

SPECIFICATION

Title of Invention

SCRIBING WHEEL AND SCRIBING METHOD USING THE SAME

Technical Field

[0001]

The present invention relates to a scribing wheel for scribing a thin sapphire substrate and to a scribing method using the scribing wheel.

Background Art

[0002]

In order to scribe a sapphire substrate to break it, there has been proposed a method adapted to irradiate the sapphire substrate with laser light to form a scribed groove, and break the sapphire substrate along the scribed groove as disclosed in Patent Literatures 1 and 2.

[0003]

In addition, a scribing method using a scribing wheel for glass cutting is also widely used. As disclosed in Patent Literature 3 and the like, a conventional scribing wheel uses a disc made of cemented carbide or polycrystalline diamond (hereinafter referred to as PCD) as a base material. PCD is one formed by sintering diamond particles together with cobalt and the like. The scribing wheel is one such that from both sides of the disc serving as the base material, the edge of

the outer circumference is obliquely ground down to form a V-shaped blade edge on the outer circumferential surface. Rotatably pivotally attaching the scribing wheel formed as described above to the scribing head or the like of a scribing apparatus, pressing the scribing wheel against a brittle material substrate with a predetermined load, and moving the scribing wheel along the surface of the brittle material substrate make it possible to scribe the brittle material substrate while rolling the scribing wheel.

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Publication JP-A 2012-106279

Patent Literature 1: Japanese Unexamined Patent Publication JP-A 2013-51298

International Patent Publication WO 2003/51784

Summary of Invention

Technical Problem

[0005]

However, the conventional scribing method using laser light has had a problem of being likely to damage the surface of a sapphire substrate to thereby degrade the quality of the substrate. Also, the conventional scribing method using a scribing wheel has had a problem that when the thickness of

a sapphire substrate is thin, irregular cracks called crevasses are likely to be formed after breaking.

[0006]

The present invention is made in consideration of such a problem, and intends to provide a scribing wheel suitable for scribing a sapphire substrate, and a scribing method using the scribing wheel.

Solution to Problem

[0007]

In order to solve the problem, the scribing wheel of the present invention is one wherein along a circumferential part, a cross section along a radial direction is of a V-shape and a ridge is formed in a center of the V-shape, a blade edge part is formed by the ridge and tilt surfaces present on both sides of the ridge, and at least the blade edge part is formed of diamond. In addition, the ridge of the blade edge part has grooves formed in an entire circumference of the circumferential part at predetermined intervals. Further, a length of each of the grooves along the circumferential part is set to be equal to or more than 9 μm and equal to or less than 12 μm , a length of a ridge between any adjacent two of the grooves is set to be equal to or more than 5 μm and equal to or less than 9 μm , and a depth of each of the grooves is set to be equal to or more than 1.5 μm and equal to or less than 4 μm .

[0008]

Note that a ratio between
the length of each of the grooves
and
the length of a ridge between any adjacent ones of the
grooves is set to be larger than 1.0.

[0009]

In order to solve the problem, the scribing method of
the present invention is one using the scribing wheel, and the
scribing method scribing a sapphire substrate by rolling the
scribing wheel while pressing the blade edge part of the
scribing wheel against the sapphire substrate.

Advantageous Effects of Invention

[0010]

According to the present invention having such features,
at least the blade edge part of the scribing wheel is made of
diamond, and the ridge part of the scribing wheel is formed
with the predetermined grooves. Scribing a sapphire substrate
using the scribing wheel having such a shape makes it possible
to obtain an effect of being able to generate sufficiently deep
vertical cracks and thereby suppress the formation of
crevasses after breaking.

Brief Description of Drawings

[0011]

FIG. 1 is front and side views of a scribing wheel

according to an embodiment of the present invention;

FIG. 2 is an enlarged view of a ridge part at a blade edge according to the present embodiment;

FIG. 3 is a diagram illustrating the dimensions of scribing wheels in Examples 1 to 7 and Comparative Examples 1 to 4 of the present invention;

FIG. 4 is a diagram illustrating evaluation results of scribing using the scribing wheels in Examples 1 to 7 and Comparative Examples 1 to 4 and evaluation results after breaking;

FIG. 5 is a schematic diagram illustrating a state where a sapphire substrate formed with scribed lines is visually checked;

FIG. 6A is a diagram illustrating a state where in a sapphire substrate formed with a scribed line, the scribed line has no horizontal crack;

FIG. 6B is a diagram illustrating a state where in a sapphire substrate formed with a scribed line, the scribed line has horizontal cracks;

FIG. 7A is a diagram illustrating a state of a cross section after breaking along a scribed line, in which no crevasse is present;

FIG. 7B is a diagram illustrating a state of a cross section after breaking along a scribed line, in which a few crevasses are present; and

FIG. 7C is a diagram illustrating a state of a cross section after breaking along a scribed line, in which many crevasses are present.

Description of Embodiments

[0012]

FIG. 1 is front and side views of a scribing wheel according to an embodiment of the present invention. When manufacturing the scribing wheel, first, as illustrated in FIG. 1(a), a through-hole 12 serving as a shaft hole is formed in the center of a disc 11 as a scribing wheel base material made of cemented carbide or the like. Then, by inserting the shaft of an unillustrated motor or the like into the through-hole 12, and while rotating the disc 11 with the central axis of the through-hole 12 as a rotation axis 12a, grinding the entire circumference of the disc 11 from both of the front and back sides of the disc obliquely with respect to the rotation axis 12a, as illustrated in FIG. 1(b), the ridge and tilt surfaces on both sides of the ridge are formed in a vertically cross-sectional V-shape. The tilt surfaces of the V-shape formed as described above are referred to as ground surfaces 13.

[0013]

Subsequently, first, the V-shaped ground surfaces 13 are preliminarily roughened in order to facilitate the attachment of a diamond film. Then, diamond having a particle size of

submicron or less and serving as nuclei are formed on the tilt surface parts, and then a diamond thin film is grown by a chemical vapor deposition reaction. In this manner, the diamond thin film 14 having a film thickness of, for example, 20 to 30 μm is formed on the ground surfaces formed as the tilt surfaces of the V-shape of the scribing wheel by the chemical vapor deposition method (CVD method).

[0014]

After that, the tip of the diamond film is polished to form a polished area including the ridge. Subsequently, in the ridge part of the polished area of the diamond film, fine grooves are formed at regular intervals. The details of the grooves will be described using FIG. 2. FIG. 2 is an enlarged view of the ridge part at a blade edge indicated by a dashed dotted line S in FIG. 1. As illustrated in FIG. 2, in the ridge part where the ground surfaces of the scribing wheel intersect with each other, the grooves 15 are formed in the entire circumference with the length of each of the grooves made constant and with the length of a ridge between any adjacent two of the grooves made constant. The grooves may be formed by removing parts of the blade edge of the scribing wheel having the diamond film using laser machining. The length A of each of the grooves 15 is preferably set to be equal to or more than 9 μm and equal to or less than 12 μm . Also, the depth B of each of the grooves 15 is preferably set to be equal to or more

than $1.5\text{ }\mu\text{m}$ and equal to or less than $4\text{ }\mu\text{m}$, and more preferably set to be equal to or more than $2\text{ }\mu\text{m}$ and equal to or less than $3\text{ }\mu\text{m}$. Further the length C of a ridge between any adjacent two of the grooves 15 is preferably set to be equal to or more than $5\text{ }\mu\text{m}$ and equal to or less than $9\text{ }\mu\text{m}$, and more preferably set to be equal to or more than $5\text{ }\mu\text{m}$ and equal to or less than $7\text{ }\mu\text{m}$. Still further, the ratio A/C between the length A of each of the grooves and the length C of a ridge between any adjacent two of the grooves 15 is preferably set to be larger than 1, and more preferably set to be larger than 1.4. Scribing using the scribing wheel formed with such grooves in the entire circumference makes it possible to form a preferred scribed line. Then, breaking along the scribed line allows a cross section having a few crevasses to be obtained.

[0015]

Note that in this embodiment, the grooves are formed by the laser machining, but may be formed by, in place of the laser machining, electric discharge machining of the diamond film, or by grinding.

[0016]

Alternatively, the scribing wheel may be configured by forming grooves in the V-shaped blade edge part of the scribing wheel base material, coating a diamond film on the grooved scribing wheel base material by a CVD method, and then polishing the resulting scribing wheel base material.

[0017]

Further, in this embodiment, the diamond film is coated on the scribing wheel base material and then polished; however, the scribing wheel base material itself may be formed of a diamond material such as single crystalline diamond or polycrystalline diamond not containing a binder.

[Examples]

[0018]

Next, examples will be described using FIG. 3. In FIG. 3, scribing wheels in Examples 1 to 7 are ones prepared on the basis of the above-described embodiment. As listed in FIG. 3, the scribing wheels in Examples 1 to 7 were ones such that the length A of each groove was 9 or 12 μm , the depth B of each groove was 1.5, 2, 3, or 4 μm , the length C of a ridge between two adjacent grooves was 6 or 8.5 μm , and a blade edge angle D was 115 °. Also, the groove/ridge ratio A/C was 1.06 to 2.00. At the same time, scribing wheels in Comparative Examples 1 to 4 were prepared such that the length A of each groove was 6, 9, or 12 μm , the depth B of each groove was 3 μm , the length C of a ridge between two adjacent grooves was 6, 8.5 or 12 μm , and a blade edge angle D was 115 °. Also, in Comparative Examples 1 to 4, the groove/ridge ratio A/C was 0.71 to 1.00.

[0019]

Then, scribing was performed by pressing each of the scribing wheels in Examples 1 to 7 and Comparative Examples

1 to 4 against a sapphire substrate having a thickness of 0.1 mm within a scribing load range of 1.20 N to 2.22 N and rolling that scribing wheel. Further, the sapphire substrate was broken along the resulting scribed line. FIG. 4 is a table listing results of evaluating scribed states on a three-point scale and results of evaluating cross-sectional states on a two-point scale. Scribed lines were evaluated by as illustrated in FIG. 5, irradiating a sapphire substrate 21 formed with a number of parallel scribed lines and visually check the scribed lines. In FIG. 4, good scribing "○", and "x" refer to an intermediate penetration state where scribed lines entirely uniformly shine. Also, "△" refers to a state where faintly shiny scribed lines are cut in spots and scribing is low penetrative. FIG. 6A indicates the quality of a scribed line, and illustrates the intermediate penetration "○" or low penetration "△" state with no horizontal crack, and FIG. 6B illustrates the "x" state with horizontal cracks. In FIG. 6B, the horizontal cracks appear on the sides of a scribed line.

[0020]

Further, sapphire substrates 21 formed with such scribed lines were broken using a breaking apparatus. A cross section having no crevasses illustrated in FIG. 7A, and a cross section having few short crevasse were evaluated to be good "○". Also, a cross section having a number of large crevasses whose length exceeds half the thickness of the substrate was evaluated to

be defective "x". From these results, and as illustrated in the drawings, it is preferable that the length A of each groove is 9 to 12 μm and the length C of a ridge between two adjacent grooves is 5 to 9 μm , and by appropriately selecting a scribing load, good scribed lines and cross section can be obtained. In particular, in Examples 1 and 2, good scribed lines and cross sections were obtained at multiple loads. In addition, the similar tendency was observed at a blade edge angle D of 110 to 125 °.

Industrial Applicability

[0021]

The present invention can provide a sapphire substrate scribing wheel making it possible to break a sapphire substrate along a cross section having few crevasses, and the scribing wheel can be preferably used for a scribing apparatus.

Reference Signs List

[0022]

10: Scribing wheel

11: Disc

12: Through-hole

13: Ground surface

14: Diamond film

15: Groove

21: Sapphire substrate

CLAIMS

1. A scribing wheel wherein along a circumferential part, a cross section along a radial direction is of a V-shape and a ridge is formed in a center of the V-shape, a blade edge part is formed by the ridge and tilt surfaces present on both sides of the ridge, and at least the blade edge part is formed of diamond, wherein

the ridge of the blade edge part has grooves formed in an entire circumference of the circumferential part at predetermined intervals, and

a length of each of the grooves along the circumferential part is set to be equal to or more than 9 μm and equal to or less than 12 μm , a length of a ridge between any adjacent two of the grooves is set to be equal to or more than 5 μm and equal to or less than 9 μm , and a depth of each of the grooves is set to be equal to or more than 1.5 μm and equal to or less than 4 μm .

2. The scribing wheel according to claim 1, wherein
a ratio between

the length of each of the grooves
and

the length of a ridge between any adjacent ones of the grooves is set to be larger than 1.0.

3. A scribing method using the scribing wheel according to claim 1 or 2, the scribing method scribing a sapphire substrate by rolling the scribing wheel while pressing the blade edge part of the scribing wheel against the sapphire substrate.