DESCRIPTION

TITLE OF THE INVENTION: Wafer holder

TECHNICAL FIELD

[0001]

The present invention relates to a wafer holder.

BACKGROUND ART

[0002]

For example, wafers of a semiconductor material produced by slicing a single-crystal ingot of the semiconductor material are used as materials for various semiconductor products. In a manufacturing process for semiconductor products, a wafer holder is used when a plurality of wafers are held in alignment. Patent document 1 discloses an example of a conventional wafer holder. The wafer holder disclosed in Patent document 1 has two groove rows. The two groove rows face each other with a space therebetween. Each groove row includes a plurality of holding grooves. Each pair of holding grooves that face each other holds a single wafer. This allows the wafer holder to hold the wafers in alignment.

PRIOR ART DOCUMENT

Patent Document

[0003]

Patent Document 1: JP-A-H2-78246

SUMMARY OF THE INVENTION

Problem to be solved by the Invention

[0004]

The width of each holding groove is preferably set to a size obtained by adding a margin to the thickness of a wafer. As the margin increases, the wafer can be inserted into the holding groove more easily. However, if the margin is too large, the wafer held by the holding groove tends to tilt. If the wafer tilts, it may come into contact with an adjacent wafer. For example, in a process of immersing a plurality of wafers in a processing solution and/or washing the wafers with a cleaning solution, portions of the wafers that are in contact with each other may be insufficiently processed. As the thickness of a wafer decreases, setting an appropriate margin

becomes more difficult.

[0005]

In view of the foregoing circumstances, an object of the present invention is to provide a wafer holder capable of holding a plurality of wafers in a more appropriate alignment.

Means to solve the Problem

[0006]

The present invention provides a wafer holder for holding a plurality of wafers in alignment in a first direction such that surfaces of the plurality of wafers face each other. The wafer holder includes two groove rows that each include a plurality of holding grooves aligned in the first direction, and that are spaced apart from each other in a second direction perpendicular to the first direction. Each of the holding grooves is open on one side in a third direction perpendicular to the first direction and the second direction, is at least partially closed on the other side in the third direction, and includes a wide portion and a narrow portion. The narrow portion is located on an inner side in the second direction relative to the wide portion and on the other side in the third direction. A width of the narrow portion in the first direction at an end on the other side in the third direction is smaller than a width of the wide portion in the first direction at an end on the other side in the third direction.

[0007]

In a preferred embodiment of the present invention, the wafer holder further includes two leg portions respectively located on the other side in the third direction relative to the two groove rows. Each of the holding grooves includes a bottom portion that closes the holding groove at an end on the other side in the third direction and on an inner side in the second direction. Each of the leg portions includes a discharge portion connected to a corresponding one of the bottom portions and extending toward the other side in the third direction.

[0008]

In a preferred embodiment of the present invention, the width of the narrow portion decreases from an outer side toward the inner side in the second direction.

[0009]

In a preferred embodiment of the present invention, the narrow portion includes the bottom portion.

[0010]

In a preferred embodiment of the present invention, each of the leg portions includes an inner surface and the inner surface includes a convex curved surface portion connected to the

bottom portion, and a flat surface portion connected to the convex curved surface portion on the other side in the third direction.

Advantages of the Invention

[0011]

According to the present invention, a plurality of wafers can be held in a more appropriate alignment.

[0012]

Other features and advantages of the present invention will be more apparent from the detailed description given below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a perspective view showing a wafer holder according to a first embodiment of the present invention.

Fig. 2 is a plan view showing the wafer holder according to the first embodiment of the present invention.

Fig. 3 is a front view showing the wafer holder according to the first embodiment of the present invention.

Fig. 4 is a side view showing the wafer holder according to the first embodiment of the present invention.

Fig. 5 is a cross-sectional view showing the wafer holder according to the first embodiment of the present invention.

Fig. 6 is a cross-sectional view showing the wafer holder according to the first embodiment of the present invention.

Fig. 7 is a partially enlarged cross-sectional perspective view showing the wafer holder according to the first embodiment of the present invention.

Fig. 8 is a partially enlarged cross-sectional perspective view showing the wafer holder according to the first embodiment of the present invention.

Fig. 9 is a partially enlarged plan view showing the wafer holder according to the first embodiment of the present invention.

Fig. 10 is a partially enlarged cross-sectional view along line X–X of Fig. 9.

Fig. 11 is a partially enlarged cross-sectional view along line XI–XI of Fig. 9.

Fig. 12 is a partially enlarged front view as viewed from line XII–XII of Fig. 9.

Fig. 13 is a partially enlarged cross-sectional view along line XIII–XIII of Fig. 12.

Fig. 14 is a partially enlarged plan view showing a wafer holder according to a first variation of the first embodiment of the present invention.

Fig. 15 is a partially enlarged plan view showing a wafer holder according to a second variation of the first embodiment of the present invention.

Fig. 16 is a partially enlarged plan view showing a wafer holder according to a third variation of the first embodiment of the present invention.

Fig. 17 is a partially enlarged cross-sectional perspective view showing a wafer holder according to a fourth variation of the first embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0014]

The following describes preferred embodiments of the present invention in detail with reference to the drawings.

[0015]

The terms such as "first", "second" and "third" in the present disclosure are used merely for identification, and are not intended to impose orders on the elements accompanied with these terms.

[0016]

Figs. 1 to 13 show a wafer holder according to a first embodiment of the present invention. A wafer holder A1 of the present embodiment includes a body 1, two rib rows 2, two leg portions 3, two groove rows 4, and an opening 5. Fig. 5 is a cross-sectional view in a yz plane intersecting ribs 20, which will be described below. Fig. 6 is a cross-sectional view in a yz plane intersecting holding grooves 40, which will be described below. Fig. 7 includes a cross section in a yz plane intersecting ribs 20, which will be described below. Fig. 8 includes a cross section in a yz plane intersecting holding grooves 40, which will be described below.

[0017]

In these figures, a first direction x is the direction in which a plurality of wafers W are aligned. A third direction z may be a vertical direction when the wafer holder A1 is in use, and one side in the third direction z may be referred to as an "upper side," while the other side may be referred to as a "lower side". In a second direction y, the side toward the center of the wafer holder A1 may be referred to as an "inner side," while the side away from the center may be referred to as an "outer side".

[0018]

The specific configuration of the wafers W held by the wafer holder A1 is not particularly limited. The wafers W may be made of a semiconductor material, such as Si or SiC. Each wafer W may have a generally circular shape with a flat portion (orientation flat), a notch, or the like. The diameter of the wafer W is not particularly limited, and may be about 50 mm to 300 mm. The thickness t of the wafer W is not particularly limited, and may be about 300 μm to 800 μm.

[0019]

The material of the wafer holder A1 is not particularly limited, and may be a fluororesin, an engineering plastic, a general-purpose resin, a ceramic, quartz glass, or the like. Examples of the fluororesin include PTFE (polytetrafluoroethylene) and PFA (tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer). Examples of the engineering plastic include PEEK (polyether ether ketone), PEI (polyetherimide), PC (polycarbonate), and PBT (polybutylene terephthalate). Examples of the general-purpose resin include PP (polypropylene). The wafer holder A1 may be integrally formed by molding, or may be formed as an assembly of a plurality of components.

[0020]

The body 1 serves as the main structure of the wafer holder A1. The specific configuration of the body 1 is not particularly limited. In the present embodiment, the body 1 includes two side portions 11 and two end portions 12, as shown in Figs. 1 to 6.

[0021]

The two side portions 11 generally extend along the first direction x, and are spaced apart from each other in the second direction y. The specific configuration of each side portion 11 is not particularly limited. In the present embodiment, each side portion 11 includes an upper end portion 111 and a plurality of frame portions 112, 113, and 114.

[0022]

The upper end portion 111 constitutes the upper end of the side portion 11 in the third direction z, and extends in the first direction x. The upper end portion 111 may also extend outward in the second direction y. The frame portions 112, 113, and 114 extend in the first direction x. The frame portions 112, 113, and 114 are arranged in this order from top to bottom in the third direction z, and are spaced apart from each other. In the example illustrated in Fig. 6, the frame portion 112 is located directly below the upper end portion 111 in the third direction z. The upper end portion 111, the frame portion 112, and the frame portion 113 are arranged at positions along the periphery of a wafer W to be held.

[0023]

The two end portions 12 are spaced apart from each other in the first direction x, each being connected to corresponding ends of the two side portions 11 in the first direction x. The specific configuration of each end portion 12 is not particularly limited. In the illustrated example, one of the end portions 12 has a wall shape without an opening. The other end portion 12 has a shape with an opening. The specific shape of each end portion 12 may be appropriately determined according to, for example, the manner of engagement with a transporting means for transporting the wafer holder A1 or the requirements of a process performed while the wafers W are held.

[0024]

The two rib rows 2 are provided to form the two groove rows 4 in the present embodiment. The two rib rows 2 are spaced apart from each other in the second direction y. Each of the two rib rows 2 includes a plurality of ribs 20 aligned in the first direction x. The ribs 20 in each rib row 2 are connected to the side portion 11.

[0025]

The specific shape of each rib 20 is not particularly limited. In the example shown in Fig. 5, each rib 20 includes an arcuate portion 21 and a straight portion 22. The arcuate portion 21 is located on the lower side in the third direction z, is connected to the frame portions 112, 113, and 114, and has an arcuate shape along the frame portions 112, 113, and 114. The straight portion 22 is located on the upper side in the third direction z, and is connected to the upper end portion 111 and the frame portion 112.

[0026]

The ribs 20 in one rib row 2 face the ribs 20 in the other rib row 2 in the second direction y, and are located at substantially the same positions as the ribs 20 in the other rib row 2 in the first direction x. In the examples shown in Figs. 10 and 11, the upper end of each rib 20 in the third direction z may have a curved shape. The thickness of each rib 20 in the first direction x is not particularly limited, and may be about 1.5 mm to 4 mm. The height of each rib 20 in the third direction z is not particularly limited, and may be about 5 mm to 12 mm.

[0027]

The two leg portions 3 are respectively connected to the two side portions 11 on the lower side in the third direction z. In other words, the two leg portions 3 are respectively located under the two groove rows 4 (described below) in the third direction z. The two leg portions 3 may be used when the wafer holder A1 is placed on a flat surface. Each leg portion 3 has an inner surface 31. The inner surface 31 is located on the inner side in the second direction y.

[0028]

The opening 5 is provided between the two end portions 12 in the first direction x and

between the two leg portions 3 (inner surfaces 31) in the second direction y. The opening 5 is open on both sides in the third direction z.

[0029]

The two groove rows 4 are provided for holding the wafers W in alignment in the first direction x. The two groove rows 4 are spaced apart from each other in the second direction y. Each of the two groove rows 4 includes a plurality of holding grooves 40. As described above, in the present embodiment, the two groove rows 4 are formed by the two side portions 11 and the two rib rows 2. However, the specific configuration for forming the two groove rows 4 is not particularly limited. For example, the two groove rows 4 may be formed by melt-molding a solid member using a mold to form the holding grooves 40 therein.

[0030]

The holding grooves 40 are aligned in the first direction x. The holding grooves 40 in one groove row 4 face the holding grooves 40 in the other groove row 4 in the second direction y, and are located at substantially the same positions as the holding grooves 40 in the other groove row 4 in the first direction x. The specific configuration of each holding groove 40 is not particularly limited. In the present embodiment, as shown in Figs. 6 and 8 to 12, each holding groove 40 has a plurality of bottom portions 411, 412, 413, and 414 and two inner side surfaces 42.

[0031]

The bottom portions 411, 412, 413, and 414 restrict the movement of a wafer W in the third direction z or in the second direction y. A gap is provided between each adjacent pair of bottom portions 411, 412, 413, and 414. In Figs. 9, 11, and 12, the bottom portions 413 and 414 are hatched with a plurality of discrete dots for ease of understanding.

[0032]

The two inner side surfaces 42 face each other in the first direction x. In the present embodiment, each inner side surface 42 is formed by one side surface of a rib 20. In the example shown in Figs. 10 and 11, the distance between the two inner side surfaces 42 in the first direction x decreases from the upper side to the lower side in the third direction z.

[0033]

As shown in Figs. 8, 9, 11, and 12, each holding groove 40 includes a wide portion 401 and a narrow portion 402. The narrow portion 402 is located on the inner side in the second direction y relative to the wide portion 401_and on the lower side in the third direction z relative to the narrow portion 402. In the illustrated example, the narrow portion 402 is located at the end of the holding groove 40 on the inner side in the second direction y and on the lower side in the

third direction z. However, the narrow portion 402 may be spaced apart in both the second direction y and the third direction z from the end of the holding groove 40 on the inner side in the second direction y and on the lower side in the third direction z.

[0034]

In the illustrated example, the wide portion 401 is a portion of the holding groove 40 extending from the bottom portion 411 to the outer end of the bottom portion 414 in the second direction y via the bottom portions 412 and 413. In the illustrated example, the narrow portion 402 is a portion of the holding groove 40 formed by the bottom portion 414. Note that the sizes, positions, etc., of the wide portion 401 and the narrow portion 402 of the holding groove 40 are not particularly limited. For example, a plurality of wide portions 401 and a plurality of narrow portions 402 may be alternately arranged.

[0035]

In the illustrated example, the width of the wide portion 401 in the first direction x is constant, and is referred to as width X1. The width of the narrow portion 402 in the first direction x is smaller than the width (width X1) of the wide portion 401 in the first direction x. The width of the narrow portion 402 in the first direction x at the lower end thereof in the third direction z (the inner end thereof in the second direction y) is referred to as width X2. The width X2 is smaller than the width X1. When the thickness t of each wafer W is about 300 μm to 500 μm, the width X1 may be about 0.5 mm to 1.5 mm, and the width X2 may be about 0.3 mm to 1.0 mm. The width X2 may be one to three times the thickness t. In order to suppress contact between adjacent wafers W, the width X2 is preferably no greater than 2.5 times the thickness t, and more preferably no greater than twice the thickness t. In order to suppress the wafers W from being caught, the width X2 is preferably greater than the thickness t.

[0036]

In the illustrated example, the narrow portion 402 includes a tapered portion 4021 and a constant-width portion 4022. The tapered portion 4021 is connected to the wide portion 401 on the lower side in the third direction z and on the inner side in the second direction y. The width of the tapered portion 4021 in the first direction x decreases from the outer side toward the inner side in the second direction y (from the upper side toward the lower side in the third direction z). The constant-width portion 4022 is connected to the tapered portion 4021 on the lower side in the third direction z and on the inner side in the second direction y. The width of the constant-width portion 4022 in the first direction x is constant. The specific configuration of the narrow portion 402 is not particularly limited. For example, the entire narrow portion 402 may be formed only by the tapered portion 4021 or the constant-width portion 4022.

[0037]

As shown in Figs. 7, 8, 12, and 13, each leg portion 3 includes a discharge portion 32. The discharge portion 32 is connected to the bottom portions 414 of the holding grooves 40 and extends to the lower side in the third direction z. The specific configuration of the discharge portion 32 is not particularly limited. The discharge portion 32 may be configured in various forms, such as a plurality of grooves connected to the bottom portions 414 of the holding grooves 40, a plurality of holes, or a surface smoothly connected to the bottom portions 414. In the illustrated example, a plurality of discharge portions 32 each formed by a groove are employed. Each of these discharge portions 32 is recessed from the inner surface 31 to the outer side in the second direction y. The size of each discharge portion 32 is not particularly limited. For example, the discharge portion 32 may have a dimension of about 0.1 mm to 10 mm in the third direction z, and may have a depth of about 0.1 mm to 1.0 mm in the second direction y.

[0038]

In the example illustrated in Fig. 7, the inner surface 31 includes a curved surface portion 311 and a flat surface portion 312. The curved surface portion 311 is located on the upper side in the third direction z and connected to the bottom portion 414. The curved surface portion 311 is a convex curved surface that is located on the upper side in the third direction z and bulges to the inner side in the second direction y. The flat surface portion 312 is a flat surface connected to the curved surface portion 311 on the lower side in the third direction z and extending along the first direction x and the third direction z. In other words, the inner surface 31 in the illustrated example has a shape further protruding from the inner end of the holding groove 40 (the bottom portion 414) in the second direction y toward the inner side in the second direction y. The discharge portion 32 is recessed from the entirety of the curved surface portion 311 and from a portion of the flat surface portion 312. Note that the discharge portion 32 formed by a groove may alternatively have a wide configuration such that a single discharge portion 32 extends across a plurality of holding grooves 40. Alternatively, unlike the present example, the inner surface 31 having the curved surface portion 311 smoothly connected to the bottom portion 414 may function as the discharge portion 32 without any groove or the like.

[0039]

The following describes advantages of the wafer holder A1.

[0040]

According to the present embodiment, as shown in Figs. 8, 9, 11, and 12, each holding groove 40 includes a wide portion 401 and a narrow portion 402. As illustrated in Fig. 1, when the wafers W are inserted into the wafer holder A1 from the upper side in the third direction z, the

wafers W are received by the wide portions 401 of the holding grooves 40. The width of each wide portion 401 in the first direction x is the width X1, for example, which is relatively wide. This allows the wafers W to be inserted into the holding grooves 40 more smoothly. As the wafers W are further inserted toward the lower side in the third direction z, the wafers W reach the narrow portions 402. The width of each narrow portion 402 in the first direction x is the width X2, for example, which is relatively narrow. As a result, when the wafers W reach the narrow portions 402, the wafers W are brought into an upright posture along the third direction z. Accordingly, the upper ends of the wafers W in the third direction z are aligned with a more uniform pitch. Thus, the wafers W can be aligned more appropriately. This makes it easier to maintain an appropriate gap between adjacent wafers and avoid contact therebetween. Accordingly, for example, in a process of immersing the plurality of wafers in a processing solution and/or washing the wafers with a cleaning solution, there is less risk of the wafers being insufficiently processed.

[0041]

Further, when a liquid adheres to the wafers W during a process for the wafers W, the liquid flows downward along the wafers W toward the lower side in the third direction z. The narrow portions 402 are provided in the holding grooves 40 on the lower side in the third direction z, and thus the gaps between the wafers W and the inner side surfaces 42 are small. The narrower the gaps, the more likely the liquid is to remain in the gaps. Residual liquid may cause unintended deterioration in the quality of the wafers W or contaminate the wafers W held for the next process. In the present embodiment, each leg portion 3 is provided with a plurality of discharge portions 32. This allows the liquid that has flowed down to the narrow portions 402 to be discharged to the opening 5 via the discharge portions 32. Accordingly, problems caused by residual liquid can be reduced.

[0042]

Aligning the wafers W more appropriately and facilitating the discharge of a liquid become increasingly important as the thickness t of each wafer W decreases. According to the wafer holder A1, the wafers W each having a small thickness t can be held in alignment with a smaller pitch. Thus, it is advantageous for improving processing efficiency when the wafers W are collectively processed while being held by the wafer holder A1. In particular, in recent years, an approach has begun to be adopted in which the pitch between adjacent wafers in a wafer holder is set to, for example, about one-half of the conventional pitch, thereby allowing a single wafer holder to hold twice as many wafers and enabling the wafers to be processed more efficiently. In this case, there is a tendency to employ thinner wafers. In view of such an industry trend, the present

embodiment allows more favorable wafer processing.

[0043]

Since each narrow portion 402 includes a tapered portion 4021, the wafers W can be prevented from being caught when the wafers W are to be inserted into the holding grooves 40.

[0044]

Since each narrow portion 402 includes a bottom portion 414, the liquid flowing down along the wafers W can be received by the bottom portions 414, and promptly guided to the discharge portions 32. This can improve the discharge efficiency of the liquid.

[0045]

Each inner surface 31 includes a curved surface portion 311 and a flat surface portion 312. Accordingly, the inner surface 31 has a shape protruding from the bottom portion 414 toward the inner side in the second direction y. Thus, although the discharge portions 32 are recessed from the inner surfaces 31 toward the outer side in the second direction y, the discharge portions 32 need not extend into the holding grooves 40 (the bottom portions 414). Accordingly, for example, the discharge portions 32 can be formed to have a shape and size suitable for liquid discharge while avoiding alteration of the shape of the holding grooves 40.

[0046]

Figs. 14 to 17 show variations of the present invention. In these figures, elements that are the same as or similar to the elements in the above example are denoted by the same reference numerals as those in the above example. The configurations of the elements in each variation and each embodiment can be combined as appropriate as long as the combination does not cause technical inconsistency.

[0047]

Figs. 14 to 16 show variations of the wafer holder A1. In these variations, the configuration of the narrow portions 402 are configured differently from those in the above example.

[0048]

In a wafer holder A11 according to a first variation shown in Fig. 14, the narrow portion 402 includes only the tapered portion 4021. In other words, throughout the narrow portion 402, the width in the first direction x decreases from the outer side toward the inner side in the second direction y.

[0049]

In a wafer holder A12 according to a second variation shown in Fig. 15, the narrow portion 402 includes only the constant-width portion 4022. In other words, throughout the narrow

portion 402, the width in the first direction x is constant.

[0050]

In a wafer holder A13 according to a third variation shown in Fig. 16, the narrow portion 402 includes the tapered portion 4021 and a reverse-tapered portion 4023. The reverse-tapered portion 4023 is connected to the tapered portion 4021 on the inner side in the second direction y. The width of the reverse-tapered portion 4023 in the first direction x increases from the outer side toward the inner side in the second direction y.

[0051]

As can be understood from the wafer holders A11, A12, and A13, the specific configuration of the narrow portion 402 is not particularly limited. As can be understood from the wafer holder A13, the present invention is not limited to the configuration in which the width of the narrow portion 402 in the first direction x at the inner end thereof in the second direction y is the smallest.

[0052]

Fig. 17 shows a wafer holder A14 according to a fourth variation of the wafer holder A1. In the present variation, the inner surface 31 includes only the flat surface portion 312 and not the curved surface portion 311. The inner surface 31 can be substantially flush with the inner end surfaces of the ribs 20 in the second direction y. In the present variation, as viewed in the third direction z, the discharge portions 32 formed by grooves may extend into the bottom portions 414 of the holding grooves 40.

[0053]

As can be understood from the present variation, the specific configuration of the inner surface 31 is not particularly limited. When the discharge portions 32 are formed by grooves, the discharge portions 32 only need to be recessed from the inner surface 31 toward the outer side in the second direction y.

[0054]

The wafer holder according to the present invention is not limited to the above embodiments. Various design changes can be made to the specific configurations of the elements in the wafer holder according to the present invention.

REFERENCE NUMERALS

[0055]

A1, A11, A12, A13, A14: Wafer holder

1: Body 2: Rib row 3: Leg portion 4: Groove row 5: Opening

11: Side portion 12: End portion 20: Rib 21: Arcuate portion

22: Straight portion 31: Inner surface 32: Discharge portion 40: Holding groove

42: Inner side surface 111: Upper end portion 112, 113, 114: Frame portion

311: Curved surface portion 312: Flat surface portion 401: Wide portion

402: Narrow portion 411, 412, 413, 414: Bottom portion

4021: Tapered portion 4022: Constant-width portion 4023: Reverse-tapered portion

W: Wafer t: Thickness x: First direction y: Second direction

z: Third direction

CLAIMS

Claim 1. A wafer holder for holding a plurality of wafers in alignment in a first direction such that surfaces of the plurality of wafers face each other, the wafer holder comprising

two groove rows that each include a plurality of holding grooves aligned in the first direction, and that are spaced apart from each other in a second direction perpendicular to the first direction,

wherein each of the holding grooves is open on one side in a third direction perpendicular to the first direction and the second direction, is at least partially closed on the other side in the third direction, and includes a wide portion and a narrow portion,

the narrow portion is located on an inner side in the second direction relative to the wide portion and on the other side in the third direction, and

a width of the narrow portion in the first direction at an end on the other side in the third direction is smaller than a width of the wide portion in the first direction at an end on the other side in the third direction.

Claim 2. The wafer holder according to claim 1, further comprising two leg portions respectively located on the other side in the third direction relative to the two groove rows,

wherein each of the holding grooves includes a bottom portion that closes the holding groove at an end on the other side in the third direction and on an inner side in the second direction, and

each of the leg portions includes a discharge portion connected to one or more of the bottom portions and extending toward the other side in the third direction.

Claim 3. The wafer holder according to claim 2, wherein the width of the narrow portion decreases from an outer side toward the inner side in the second direction.

Claim 4. The wafer holder according to claim 3, wherein the narrow portion includes the bottom portion.

Claim 5. The wafer holder according to claim 4, wherein the inner surface" with "each of the leg portions includes an inner surface and the inner surface includes a convex curved surface portion connected to the bottom portion, and a flat surface portion connected to the convex curved surface portion on the other side in the third direction.