the second preferred embodiment, plural inspection wires 23 are provided not only in each inspection area 15b but also in each street 13-2. More specifically, plural third inspection wires 23c (23c-1, 23c-2, 23c-3, and 23c-4) are additionally provided in each street 13-2 interposed between the adjacent inspection areas 15b. These plural third inspection wires 23c are spaced from each other by a predetermined distance in the first direction A perpendicular to the direction of extension of the street 13-2.

The plural third inspection wires 23c have the same length in the second direction B, which is also the same as the length of the first inspection wire 23a-1. A pair of third electrode pads 25c is provided at both ends of each third inspection wire 23c. Each third electrode pad 25c is the same as each first electrode pad 25a in material, shape, and size. Further, plural fourth

inspection wires 23d (23d-1, 23d-2, 23d-3, and 23d-4) are similarly provided in the street 13-2 so as to be spaced a given distance from the plural third inspection wires 23c in the second direction B. The plural fourth inspection wires 23d are also spaced from each other by a predetermined distance in the first direction A perpendicular to the direction of extension of the street 13-2.

Similarly to the plural third inspection wires 23c, the plural fourth inspection wires 23d have the same length in the second direction B, which is also the same as the length of the second inspection wire 23b-1. A pair of fourth electrode pads 25d is provided at both ends of each fourth inspection wire 23d. Each fourth electrode pad 25d is the same as each second electrode pad 25b in material, shape, and size. The plural third inspection wires 23c form a third set 23C, and the plural fourth inspection wires 23d form a fourth set 23D. To closely arrange the third set 23C and the fourth set 23D, the distance between the third electrode pad 25c and the fourth electrode pad 25d adjacent to each other in the second direction B is set equal to the distance between the first electrode pad 25a of the first inspection wire 23a-1 and the second electrode pad 25b of the second

inspection wire 23b-1 adjacent to each other in the second direction B. Further, plural third sets 23C and plural fourth sets 23D are alternately arranged along the street 13-2.

As described above, the plural inspection wires 23 (23c and 23d) are provided in each street 13-2 of the inspection substrate 11 according to the second preferred embodiment. Accordingly, it is possible to quantitatively evaluate the range in the street 13-2 where the influence of the leakage light D is exerted. Further, according to the number of third and fourth inspection wires 23c and 23d broken by the leakage light D, it is possible to calculate the frequency at which the leakage light D reaches the third and fourth inspection wires 23c and 23d. The arrangement of the third and fourth inspection wires 23c and 23d is not limited to that depicted in FIG. 7. For example, the third and fourth inspection wires 23c and 23d may be arranged continuously through the third and fourth electrode pads 25c and 25d in the second direction B. Further, the third and fourth inspection wires 23c and 23d may also be provided in each street 13-1 extending in the first direction A in addition to in each street 13-2.

There will now be described an inspection substrate

11 according to a third preferred embodiment with reference to FIG. 8. FIG. 8 is an enlarged plan view of an essential part of a device area 15A according to the third preferred embodiment. In the device area 15A of the inspection substrate 11 according to the third preferred embodiment, plural inspection wires 23 (corresponding to a modification of the first inspection wires 23a) are provided in each inspection area 15b along each street 13-2. More specifically, plural fifth inspection wires 23e (23e-1, 23e-2, 23e-3, 23e-4, and 23e-5) are provided in each inspection area 15b so as to extend along each street 13-2. The plural fifth inspection wires 23e have the same length in the second direction B, which is substantially the same as the length of one side of each inspection area 15b in the second direction B. Both ends of each fifth inspection wire 23e are aligned in the first direction A.

A pair of fifth electrode pads 25e is provided at both ends of each fifth inspection wire 23e. Further, one or more additional fifth electrode pads 25e are provided on each fifth inspection wire 23e between both ends thereof so as to be arranged at given intervals. The additional fifth electrode pads 25e provided on each fifth inspection wire 23e are aligned in the first

direction A. In other words, the positions of these additional fifth electrode pads 25e provided on each fifth inspection wire 23e in the second direction B are the same as the positions of those provided on its adjacent fifth inspection wire 23e in the first direction A. In FIG. 8, for convenience of illustration, some of the plural fifth inspection wires 23e are simply depicted as inspection wires 23, and some of the plural fifth electrode pads 25e are simply depicted as electrode pads 25.

By using the inspection substrate 11 according to the third preferred embodiment, a continuity test is performed in such a manner that a first probe is brought into contact with one of any pair of fifth electrode pads 25e adjacent to each other in the second direction B in each fifth inspection wire 23e, and a second probe is brought into contact with the other of this pair of fifth electrodes 25e. In this condition, a current is applied between the first probe and the second probe. Accordingly, it is possible to check whether or not a break has occurred in a part of the fifth inspection wire 23e between this pair of fifth electrode pads 25e. Further, according to the number of broken areas in the fifth inspection wires 23e, it is possible to calculate the

frequency at which the leakage light D reaches the fifth inspection wires 23e.

As described above, the inspection wires 23 according to the third preferred embodiment have the same length in the second direction B irrespective of the distance from the street 13-2. Accordingly, in the case where the leakage light D reaches an area between the first inspection wire 23a-5 and the second inspection wire 23b-5 adjacent to each other in the second direction B in the first preferred embodiment, the leakage light D can reach the fifth inspection wire 23e-5 in the third preferred embodiment. Accordingly, the frequency at which the leakage light D reaches the inspection wires 23 can be calculated more accurately as compared with the first preferred embodiment.

In the third preferred embodiment, plural fifth inspection wires 23e are similarly provided along four sides of each rectangular inspection area 15b. That is, assuming that the plural fifth inspection wires 23e-1 to 23e-5 form a fifth set 23E, the fifth set 23E is provided along each of the four sides of each rectangular inspection area 15b. More specifically, the fifth set 23E is provided along one side of each inspection area 15b so as to extend in the second direction B. The fifth set 23E

is further provided along another side opposite to the above one side in the first direction A. The fifth set 23E is further provided along another side of the inspection area 15b so as to extend in the first direction A. The fifth set 23E is further provided along the remaining one side extending in the first direction A. Accordingly, along all of the four sides of each inspection area 15b, the frequency at which the leakage light D reaches the inspection wires 23 can be calculated according to the number of broken areas in the fifth inspection wires 23e. Also in the third preferred embodiment, along all of the four sides of each inspection area 15b, it is possible to quantitatively evaluate the distance from the street 13 where the influence of the leakage light D is exerted.

The structure, method, etc. according to the above preferred embodiments may suitably be modified without departing from the scope of the object of the present invention. For example, the layout of the inspection wires 23 and the shape and layout of the electrode pads 25 are not limited to those depicted in the drawings. For example, the third inspection wires 23c and the fourth inspection wires 23d according to the second preferred embodiment may be provided in each street 13 of the

inspection substrate 11 according to the third preferred embodiment. Further, in each preferred embodiment mentioned above, each inspection wire 23 is checked for any break by determining whether or not a current measurable in a predetermined measurement range flows between the first probe and the second probe. As a modification, a change in resistance in each inspection wire 23 may be measured to determine whether or not each inspection wire 23 is partially damaged or broken.

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. An inspection substrate for use in inspecting a laser beam for leakage light, the laser beam having a transmission wavelength to the inspection substrate, the inspection substrate comprising:

a first surface to which the laser beam is to be applied;

a second surface opposite to the first surface;

a street set on the second surface;

a plurality of first inspection wires provided on the second surface so as to extend along the street, the plurality of first inspection wires being located at different distances from the street;

a plurality of first electrode pads provided on each of the plurality of first inspection wires so as to be spaced from each other in a direction along the street;

a plurality of second inspection wires provided on the second surface so as to extend along the street, the plurality of second inspection wires being spaced from the plurality of first inspection wires along the street, the plurality of the second inspection wires being located at different distances from the street; and

a plurality of second electrode pads provided on each of the plurality of second inspection wires so as to be spaced from each other in a direction along the street.

2. An inspecting method for inspecting a laser beam for leakage light by using an inspection substrate, the laser beam having a transmission wavelength to the inspection substrate, wherein

the inspection substrate includes

a first surface to which the laser beam is to be applied,

a second surface opposite to the first surface,

a street set on the second surface,

a plurality of first inspection wires provided on the second surface so as to extend along the street, the plurality of first inspection wires being located at different distances from the street, and

a plurality of first electrode pads provided on each of the plurality of first inspection wires so as to be spaced from each other in a direction along the street, and

the inspecting method includes

a holding step of holding the second surface side of the inspection substrate on a chuck table,

a laser processing step of applying the laser beam to the first surface of the inspection substrate along the street after performing the holding step, thereby forming a modified layer inside the inspection substrate along the street, and

a leakage light checking step of bringing a probe into contact with each of the first electrode pads after performing the laser processing step, thereby determining whether or not each first inspection wire has been broken by the leakage light and checking for the leakage light.