DESCRIPTION

SCRIBING HEAD AND SCRIBING APPARATUS

TECHNICAL FIELD

The present invention relates to a scribing head used to form a scribing line on a substrate and a scribing apparatus including the scribing head.

BACKGROUND ART

For example, when a glass substrate (including a brittle material) is cut into a desired size, a cutting edge of a cutter wheel is pressed onto a surface of the brittle material with a predetermined force and is moved on the surface of the glass substrate. As a result, a scribing line is formed (hereinafter, referred to as a "scribing step"). Thereafter, a predetermined force is applied to the glass substrate along the scribing line (hereinafter, referred to as a "breaking step"). As a result, the glass substrate is cut along the scribing line.

Figure 7 shows an example of a structure of a conventional scribing apparatus **10**. The scribing apparatus **10** performs the scribing step.

The scribing apparatus **10** includes a table **11**, a first guide rail **12A**, a second guide rail **12B** and a ball screw **13**.

The table **11** is structured so as to be rotatable in a horizontal plane. A vacuum adsorption means (not shown)

is provided in the table **11**. The vacuum adsorption means fixes a substrate G (e.g., brittle substrate including a glass plate) mounted on the table **11** to the table **11**. The first guide rail **12A** and the second guide rail **12B** support the table **11** such that the table **11** is movable in the Y-direction. The first guide rail **12A** and the second guide rail **12B** are provided in parallel to each other. The ball screw **13** moves the table **11** along the first guide rail **12A** and the second guide rail **12B**.

The scribing apparatus **10** further includes a first pillar **19A**, a second pillar **19B**, a guide bar **14**, a sliding unit **15** and a first motor **16**.

The first pillar **19A** and the second pillar **19B** are vertically provided on a base of the scribing apparatus **10** having the first guide rail **12A** and the second guide rail **12B** interposed therebetween. The guide bar **14** is provided above the table **11** along the X-direction and constructed between the first pillar **19A** and the second pillar **19B**. The sliding unit **15** is provided on the guide bar **14** so as to be slidable. The first motor **16** slides the sliding unit **15**.

The scribing apparatus **10** further includes a scribing head **9**, a second motor **17** for moving the scribing head **9** upward and downward, a first CCD camera **18A** and a second CCD camera **18B**. The second motor **17** holds the scribing head **9** at a predetermined height in the scribing step. The first CCD camera **18A** and the second CCD camera **18B** are provided above the guide bar **14** and detect an alignment mark formed on the substrate G.

The scribing head **9** is provided in the sliding unit

15. The scribing head 9 includes a cutter wheel 29.

The scribing head 9 presses the cutter wheel 29 onto the surface of the substrate G. When the motor 16 slides the sliding unit 15, the scribing head 9 moves along the guide bar 14. As a result, the cutter wheel 29 moves on the surface of the substrate G while it is being pressed onto the surface of the substrate G, and a scribing line is formed on the surface of the substrate G.

International Publication No. WO 03/011777 pamphlet (Reference 1) discloses a scribing head. This scribing head includes a servo motor and a cutter wheel 29. The scribing head is structured such that the torque of a rotation axis of the servo motor is transmitted to the cutter wheel 29 directly or via a gear, and the cutter wheel 29 is pressed onto the surface of the substrate G. Since the cutter wheel 29 is pressed onto the substrate G with a predetermined force by the servo motor, for example, when compared to the case in which the cutter wheel 29 is pressed onto the substrate G with a predetermined force by an air cylinder, an excellent temporal followablity with respect to the change of reaction force from the substrate G, and an excellent controllability and responsiveness with respect to the magnitude of the reaction force are obtained.

Figure 8 shows an example of a structure of a conventional scribing head 9. The scribing head 9 is a scribing head disclosed in Reference 1. The scribing head 9 is structured so as to directly transmit the torque of the rotation axis of the servo motor to the cutter wheel 29.

The scribing head 9 includes a servo motor 402, a holder holding member 404, a cutting edge holder 28 which is held by the holder holding member 404 and a cutter wheel 29 which is rotatable about a pin inserted at the lower end of the cutting edge holder 28.

The servo motor 402 of scribing head 9 is, for example, held by a sliding unit 15 (see Figure 7). When a rotation axis 402A of the servo motor 402 is turned, the cutter wheel 29 is moved upward and downward via the holder holding member 404 and the cutting edge holder 28. Owing to such a structure, the servo motor 402 generates a torque in a direction in which the rotation axis 402A turns clockwise (see Figure 8), and presses the cutter wheel 29 onto a brittle material substrate.

Figure 9 shows a structure of another example of the conventional scribing head 400. Figure 9(a) shows a side view of the scribing head 400. Figure 9(b) shows a front view of relevant parts of the scribing head 400. The scribing head 400 is a scribing head disclosed in Reference 1. In Figure 9, the same components as those shown in Figure 8 are denoted by the same reference numerals, and the description thereof will be omitted.

The scribing head 400 includes a first side wall 401A, a second side wall 401B, a servo motor 402 which is fixed between the first side wall 401A and the second side wall 401B in an upside down manner, an L-shaped holder holding member 404, a spindle 403, which is provided at the bottom portion of the first side wall 401A and the second side wall 401B, for supporting the holder holding member 404 such that the holder holding member 404 is rotatable, and a scribing

line forming mechanism **21**. The scribing line forming mechanism **21** includes a turning axis **27**, a cutting edge holder **28** and a cutter wheel **29**. The cutting edge holder **28** is fixed to the turning axis **27** and is held by the holder holding member **404** so as to be turnable via the turning axis **27**.

A first bevel gear **405A** is firmly fixed to an output axis of the servo motor **402**. A second bevel gear **405B** is firmly fixed to the spindle **403**. The first bevel gear **405A** and the second bevel gear **405B** are provided so as to engage with each other. Thus, when the servo motor **402** is rotated in a positive direction or a negative direction, the holder holding member **404** turns about the spindle **403**, and the scribing line forming mechanism **21** moves upward or downward, respectively. Owing to such a structure, the servo motor **402** generates a torque in a direction in which the spindle **403** turns clockwise (see Figure **9(b)**) and presses the cutter wheel **29** onto the brittle material substrate.

Furthermore, Japanese Laid-Open Publication No. 2001-206727 (Reference 2) discloses a scribing head A which is another example of the conventional scribing head. The scribing head A, similar to the scribing head **400**, transmits the motive power of a servo motor to a cutter wheel via a gear (specifically, a rack-and-pinion).

Reference 1: International Publication No. WO 03/011777 pamphlet

Reference 2: Japanese Laid-Open Publication No. 2001-206727

DISCLOSURE OF THE INVENTION

Generally, the surface of the substrate G is not a perfectly flat face. The substrate G has undulations across the entire substrate G in addition to slight differences in thickness of the substrate G itself. Furthermore, while the cutter wheel **29** is pushed into the substrate G by an amount of about several μm to several tens of μm, a scribing line is formed. Thus, it seems that the substrate G is formed flatly with a high accuracy. However, the substrate G has sharp undulations in the order of several μm. As a result, in order to perform a scribing on the substrate G while maintaining a predetermined cutting edge load, the servo motor **402** must move the cutter wheel **29** upward and downward in accordance with the change of the undulations of the main surface of the substrate G.

The holder holding member **404** included in the scribing head **9** turns about the rotation axis **402A**. Thus, due to the undulations of the main surface of the substrate G, the angle of the holder holding member **404** with respect to the main surface of the substrate G changes. Therefore, the cutting edge load of the cutter wheel **29** vertical to the main surface of the substrate G does not correspond to the torque of the servo motor **402** in a linear manner. As a result, even if the torque of the servo motor **402** is maintained at a predetermined value, the cutting edge load of the cutter wheel **29** vertical to the main surface of the substrate G changes due to the angular change of the holder holding member **404**.

In order to solve this problem, it is considered that the torque of the servo motor **402** is corrected by detecting the angle of the holder holding member **404** with respect to

the main surface of the substrate G. However, the computational control process for correcting the toque becomes complex, and at the same time, a time-lag occurs, wherein the time-lag is the time lapsed from the time the angle of the bearing case **25** is detected to the time the change of the corrected torque actually acts on the servo motor **402**. Therefore, it is difficult to maintain the cutting edge load constant in response to the undulations of the substrate G.

A gear-type motive power transmission means (e.g., at least one of the first bevel gear **405A** and the second bevel gear **405B**) included in a gear-type scribing head (scribing head **400** and scribing head **A**) has a backlash (clearance between cutting faces adjacent to each other) for ensuring a smooth operation. As a result, when the servo motor **402** cannot follow the upward-and-downward operation of the cutter wheel **29**, there are cases in which the cutting edge load instantaneously and vastly changes. Even if the servo motor **402** is constantly and electrically tuned, there is a limitation in improving the followability so as to correspond to the undulations of the main surface of the substrate G. Also, it is not feasible in view of time and cost to tune the servo motor **402** such that the servo motor **402** possesses an optimal electrical control characteristic.

Furthermore, in the gear-tpye motive power transmission means, the efficiency that the torque is transmitted to the cutter wheel **29** from the servo motor **402** and is converted into a load (positive efficiency); and the transmission efficiency that the change of the torque from the cutter wheel **29** is transmitted to the servo motor **402** (negative efficiency) are not always same. Therefore, the

responsiveness of the servo motor **402** to the increase of the cutting edge load becomes inefficient. Specifically, when the cutting edge load is increased due to undulations on the main surface of the substrate G and the like, it is difficult to operate such that the output axis of the servo motor **402** is pushed back in a direction opposite to the load direction in order to keep a predetermined torque while an excellent preciseness and responsiveness of the servo motor **402** are ensured. As a result, an excessive load beyond the predetermined cutting edge load is applied to the main surface of the substrate G. Therefore, there is a risk that a defect (e.g., fissure and chip) occurs in the vicinity of the formed scribing line on the substrate G.

Furthermore, the scribing head **9** needs a footprint space for the servo motor **402** on the side of the cutter wheel **29**. Thus, when a plurality of scribing heads is provided in line in a direction perpendicular to the movement direction in a scribing step and the scribing head **9** is used in a multi-scribing apparatus for simultaneously forming a plurality of scribing lines which are parallel to each other, it is difficult to shorten the separation distance between the cutter wheels **29**. As a result, the lower limit for the interval of each scribing line to be formed simultaneously is significantly limited.

The present invention is made in view of the problems described above. The objective of the present invention is to provide: a scribing head capable of maintaining the load precisely accurate for pressing the scribing line forming means (e.g., cutter wheel) onto a substrate and being structurally compact when viewed from the movement direction of the scribing head in a scribing step; and a scribing

apparatus including the scribing head.

A scribing head according to the present invention includes: a scribing line forming means structured so as to form a scribing line on a substrate; and a moving means for moving the scribing line forming means such that the scribing line forming means presses the substrate with a constant magnitude, wherein the moving means includes:a rotation means rotating about a rotation axis, the axial center of the rotation axis being provided so as to align with a predetermined direction in which the scribing line forming means moves, and a motive power transmission means for transmitting a motive power between the motive power transmission means and the scribing line forming means such that the scribing line forming means moves on a straight line along the axial center of the rotation axis in response to the rotation of the rotation means, the motive power transmission means being provided along the predetermined direction, thereby the objective described above being achieved.

According to the scribing head and the scribing apparatus of the present invention, a rotating means, a motive power transmission means and a scribing line forming means are provided in line along the direction in which the scribing line forming means moves. Therefore, neither the rotation means nor the motive power motive transmission means is provided on the side of the scribing line forming means. As a result, it is possible to omit the space on the side of the scribing line forming means.

While the motive power transmission means continues the transmission of motive power between the motive power

transmission means and the scribing line forming means, the scribing line forming means may form the scribing line on the substrate.

As described above, the scribing line forming means can form the scribing line on the substrate G without the transmission of motive power between the motive power transmission means and the scribing line forming means being interrupted. As a result, the scribing line forming means can always press against the substrate G.

The motive power transmission means may be structured such that the transmission efficiency of the force to be transmitted to the scribing line forming means from the motive power transmission means and the transmission efficiency of the force to be transmitted to the motive power transmission means from the scribing line forming means are approximately the same.

The motive power transmission means can effectively convert the change of force, received from the scribing line forming means, into a rotational direction and transmit it to the rotation means. Furthermore, the motive power transmission means can effectively convert the change of force, received from the rotation means, into a linear direction and transmit it to the scribing line forming means. As a result, the scribing line forming means can be effectively press against the substrate with a constant magnitude.

The motive power transmission means may include a face which is tilted by approximately 45 degrees with respect to the circumferential direction of the rotation axis along a direction in which the motive power transmission means

rotates. The motive power transmission means can most effectively convert the change of force, received from the scribing line forming means, into a rotational direction and transmit it to the rotation means. Furthermore, the motive power transmission means can most effectively convert the change of force, received from the rotation means, into a linear direction and transmit it to the scribing line forming means. As a result, the scribing line forming means can effectively press against the substrate with a constant magnitude.

The motive power transmission means may include a cylindrical cam.

The motive power transmission means may include a ball screw.

The substrate may be a kind of substrate among a glass plate, a glass substrate, a quartz plate, a quartz substrate, a sapphire plate, a sapphire substrate, a semiconductor wafer, a ceramic plate, a ceramic substrate, a solar cell substrate, a liquid crystal display panel, an organic EL panel, an inorganic EL panel, a transmissive projector substrate and a reflective projector substrate.

A scribing apparatus according to the present invention includes: at least one scribing head described above; and a first moving means for moving the scribing head on a surface, the surface being approximately parallel to the substrate, such that the scribing line forming means forms the scribing line on the substrate, thereby the objective described above being achieved.

In the scribing apparatus according to the present invention, the scribing head according to the present invention is provided. Therefore, a rotating means, a motive power transmission means and a scribing line forming means are provided in line along the direction in which the scribing line forming means moves. Therefore, the motive power transmission means not is provided on the side of the scribing line forming means. As a result, it is possible to omit the space on the side of the scribing line forming means.

At least two scribing heads of the at least one scribing head described above are provided approximately parallel to a scribing direction.

In the scribing apparatus according to the present invention, the scribing head according to the present invention, which requires only a small amount of attachment space, is provided. Thus, a plurality of scribing heads can be provided with a smaller amount of space than that required when a conventional scribing head is provided.

Furthermore, since at least two scribing heads according to the present invention is provided approximately vertical to the scribing direction, scribing lines, the number of which corresponds to the number of plurality of scribing heads, are formed with close intervals. As a result, it is possible to cut a plurality of unit substrates from one substrate at once thereby improving the production efficiency.

According to the scribing head and the scribing apparatus of the present invention, a rotating means, a motive power transmission means and a scribing line forming means

are provided in line along the direction in which the scribing line forming means moves. Therefore, neither the rotation means nor the motive power transmission means is provided on the side of the scribing line forming means. As a result, it is possible to omit the space on the side of the scribing line forming means.

BREIF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram showing an example of a structure of a scribing apparatus **100** according to an Embodiment of the present invention.

Figure **2** is a diagram showing a structure of a cylindrical cam-type scribing head **700** according the Embodiment of the present invention.

Figure **3** is a diagram showing a structure of a scribing line forming mechanism **510** included in the scribing head **700**.

Figure **4** is a diagram showing a controlling process procedure for controlling the scribing head **700** according to the Embodiment of the present invention.

Figure **5** is a diagram showing a structure of a ball screw **513**.

Figure **6** is a diagram showing a structure of a scribing apparatus **800** which is another example of the scribing apparatus.

Figure **7** is diagram showing an example of a structure

of a conventional scribing apparatus **10**.

Figure **8** is a diagram showing an example of a structure of a conventional scribing head **9**.

Figure **9** is a diagram showing a structure of a scribing head **400**, which is another example of the conventional scribing head.

26 axle bearing
27 turning axis
28 holder
29 cutter wheel
501 side wall
502 servo motor
503 cylindrical cam
504 holder holding member
505 elastic member
506 cam follower
507 linear bearing
510 scribing line forming mechanism
700 cylindrical cam-type scribing head

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, Embodiments of the present invention will be described with reference to the accompanying drawings.

1. Scribing apparatus

Figure **1** shows an example of a structure of a scribing apparatus **100** according to an Embodiment of the present

invention. The scribing apparatus **100** includes a table **111**, a first guide rail **112A**, a second guide rail **112B** and a ball screw **113**.

The table **111** is structured so as to be rotatable in a horizontal plane. A vacuum adsorption means (not shown) is provided in the table **111**. The vacuum adsorption means fixes a substrate G (e.g., brittle substrate including a glass plate) mounted on the table **111** to the table **111**. The first guide rail **112A** and the second guide rail **112B** support the table **111** such that the table **111** is movable in the Y-direction. The first guide rail **112A** and the second guide rail **112B** are provided in parallel to each other. The ball screw **113** moves the table **111** along the first guide rail **112A** and the second guide rail **112B**.

The scribing apparatus **100** further includes a first pillar **119A**, a second pillar **119B**, a guide bar **114**, a sliding unit **115** and a first motor **116**.

The scribing apparatus **100** further includes a scribing head **700**, a second motor **117** for moving the scribing head **700** upward and downward, a first CCD camera **118A**, a second CCD camera **118B**. The scribing head **700** is provided in the sliding unit **115**. The second motor **117** moves the scribing head **700** upward and downward prior to and subsequent to the scribing step. The second motor fixes the scribing head **700** to a predetermined height in the scribing step and holds it. The first CCD camera **118A** and the second CCD camera **118B** are provided above the guide bar **114** and detect an alignment mark formed on the substrate G.

The first pillar **119A** and the second pillar **119B** are

vertically provided on a base of the scribing apparatus **100** having the first guide rail **112A** and the second guide rail **112B** interposed therebetween. The guide bar **114** is provided above the table **111** along the X-direction and constructed between the first pillar **119A** and the second pillar **119B**. The sliding unit **115** is provided on the guide bar **114** so as to be slidable. The first motor **116** slides the sliding unit **115** along the guide bar **114**.

The scribing head **700** presses the cutter wheel **29** onto the surface of the substrate G . When the motor **116** slides the sliding unit **115**, the scribing head **700** moves along the guide bar **114**. As a result, the cutter wheel **29** moves on the surface of the substrate G while it is being pressed onto the surface of the substrate G. As a result, a scribing line is formed on the surface of the substrate G.

The structure can be made by omitting the second motor **117**, in which the scribing line forming means **29** is caused to move upward and downward prior to and subsequent to the scribing step by the operation of the scribing head **700**. The scribing head **700** will be described later.

2. Scribing head

Figure **2** shows a structure of the scribing head **700** according the Embodiment of the present invention. Figure **3** shows a structure of a scribing line forming mechanism **510** included in the scribing head **700**. Hereinafter, the structure of the scribing head **700** according to the Embodiment of the present invention will be described with reference to Figure **2** and Figure **3**.

The cylindrical cam-type scribing head 700 includes a side wall 501, a servo motor 502, a cylindrical cam 503, a cam follower 506, a holder holding member 504, an elastic member 505, a linear bearing 507 and a scribing line forming mechanism 510. The servo motor 502 is fixed to the side wall 501 in an upside down manner. The cylindrical cam 503 is connected to the output axis of the servo motor 502. The cam follower 506 contacts a cam face 532 included in the cylindrical cam 503. The holder holding member 504 axially supports the cam follower 506 such that the cam follower 506 is rotatable. The elastic member 505 energizes the holder holding member 504 in a direction toward the cylindrical cam 503. The linear bearing 507 is fixed to the side wall 501 and engages the holder holding member 504 in a manner such that the linear bearing 507 can move the holder holding member 504 upward and downward. The scribing line forming mechanism 510 and the cam follower 506 integrally move upward and downward via the holder holding member 504 or the like, and transmits an external force in the upward and downward direction, which is applied from the cam 503 and the substrate G, to the substrate G and the cam 503, respectively.

The scribing line forming mechanism 510 includes an axle bearing 26 attached to the holder holding member 504, a turning axis 27 which is axially supported by the axle bearing 26 so as to be rotatable, a holder 28 which is rotatable about the turning axis 27 and a scribing line forming means 29 which is rotatable about a pin inserted at the lower end of the holder 28 (see Figure 3). The scribing line forming means 29 includes, for example, a cutter wheel.

Hereinafter, a plurality of components included in

the scribing head 700 will be described in detail with reference back to Figure 2.

The servo motor 502 energizes the cam follower 506 via the cylindrical cam 503 such that the scribing line forming means 29 presses the substrate G with a predetermined load. For convenience in describing the operation of the servo motor 502 in the Embodiment of the present invention, the turning direction of the rotation axis of the servo motor 502 which moves the cam follower 506 downward is a positive direction and the turning direction of the rotation axis of the servo motor 502 which moves the cam follower 506 upward is a negative direction. The rotating operations of the turning axis in the positive direction and the negative direction are referred to as a "positive rotation" and a "negative rotation", respectively.

The servo motor 502 is provided such that the central axis of the rotation axis of the servo motor 502 is along the direction in which the holder holding member 504 moves upward and downward.

The cylindrical cam 503 is connected to an output axis of the servo motor 502 and is provided between the servo motor 502 and the holder holding member 504. The cylindrical cam 503 transmits the motive power between the cylindrical cam 503 and the scribing line forming means 29 such that the scribing line forming means 29 moves on a straight line along the central axis of the rotation axis in accordance with the rotation of the servo motor 502. Specifically, the cam face 532 of the cylindrical cam 503 is tilted along the rotation axis of the cylindrical cam 503 by a predetermined angle (hereinafter, referred to as a "lead angle"). The

position of a part of the cam face **532**, the part contacting the cam follower **506** in a direction in which the cam follower **506** moves upward and downward, changes along with the rotation of the cylindrical cam **503**. Therefore, when the rotation axis of the servo motor **502** is rotated, the scribing line forming means **29** integrally moves upward and downward with the cam follower **506**. When the function of the cam **503** is viewed from a point of force to be transmitted by the cam **503**, the cam follower **506** is energized in a direction in which the cam follower **506** moves upward and downward by a partial force in a direction, in which the cam follower **506** moves upward and downward in accordance with the tilted angle of the cam face **532**, of the output of the servo motor **502** transmitted to the cam follower **506** via the cylindrical cam **503**.

As described above, according to the scribing head **700**, the servo motor **502**, the cylindrical cam **503** and the scribing line forming means **29** are provided in line along the direction in which the scribing line forming means **29** moves upward and downward. Therefore, neither the servo motor **502** nor the motive power transmission means between the servo motor **502** and the scribing line forming means **29** is provided on the side of the scribing line forming means **29**. As a result, it is possible to omit the space on the side of the scribing line forming means **29**.

In the scribing step, the cam **503** and the cam follower **506** press against each other due to the energizing force by the servo motor **502** and the reaction force, from the substrate G, to this energizing force. Thus, the cam follower **506** and the cam face **532** are always in contact with each other. While the cylindrical cam **503** continues the

transmission of motive power between the servo motor **502** and the scribing line forming means **29**, the scribing line forming means **29** forms a scribing line on the substrate G. As described above, the scribing line forming means **29** can form the scribing line on the substrate G without the transmission of motive power between the servo motor **502** and the scribing line forming means **29** being interrupted. As a result, the scribing line forming means 29 can always press against the substrate G.

The cam face **532** of the cylindrical cam **503** is structured such that the transmission efficiency of the pressuring force to be transmitted to the scribing line forming means **29** from the servo motor **502** and the transmission efficiency of the reaction force to be transmitted to the servo motor **502** from the scribing line forming means **29** are approximately the same.

In both cases: in which the cam **503** and the servo motor **502** are rotated in the negative direction when the increase of the reaction force applied to the scribing line forming means **29** from the substrate G increases the force for the cam follower **506** to press against the cam face **532**; and in contrast, in which the cam **503** and the servo motor **502** are rotated in the positive direction when the decrease of the load of the scribing line forming means **29** to the substrate G decreases the force for the cam follower **506** to press against the cam face **532** due to the undulations of the main surface of the substrate G, the responsiveness of the servo motor **502** can be approximately the same. Therefore, when the torque of the rotation axis of the servo motor **502** is maintained to be constant, the scribing line forming means **29** can move upward and downward along the

undulations of the surface of the substrate G, and the load applied to the substrate G from the scribing line forming means **29** can be kept at a constant predetermined value. As a result, the scribing line forming means **29** can press against the substrate G with a constant load.

The lead angle of the cylindrical cam **503** is preferably about 45 degrees. In this case, the transmission efficiency of power which the cylindrical cam **503** receives from the cam follower **506**, converts into a power in a rotational direction and transmits it to the servo motor **502**; and the transmission efficiency of power which cylindrical cam **503** receives from the servo motor **502** and converts into a power in a upward-and-downward direction and transmits it to the cam follower **506**, can be approximately the same.

Furthermore, the load of the scribing line forming means **29** in the upward-and-downward direction and the rotational torque of the motor axis of the servo motor **502** can be linearly maintained. Furthermore, the position of the scribing line forming means **29** in the upward-and-downward direction and the rotation position of the servo axis of the servo motor **502** can be linearly maintained. Thus, the scribing head **700** can easily perform the load control and position control of the scribing line forming means **29** without negatively affecting the responsiveness thereof when compared to the conventional scribing head **9** and scribing head **400**.

According to the scribing head **700** of the present invention, the servo motor **502** rotates the cylindrical cam **503** by a positive direction or a negative direction. Thus, it is possible to move the holder holding member **504** upward

and downward along the linear bearing **507** via the cam follower **506**. As a result, the scribing line forming mechanism **510** can be moved upward and downward.

According to the scribing head **700** of the present invention, the cylindrical cam **503** is rotated by rotatingly driving the servo motor **502**, thereby moving the holder holding member **504** via the cam follower **506**. Thus, the position of the upward-and-downward direction of the holder holding member **504** changes smoothly. As a result, compared to the conventional scribing head **400** (see Figure **9**) and scribing head **A** (see Reference 2) which energizes the cutter wheel using a gear, an excellent following capability of the scribing line forming means **29** for undulations on the surface of the substrate G can be obtained.

Furthermore, according to the scribing head **700** of the present invention, it is possible to move the scribing line forming mechanism **510** upward and downward in a straight line manner. Thus, compared to the case in which the scribing line forming mechanism **21** is provided in the holder holding member **404** which turns as in the case of the conventional scribing head **9** and scribing head **400**, the change of the torque to be transmitted to the scribing line forming means **29** is small. Furthermore, responsiveness of the upward-and-downward operation of the scribing line forming mechanism **510** is improved.

Furthermore, according to the cylindrical cam-type scribing head **700**, since the structure of the scribing head can be compact, there is an advantage that it can be accommodated in a small footprint space.

As described above, the scribing head and the scribing apparatus according to the Embodiment of the present invention has been described with reference to Figure 1 to Figure 3.

In the examples shown in Figure 1 to Figure 3, the scribing line forming means 29 corresponds to "a scribing line forming means structured so as to form a scribing line on a substrate", the servo motor 502 and the cylindrical cam 503 correspond to "a moving means for moving the scribing line forming means such that the scribing line forming means presses the substrate with a constant magnitude", the servo motor 502 corresponds to "a rotation means rotating about a rotation axis, the axial center of the rotation axis being provided so as to align with a predetermined direction in which the scribing line forming means moves", and the cylindrical cam 503 corresponds to "a motive power transmission means for transmitting a motive power between the motive power transmission means and the scribing line forming means such that the scribing line forming means moves on a straight line along the axial center of the rotation axis in response to the rotation of the rotation means, the motive power transmission means being provided along the predetermined direction". Furthermore, the first motor 116 corresponds to "a first moving means for moving the scribing head on a surface such that the scribing line forming means forms the scribing line on the substrate, the surface being approximately parallel to the substrate".

However, the scribing head and the scribing apparatus according to the Embodiment of the present invention are not limited to those shown in Figure 1 to Figure 3. A scribing head and a scribing apparatus having arbitrary structure

can be included in the scope of the present invention as long as the function of each means described above is achieved.

3. Control of the operation of the scribing head

Figure **4** shows a controlling process procedure for controlling the scribing head **700** according to the Embodiment of the present invention. Hereinafter, the controlling process procedure for controlling the scribing head **700** in order to scribe the substrate G by the scribing head **700** will be described with reference to Figure **4**.

Specifically, Figure **4** shows a timing-chart of the operation of the scribing line forming means **29** for forming one scribing line. Categories are: an X-axis operation (operation in which the scribing head **700** moves on the substrate); a Z-axis position setting (setting position of the scribing line forming means **29** in a vertical direction); a Z-operation (operation in which the scribing line forming means **29** moves in the vertical direction); and changes of a torque limit value (changes of the torque limit value of the servo motor **502**).

An example, in which the scribing line forming means **29** moves from the left (position a) to the right (position e) on the substrate G in order to scribe in a direction which the positional data in the X-axis increases, is shown. In the example which will be described with reference to Figure **4**, the torque of the servo motor **502** is limited based on the position data in the X-axis.

First, the position data in the X-axis is set in a control section which is included in the gear-type scribing

head **700**. The position data in the X-axis includes: data showing an X-axis cutting-in position (position a); data showing an X-axis pushing-in position (position c); data showing an X-axis pushing-in completion position (position d); data showing an X-axis cutting-in completion position (position e); and data showing an X-axis scribing completion position (position f). The X-axis cutting-in position (position a), the X-axis pushing-in position (position c), the X-axis pushing-in completion position (position d), the X-axis cutting-in completion position (position e) and the X-axis scribing completion position (position f) exist between an X-axis operation starting position (position S1) and an X-axis operation completion position (position E1).

After the position data in the X-axis is set in the control section, the process proceeds to step 1.

Step 1: In the operation of the scribing line forming means **29** for forming one scribing line, a position-determining torque value is output. After the position-determining torque value is output, the process proceeds to step 2.

Step 2: The scribing line forming means **29** is moved to a Z-axis waiting position (position Z1). After the scribing line forming means **29** is moved, the process proceeds to step 3.

Step 3: At the time when the scribing line forming means **29** has moved to the X-axis cutting-in position (position a), the scribing line forming means **29** moves to a Z-axis cutting-in position (position Z2), and the position along the Z-axis of the scribing line forming means **29** is held.

The Z-axis cutting-in position (position Z2) is a position where the scribing line forming means **29** has moved downward by E from point 0 (surface of the substrate G) in the vertical direction. After the position is held, the process proceeds to step 4.

Step 4: A climbing torque limit value is set, and the servo motor **502** outputs the climbing torque limit value. In other words, when the scribing line forming means **29** moves in the horizontal direction and climbs the substrate G (position b), the position of the scribing line forming means **29** in the Z-axis cutting-in position is deviated. Thus, while IN-POS (in position) signal output from a servo amplifier is ON, the servo motor **502** tries to move the position of the scribing line forming means **29** back to the original Z-axis cutting-in position and increases the torque, thereby causing the need for limiting the climbing torque. Therefore, the climbing torque limit value is set. The climbing torque limit value is a small value such that a chip does not occur at the end of the substrate G when the scribing line forming means **29** climbs the substrate G.

Step 5: When the scribing line forming means **29** has climbed the substrate G (position b), the position of the scribing line forming means **29** of the Z-axis cutting-in position is deviated. When the IN-POS (in position) signal output from the servo amplifier is OFF, a pushing torque limit value is set at position c by a controller which issues an instruction to the servo motor (e.g., NC or sequencer) after the scribing line forming means **29** has moved by a preset predetermined distance. The servo motor **502** outputs the pushing torque limit value. If the setting position in the Z-axis remains to be the Z-axis cutting-in position, a

displacement is small, and an appropriate pushing torque for scribing cannot be obtained. Thus, the setting position in the Z-axis set at the Z-axis pushing position which is further below the Z-axis cutting-in position from the upper surface of the substrate G.

Step 6: The gear-type scribing head **700** is moved to the X-direction (position d) at a preset scribing speed by using the driving torque (which is limited to the pushing torque limit value) for trying to move to the Z-axis pushing position as a scribing pressure. When the gear-type scribing head **700** has reached position d, the process proceeds to step **7**.

Step 7: The scribing speed is decreased to a cutting-through speed which can cut the substrate G. The cutting-through speed is preset. A cutting-through torque limit value is set. The servo motor **502** outputs the cutting-through torque limit value. The position in the Z-axis is set as the Z-axis cutting-in position. The cutting-through torque limit value is set as a small value as in the case of climbing such that a chip does not occur at the end of the substrate G when the scribing line forming means **29** is cutting through the substrate G (X-axis cutting-in completion position, position e).

Step 8: When the scribing line forming means **29** has cut through the substrate G (position e), the position of the scribing line forming means **29** in the vertical direction again returns to the Z-axis cutting-in position.

Step 9: When the gear-type scribing head **700** has reached position f, a position-determining torque is set,

and the servo motor outputs the position-determining torque value. Then, the scribing line forming means **29** once again moves to the Z-axis waiting position. A series of scribing operations is completed.

When a scribing line is formed on the substrate G by the gear-type scribing head **700**, as previously described, the cutting edge's ridge of the scribing line forming means **29** holds the position which overlaps the movement path of the axial center Q of the second turning axis run by the gear-type scribing head **700**. Therefore, a scribing line with a high degree of straightness is formed.

When the servo motor **502** is rotatingly driven, it is possible to move the scribing line forming means **29** upward and downward via the holder holding member **404**. Thus, it is possible to directly act the rotating torque as a scribing pressure via the servo motor **502**, and a scribing pressure appropriate for the substrate G can be arbitrarily selected.

4. Ball screw-type scribing head

The scribing head **700** according to the Embodiment of the present invention uses the cylindrical cam **503** and the cam follower **506** as a motive power transmission means. However, the scribing head can use a ball screw instead.

Figure **5** shows a structure of a ball screw **513**. The ball screw **513** includes a ball screw nut **515** and a screw axis **516**. Hereinafter, the structure of the scribing head including the ball screw **513** instead of the cylindrical cam **503** and the cam follower **506** will be described partly incorporating the reference to Figure **2**. The structure of

the scribing head using the ball screw **513** as a motive power transmission means has the same structure as that of the scribing head **700** shown in Figure **2** except that the cylindrical cam **503** and the cam follower **506** are changed to the ball screw 513.

The ball screw nut **515** is fixed to the holder holding member **504**. The screw axis **516** is connected to the rotation axis of the servo motor **502**. Thus, when the rotation axis of the servo motor **502** is rotated, the screw axis **516** rotates together with the rotation axis. Therefore, the ball screw nut **515** moves upward and downward along the axis direction of the screw axis **516**, and the holder holding member **504** to which the ball screw nut **515** is fixed moves upward and downward.

When the motive power transmission means structured as described above is described in view of an acting force, the torque of the rotation axis of the servo motor **502** is transmitted as a force which tries to move the ball screw nut **515** and the scribing line forming means **29** downward via the screw axis **516**. The reaction force generated when the scribing line forming means **29** is pressed onto the substrate G is transmitted as a force which tries to rotate the screw axis **516** and the rotation axis of the servo motor **502** in the negative direction via the ball screw nut **515**.

5. Scribing apparatus including a multi-head

Figure **6** shows a structure of a scribing apparatus **800** which is another example of the scribing apparatus. In Figure **6**, the same components as those shown in Figure **1** are denoted by the same reference numerals, and the

description thereof will be omitted.

The scribing apparatus **800** has the same structure as the scribing apparatus **100** which has been described with reference to Figure **1** except that in the scribing head **800**, a plurality of scribing heads is included, instead of the scribing head **700** included in the scribing apparatus **100**. The plurality of scribing heads is arranged in line in the X-direction (lateral direction in Figure **6**). When the table **111** on which the substrate G is mounted is moved in the Y-direction, a plurality of scribing lines along the Y-direction is formed on the substrate G.

The plurality of scribing heads described above includes at least one of the scribing head **700** which has been described with reference to Figure **2** and the scribing head using the ball screw-type motive power transmission means which has been described with reference to Figure **5**.

In any one of the scribing heads according to the Embodiment, the servo motor **502** is mounted in the vertical direction. Particularly, only a small amount of footprint space is required when viewed from the movement direction of the scribing head. Therefore, when compared to the conventional scribing head in which the servo motor is used for a pressing means, it is possible to shorten the interval between each scribing line forming means **29** included in the scribing head. When a plurality of scribing heads is mounted in a scribing apparatus, numerous scribing heads can be attached within a small amount of space when compared to a conventional scribing head having a motor mounted thereon.

The scribing apparatus **800** according to the present

invention runs the plurality of scribing heads simultaneously. Therefore, scribing lines, the number of which corresponds to the number of the plurality of scribing heads, are formed in close intervals. As a result, when a plurality of unit substrates are cut from one substrate, production efficiency can be improved.

In the scribing apparatus **800**, a plurality of scribing heads is arranged in line in the X-direction. When the table **111** on which the substrate G is mounted is moved in the Y-direction, the scribing apparatus **800** forms scribing lines on the substrate G, the scribing lines being parallel to the Y-direction. Alternatively, in the scribing apparatus **800**, a plurality of scribing heads is arranged in line in the Y-direction. When the plurality of scribing heads is moved along the guide bar **114**, the scribing apparatus **800** may form scribing lines on the substrate G, the scribing lines being parallel to the X-direction.

The scribing apparatus **800** according to the Embodiment includes a plurality of scribing heads in line, thereby simultaneously forming a plurality of scribing lines on one surface of the substrate. In addition to this, for example, a plurality of scribing heads may be arranged in the scribing apparatus **800** such that the scribing line forming means **29** is contacted to each substrate of a bonded substrate for which two brittle material substrates are bonded and one or more scribing line are simultaneously formed on each substrate.

As described above, the Embodiment of the present invention has been described with reference to Figure 1 to Figure 6.

Each means described in the Embodiment shown in Figure 1 to Figure 6 can be implemented by hardware, software or the combination of the hardware and the software. Even if each means is implemented by hardware, software or the combination of the hardware and the software, a scribing line forming processing for performing the function of the scribing head according to the present invention or the scribing apparatus according to the present invention can be performed. The scribing line forming processing has arbitrary procedures as long as it can perform the function of the scribing head according to the present invention or the scribing apparatus according the present invention.

For example, a scribing line forming processing program for causing an execution of the function of the scribing head according to the present invention or the function of the scribing apparatus according to the present invention is stored in the scribing head according to the present invention or the scribing apparatus according to the present invention.

When the scribing head or scribing apparatus is shipped, the processing program can be previously stored in a storage means included in the scribing head or the scribing apparatus. Alternatively, after the scribing head or scribing apparatus is shipped, the processing program can be stored in the storage means. For example, a user can download a processing program with or without charge from a particular website on the Internet and install the processing program downloaded onto a scribing head or a scribing apparatus.

When a processing program is recorded in a computer-readable recording medium (e.g., flexible disc, CD-ROM and DVD-ROM), the processing program can be installed in a scribing head or a scribing apparatus by using an input device. The processing program installed is stored in the storage means.

The scribing head and the scribing apparatus according to the present invention can be applied to the cutting of, for example, a liquid crystal display panel, a plasma display panel, an organic EL panel, an inorganic EL panel which are a kind of flat display panel, a transmissive projector substrate and a reflective projector panel.

Furthermore, the scribing head and the scribing apparatus according to the present invention can be applied to the cutting of, for example, one single substrate (e.g., glass plate, glass substrate, quartz plate, quartz substrate, sapphire plate, sapphire substrate, semiconductor wafer, ceramic plate and ceramic substrate). Furthermore, the scribing line forming mechanism, the scribing head and the scribing apparatus according to the present invention can be effectively applied to the cutting of a bonded substrate for which a plurality of substrates are bonded.

As described above, the scribing line forming mechanism, the scribing line head and the scribing apparatus according to the present invention have been described above with reference to Figure 1 to Figure 6. However, the present invention should not be interpreted solely based on the embodiments described above. It is understood that the scope of the present invention should be interpreted solely based on the claims. It is also understood that those skilled in

the art can implement equivalent scope of technology, based on the description of the present invention and common knowledge from the description of the detailed preferred embodiments of the present invention. Furthermore, it is understood that any patent, any patent application and any references cited in the present specification should be incorporated by reference in the present specification in the same manner as the contents are specifically described therein.

INDUSTRIAL APPLICABILITY

According to the scribing head and the scribing apparatus of the present invention, a rotating means, a motive power transmission means and a scribing line forming means are provided in line along the direction in which the scribing line forming means moves. Therefore, neither the rotation means nor the motive power transmission means is provided on the side of the scribing line forming means. As a result, it is possible to omit the space on the side of the scribing line forming means.

CLAIMS

1. A scribing head comprising:

a scribing line forming means structured so as to form a scribing line on a substrate; and

a moving means for moving the scribing line forming means such that the scribing line forming means presses the substrate with a constant magnitude, wherein

the moving means includes:

a rotation means rotating about a rotation axis, the axial center of the rotation axis being provided so as to align with a predetermined direction in which the scribing line forming means moves, and

a motive power transmission means for transmitting a motive power between the motive power transmission means and the scribing line forming means such that the scribing line forming means moves on a straight line along the axial center of the rotation axis in response to the rotation of the rotation means, the motive power transmission means being provided along the predetermined direction.

2. A scribing head according to claim 1, wherein while the motive power transmission means continues the transmission of motive power between the motive power transmission means and the scribing line forming means, the scribing line forming means forms the scribing line on the substrate.

3. A scribing head according to claim 1, wherein the motive power transmission means is structured such that the transmission efficiency of the force to be transmitted to the scribing line forming means from the motive power transmission means and the transmission efficiency of the force to be transmitted to the motive power transmission

means from the scribing line forming means are approximately the same.

4. A scribing head according to claim 2, wherein the motive power transmission means includes a face which is tilted by approximately 45 degrees with respect to the circumferential direction of the rotation axis along a direction in which the motive power transmission means rotates.

5. A scribing head according to claim 1, wherein the motive power transmission means includes a cylindrical cam.

6. A scribing head according to claim 1, wherein the motive power transmission means includes a ball screw.

7. A scribing head according to claim 1, wherein the substrate is a kind of substrate among a glass plate, a glass substrate, a quartz plate, a quartz substrate, a sapphire plate, a sapphire substrate, a semiconductor wafer, a ceramic plate, a ceramic substrate, a solar cell substrate, a liquid crystal display panel, an organic EL panel, an inorganic EL panel, a transmissive projector substrate and a reflective projector substrate.

8. A scribing apparatus comprising:

at least one scribing head according to claim 1; and

a first moving means for moving the scribing head on a surface such that the scribing line forming means forms the scribing line on the substrate, the surface being approximately parallel to the substrate.

9. A scribing apparatus according to claim 7, wherein at

least two scribing heads of the at least one scribing head according to claim 1 are provided approximately parallel to a scribing direction.