appropriate film formation method, and then only the substrate is removed by etching or the like while a peripheral frame-like region is left (back-etching). Since etching is generally performed by an existing semiconductor production process, the substrate is processed in a state of being disc-shaped, namely, in a so-called wafer state. Therefore, in order to produce a pellicle film, the substrate for the pellicle film is removed by back-etching and then the pellicle film is trimmed. However, such a pellicle production method has a problem that particles generated at the time of trimming are accumulated on a surface of the film and thus contaminate the pellicle film.

CITATION LIST

PATENT LITERATURE

[0005]

Patent Literature 1: Japanese Laid-Open Patent Publication No. 2013-004893

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006]

A pellicle may be contaminated with dust or the like for various reasons during the production thereof. Especially, there is a problem that the risk that the dust or the like is attached is high during trimming or various other processes performed on the pellicle film.

[0007]

A conceivable method for preventing the contamination is to clean the completed pellicle film. However, a pellicle film for EUV, which is an

extremely thin film, has a thickness of a nanometer order and thus is very easy to be broken. Another conceivable method for preventing the contamination is to perform the trimming by stealth dicing. However, even with trimming by stealth dicing, there occurs a phenomenon that particles are generated during expansion and are attached to the pellicle film. This does not fundamentally solve the problem.

[0008]

Embodiments of the present invention provide a pellicle film for EUV, a pellicle frame, a pellicle and a method for producing the same that decrease the attachment of dust or the like.

SOLUTION TO PROBLEM

[0009]

Disclosed herein is a method for producing a pellicle, including forming a pellicle film on a substrate; trimming the pellicle film; and removing at least a part of the substrate from the pellicle film after trimming the pellicle film.

[0010]

According to a first aspect, there is provided a method for producing a pellicle, including forming a pellicle film on a substrate; trimming the substrate; and removing at least a part of the substrate after trimming the substrate.

[0011]

In an embodiment, the method for producing a pellicle may include removing at least particles attached to a surface of the pellicle film before removing the part of the substrate.

[0012]

In an embodiment, the method for producing a pellicle may include chamfering an end portion of the substrate before removing the particles.

[0013]

In an embodiment, the method for producing a pellicle may include forming a hole in at least the substrate before removing the particles.

[0014]

In an embodiment, the method for producing a pellicle may include forming a hole in at least the pellicle film and the substrate before removing the particles.

[0015]

In an embodiment, the method for producing a pellicle may include forming a hole in at least the pellicle film before removing the particles.

[0016]

In an embodiment, the hole may be formed by use of an ultra-short pulse laser.

[0017]

In an embodiment, the step of removing the part of the substrate is a wet etching step, and the hole may be formed by the wet etching step.

[0018]

In an embodiment, the substrate may be trimmed by use of an ultra-short pulse laser.

[0019]

According to a second aspect, there is provided a pellicle frame, including a pellicle film; and a first frame. The pellicle film is extended over the first frame; and the first frame includes at least one curved portion at an end portion thereof.

[0020]

According to a third aspect, there is provided a pellicle frame, including a pellicle film; and a first frame. The pellicle film is extended over the first frame; the first frame includes inclining surface at an end portion thereof; and a top surface and the inclining surface of the first frame make an angle of 100 degrees to 170 degrees.

[0021]

According to a fourth aspect of the present invention, there is provided a pellicle, including the above pellicle frame; and a second frame; wherein: the pellicle frame is connected with the second frame; and the second frame includes a curved portion at an end portion thereof.

[0022]

According to embodiments of the present invention, an "end portion" of the first frame refers to a side surface, an edge or a corner edge. Specifically, the "end portion" encompasses an edge made by two adjacent side surfaces of a substrate (in the case where the substrate is used as the first frame, the first frame), an edge made by a top surface (surface in contact with the pellicle film) and a side surface of the substrate, and a corner edge including a point at which the top surface and two adjacent side surfaces of the substrate cross each other.

ADVANTAGEOUS EFFECTS OF INVENTION

[0023]

With a pellicle frame, a pellicle, and a method for producing the same according to embodiments of the present invention, the step of hole formation, trimming or the like that accompanies generation of dust is performed before a substrate below the pellicle film is removed. With such an arrangement, even if dust or the like is attached to the pellicle film by such a step that accompanies the generation of dust, the pellicle film may

swing cleaning, ultrasonic cleaning, and cleaning with high-pressure atomization of aerosol such as argon or the like.

[0055]

Examples of the dry cleaning include ash cleaning with O_2 plasma, argon sputtering, and the like.

[0056]

According to the present invention, the method includes a step of removing a part of the substrate (S105). FIG. 5 provides schematic views of a pellicle film in a state where a part of the substrate has been removed. The substrate may be removed with a frame-shaped part thereof being left. In this case, a pellicle film for EUV, although being extremely thin film, is prevented from being broken because the pellicle is supported by the frame-shaped substrate.

[0057]

The substrate may be removed by etching such as wet crystalline anisotropic etching, dry anisotropic etching, dry isotropic etching or the like. The substrate may be removed by etching or polishing. Alternatively, the etching or the polishing may be combined with a method of thinning the substrate (e.g., CMP polishing or the like).

[0058]

In the case where the substrate is removed by etching, the at least one hole 110 may be formed in the etching step.

[0059]

The step of thinning the substrate may be performed before the hole is formed or before the substrate is removed. Incorporation of this step into the method shortens the time required for the etching. When to perform this step is not specifically limited.

is incorporated, the physical strength of the substrate may be undesirably decreased temporarily. The use of the reinforcing frame prevents the substrate from being broken.

[0065]

The pellicle frame thus formed may be connected with the second frame 118 by an adhesive, a pressure-sensitive adhesive or the like (FIG. 5(c) and FIG. 5(d)). There is no specific limitation on the shape, size or material of the second frame to be connected. In the case where, for example, as shown in FIG. 5, the pellicle film is trimmed to have a generally rectangular shape and the first frame 116 is formed by back-etching, the second frame having substantially the same shape as that of the first frame 116 may be separately formed and connected with the first frame 116. The pellicle for EUV is limited in the height thereof. It is preferable that the pellicle film and the frame have a total height of 2 mm or less. The second frame to be connected with the first frame 116 may have a jig hole as shown in FIG. 5(d) or may not have a jig hole as shown in FIG. 5(c).

[0066]

A second frame having no through-hole may be connected as shown in FIG. 5(e), or a second frame having a through-hole may be connected as shown in FIG. 5(f). The through-hole in FIG. 5(f) may act as a ventilation hole.

[0067]

The first frame having the pellicle film formed thereon is used in an EUV laser environment. Therefore, the first frame may be formed of an aluminum alloy or the like used in a pellicle for an ArF laser. In order to decrease the thermal strain of the entirety of the pellicle, it is

pellicle collides against any component during transportation or at the time of handling after the production. From the point of view of removing the acute angled portions, the chamfering needs to be performed in the range of about 10 μm to about 3 mm.

[0093]

R-chamfering may be performed by mechanical polishing such as diamond polishing or the like, excimer laser processing, wet etching, dry etching (by use of, for example, XeF_2, etc.) or the like. Mechanical polishing such as diamond polishing or the like is preferable from the point of view of ease of processing. C-chamfering may be performed by mechanical polishing such as diamond polishing or the like, excimer laser processing, wet etching, dry etching (by use of, for example, XeF_2, etc.) or the like. Among R-chamfering and C-chamfering, R-chamfering is preferable. A reason for this is that with C-chamfering, acute angled portions are left and cause generation of particles, whereas with R-chamfering, particles are not easily generated. Especially, a silicon wafer is harder than aluminum. Therefore, with C-chamfering, acute angled portions are left, and particles are easily generated by, for example, cracking of the acute angled portions. For substantially the same reasons, it is preferable that the pellicle, the first frame and the pellicle frame in a finished state have an R-chamfered shape including a curved portion, not a C-chamfered shape. A preferable value of radius of curvature of an R-chamfered shape having a curved portion is any of the above-described the preferable values of radii R1, R2 or R3 described above.

[0094]

In this embodiment, after the trimming but before the etching, a

pellicle that were of high quality and would not easily generate particles after the production thereof (during transportation, at the time of demounting, etc.) were produced. If R-chamfering or C-chamfering is performed after the substrate below the pellicle film is removed, the pressure applied at the time thereof breaks the pellicle film because the pellicle film is thin. In addition, the R-chamfering or the C-chamfering usually accompanies generation of dust. Therefore, it is very undesirable to perform the R-chamfering or the C-chamfering after the substrate below the pellicle film is removed, in order to produce a high quality pellicle.

[0114]

(EXAMPLE 3)

Example 3 is the same as example 2 except for step 5 (steps 1 through 4 and 6 through 9 are the same as in example 2). In example 3, in step 5, a side surface was roll-polished by a polishing roll provided with a recessed portion having a radius of curvature of 1 mm.

[0115]

In this example, the pellicle was R-chamfered before being back-etched. Therefore, a curved portion was formed at an end portion of the pellicle frame and the pellicle. Thus, the pellicle frame and the pellicle that were of high quality and would not easily generate particles after the production thereof (during transportation, at the time of demounting, etc.) were produced.

[0116]

(EXAMPLE 4)

Example 4 is the same as example 2 except for steps 3, 6 and 8 (steps 1, 2, 4, 5, 7 and 9 are the same as in example 2). In this

in the art would make various modifications without departing from the gist of the present invention defined in the claims. These modifications should be construed as being encompassed in the technological scope of the present invention.

REFERENCE SIGNS LIST

[0121]

100: Substrate

102: Pellicle film

110: Hole

112: Pressure-sensitive adhesive sheet

114: Bridge

116: First frame

118: Second frame

200: Substrate

202: Pellicle film

204, 208: Silicon nitride layer

206: Polycrystalline silicon layer

210: Hole

300: Substrate

302: Pellicle film

303: Protective film

316: First frame