

Wafer Holder and Method of Producing a Semiconductor Wafer

The invention relates to a wafer holder and a method of producing a semiconductor wafer with ground sides and a rounded edge, in which the wafer holder is used.

5 The production of a semiconductor wafer comprises the cutting of the semiconductor wafer from a crystal and a series of material-removing machining steps. Suitable as cutting tools are annular, ribbon and wire saws. If a wire saw is used, a plurality of semiconductor wafers can be cut
10 simultaneously from a crystal. Wire-sawn semiconductor wafers are severely contaminated after the cutting operation because of the sawing suspension used in wire sawing. Regardless of the cutting method used, a semiconductor wafer cut from a crystal has damage in the
15 near-surface region which has to be removed by subsequent material-removing machining steps. Said machining steps are also necessary in order to provide the semiconductor wafer with a rounded edge, as smooth a surface as possible and parallel sides. After the cutting operation, the thickness
20 variation of the semiconductor wafer, the flatness of its side faces and the structure of its edge still do not meet the requirements which are laid down for the subsequent processing of the semiconductor wafer to produce electronic components. The material-removing machining steps normally
25 include the edge rounding, lapping, etching and polishing of the cut semiconductor wafer. Occasionally it has also already been proposed to replace the lapping in which both sides of the semiconductor wafer are machined simultaneously by two grinding steps which are to be
30 carried out one after the other and in which one side of the semiconductor is ground in each case. US 5,400,548 describes such a grinding method. During the grinding, the semiconductor wafer lies on the support of a wafer holder (chuck). Standard wafer holders have a support made of
35 porous ceramic material. The semiconductor wafer is fixed

to the wafer holder by vacuum suction. That side of the semiconductor wafer is ground which is opposite the side lying on the wafer holder. During edge rounding, the edge of the semiconductor wafer is ground.

5 The grinding of the sides of the semiconductor wafer permits a good parallelism of the sides to be achieved. On the other hand, it has emerged that the flatness of the sides thereby obtainable does not meet the requirements. In order to achieve the desired flatness,
10 subsequent material-removing machining steps, such as etching and polishing, have to take a more expensive form. Accordingly, the material removal to be included in the calculation for the production of a semiconductor wafer with desired wafer shape increases so that the wafer yield
15 for a certain crystal length decreases.

 During grinding or edge rounding of a semiconductor wafer, undesirable material splintering must be expected on that side of the semiconductor wafer situated opposite the wafer holder. In specialist circles, they are referred
20 to as crow's feet. Another phenomenon which impairs the quality of the semiconductor wafer relates to local depressions (dimples) on the sides of the semiconductor wafer which can be produced during the grinding of the sides. The danger of the occurrence of crow's feet and
25 depressions is all the higher, the greater the extent to which the semiconductor wafer to be machined is contaminated with particles. Wire-sawn semiconductor wafers, in particular, therefore have to be laboriously cleaned prior to the grinding or the edge rounding.

30 The object was therefore to achieve the result that a semiconductor wafer can be ground and edge-rounded even if it has been crudely cleaned and its surface is still appreciably contaminated with particles without the difficulties described above having to be expected.

35 The invention relates to a wafer holder (chuck) having a support for fixing a semiconductor wafer during

grinding wherein the support is composed of a soft material.

5 The wafer holder differs from known wafer holders in that the material of which its support is made preferably has an organic nature and is softer than the rigid ceramic material hitherto used. The material must be soft enough for particles which are situated between the semiconductor wafer and the wafer holder to be embedded in the support of the wafer holder by the compression force
10 exerted during the fixing of the semiconductor wafer. In addition, the material must be soft enough for the semiconductor wafer not to be deformed but for the support to be elastically deformed if an uneven side of the semiconductor wafer is laid on the surface of the support
15 and is fixed on the wafer holder. The material of the support should have a Shore A hardness of 5 to 99, preferably 50 to 92 and particularly preferably 80 to 90. It is furthermore preferable that, prior to the use of the wafer holder, the support is surface-ground and a surface
20 which is as flat as possible can thereby be given to it. The support of the wafer holder is preferably composed of an elastic organic material having a porous structure. Particularly preferred is a material such as, for example, polyurethane. The support may, for example, be stretched
25 over or glued to the wafer holder. If the semiconductor wafer is fixed on the wafer holder by means of vacuum suction, it is expedient to provide the support beforehand with suction channels, for example by perforating it at a plurality of points.

30 The invention also relates to a method in which the wafer holder is used. The method is one wherein the semiconductor wafer is fixed on a wafer holder having a soft support during grinding of the first side and is fixed on a wafer holder having a hard support during grinding of
35 the second side.

In connection with the invention, a support is

described as hard if an uneven side of a semiconductor wafer lies on the surface of the support and the semiconductor wafer is elastically deformed during fixing on the wafer holder. Said supports are composed of
5 inorganic material, in particular ceramic material. The Shore A hardness of such a material is preferably above 99.5.

The invention and its advantages are explained in greater detail below by reference to figures. Figure 1
10 shows diagrammatically the operations during grinding of the sides of a semiconductor wafer if a standard wafer holder having hard support is used. Figure 2 shows a corresponding diagram of the operations if the semiconductor wafer is ground in accordance with the
15 invention.

Reference is first made to Figure 1. The operations shown during grinding of the sides of a semiconductor wafer are a description of the prior art. As can be gathered from Figure 1a, a semiconductor wafer 1 which has been cut from
20 a crystal has neither flat nor parallel sides. The sides have an undulating profile and the wafer thickness varies over the wafer diameter. One side of the semiconductor wafer is described below as front 2 and the side situated opposite it as back 5. If the semiconductor wafer 1 is laid
25 on the hard support 4 of a wafer receptacle 3 and is fixed thereon, for example by vacuum suction (Figure 1b), the uneven back 5 of the semiconductor wafer is pressed against the support 4. In this process, the semiconductor wafer is elastically formed and fits snugly against the surface of
30 the support. Undulating uneven regions on the back are partly smoothed out and partly reduced in amplitude. A particle which is situated between the support and the semiconductor wafer deforms the wafer, as a result of which the amplitude of the undulation on the front of the
35 semiconductor wafer situated opposite the particle is locally increased. If the compression force originating

from the particle exceeds a certain value, material chips off at this point and a crow's foot is produced. This situation may occur both during grinding of the sides of the semiconductor wafer and during rounding of the edge of the semiconductor wafer.

The grinding of the front of the semiconductor wafer does indeed initially produce a flat side. The latter becomes undulating again, however, as soon as the fixing of the semiconductor wafer is removed and the elastically deformed semiconductor wafer 1 can relax (Figure 1c). In the subsequent grinding step, the back 5 of the semiconductor wafer is ground, the front 2 of the semiconductor wafer being fixed on the hard support 4 of the wafer holder 3. Although the undulation of the front is reduced by the first grinding step, it is not completely removed. The semiconductor wafer is therefore elastically deformed again as soon as its front 2 is fixed on the support 4 of the wafer holder 3 (Figure 1d). If the fixing of the semiconductor wafer is removed after grinding the back, a semiconductor wafer 1 is obtained whose sides already have the desired parallelism, but still have an undesirably high residual undulation (Figure 1e).

If a particle is situated between the semiconductor wafer and the wafer holder during the grinding of the semiconductor wafer and locally deforms the semiconductor wafer, too much material is ground off at this point and a depression (dimple) is produced on the side of the semiconductor wafer (not shown).

The method according to the invention provides that, to grind the first side, which is referred to as front below, the semiconductor wafer is fixed on a wafer holder having a soft support. This is shown in Figure 2. The sides of the semiconductor wafer 1 cut from a crystal are not flat and do not lie parallel to one another (Figure 2a). The semiconductor wafer may quite easily be contaminated with particles without crow's feet and

depressions being produced during grinding or edge rounding. Even heavily contaminated wire-sawn semiconductor wafers have to be cleaned only crudely before grinding. It is sufficient to rinse the sawing suspension off to such an extent that its liquid constituents are removed in the process. Particles which are situated between the semiconductor wafer and the support even after wafer cleaning are forced into the soft support 6 when the semiconductor wafer 1 is fixed on the wafer holder 3 without deforming the semiconductor wafer. The uneven regions on the back 5 of the semiconductor wafer are likewise taken up by the support during the grinding of the front 2 (Fig. 2b).

The soft support is, for example, glued to a conventional wafer holder or stretched over it. A conventional wafer holder may also be used in which the hard support is replaced by a soft support. It is preferable that the soft support on the wafer holder is surface-ground at least once to render it even before the wafer holder is used for machining semiconductor wafers. It is also expedient to cleanse the soft support of particles after every wafer machining, for example by means of a brush. Cleaning of the ground front, which can be carried out in the grinding machine with the semiconductor wafer lying on the wafer holder and serves to remove particles is furthermore preferred.

The semiconductor wafer fixed on the wafer holder is not elastically deformed so that the first grinding step results in a flat front which remains intact even after the semiconductor wafer 1 is removed from the wafer holder (Figure 2c). The invention furthermore makes provision for using a wafer receptacle 3 having a hard support 4 in grinding the back 5 of the semiconductor wafer. For this purpose, the semiconductor wafer ground on one side is turned over and the front 2 already ground flat is fixed on the wafer holder 3. Since the front is a flat reference

face, the semiconductor wafer is no longer elastically deformed in this operation. As a result of using a wafer holder 3 having a hard support 4, the back 5 of the semiconductor wafer can be ground parallel to said reference face with high precision (Figure 2d). The abrasion produced in this operation can be rinsed off in the grinding machine while the semiconductor wafer is still lying on the wafer holder. The semiconductor wafer 1 retains its flat- and parallel-ground sides even after removal from the wafer holder (Figure 2e).

The edge of the semiconductor wafer can be rounded before or after the grinding of the sides. If the edge is rounded before the sides are ground and consequently still has contamination from the sawing, the semiconductor wafer must be fixed on a wafer holder with a soft support in order to avoid the formation of crow's feet. On the other hand, it is preferable that a semiconductor wafer whose sides are already ground and clean is fixed on a wafer holder having hard support for rounding the edge.

One side of a semiconductor wafer can also be ground in two steps in which two different grinding tools are used (two-spindle grinding method). The first step comprises a coarse grinding and the second step a fine grinding of the side. In order also to be able to utilize the invention for this method, it is proposed first to coarse-grind and then fine-grind both sides of the semiconductor wafer. During coarse grinding of the sides, the semiconductor wafer is to be fixed on a wafer holder having a soft support. During fine grinding of the sides, the semiconductor wafer should be fixed on a wafer holder having a hard support.

A semiconductor wafer whose edge and sides have been machined according to the invention is then subjected to a further material-removing treatment which smooths its surface. This may comprise etching and polishing the semiconductor wafer, the etching step optionally being

dispensed with. The polishing step may comprise a single-sided polishing of both sides of the semiconductor wafer or only one side, or a double-sided polishing.

Example:

The effectiveness of the method was tested on silicon wafers having 200 mm diameter. In this connection, the following fabrication sequence was chosen: wire sawing
5 - crude cleaning - grinding of the front (wafer holder having a soft support) - cleaning of the front in the grinding machine - grinding of the back (wafer holder having a hard support) - cleaning of the back in the grinding machine - edge rounding (wafer holder having a
10 hard support).

As a comparison, wafers were fabricated using the same fabrication sequence but with grinding of the front on a wafer holder having a hard support. After a further treatment by etching and double-sided polishing of all the
15 silicon wafers, optical examinations were performed with a "magic mirror". The examinations showed that it was possible to reduce the uneven regions produced during sawing markedly better if the semiconductor wafers were treated according to the invention. The examination also
20 showed that in a treatment according to the invention of the semiconductor wafers adhering particles did not have a negative effect on the treatment result although the only crudely cleaned semiconductor wafers were appreciably contaminated with particles.



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Claims:

1. A wafer holder (chuck) having a support for fixing a semiconductor wafer during grinding, wherein the support is composed of a soft material.
- 5 2. The wafer holder as claimed in claim 1, wherein the support has a Shore A hardness of 5 to 99.
3. The wafer holder as claimed in claim 1 or 2, wherein the support is composed of polyurethane.
- 10 4. The wafer holder as claimed in any of claims 1 to 3, wherein the support is surface-ground flat.
- 15 5. A method of producing a semiconductor wafer having two flat-ground sides and a rounded edge by cutting the semiconductor wafer from a single crystal and by grinding the sides and the edge of the semiconductor wafer, the semiconductor wafer being fixed on a support of a wafer holder, wherein the semiconductor wafer is fixed on a wafer holder having a soft support during grinding of the first side and is fixed on a wafer holder having a hard support during grinding of the second side.
- 20 6. The method as claimed in claim 5, wherein, after cutting the semiconductor wafer from the crystal, the edge of the semiconductor wafer is first rounded and, during this operation, the semiconductor wafer is fixed on a wafer holder having a soft support.
- 25 7. The method as claimed in claim 5, wherein, after cutting the semiconductor wafer from the crystal, the sides of the semiconductor wafer are first ground and then the edge of the semiconductor wafer is rounded, and during rounding of the edge, the semiconductor wafer is fixed on



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a wafer holder having a hard support.

8. The method as claimed in any of claims 5 to 7, wherein the semiconductor wafer is crudely cleaned after cutting from the crystal.

5 9. The method as claimed in any of claims 5 to 8, wherein the semiconductor wafer is etched and polished following the grinding of the sides and the rounding of the edge.

10 10. The method as claimed in any of claims 5 to 8, wherein the semiconductor wafer is polished following the grinding of the sides and the rounding of the edge.

15 11. A method for producing a semiconductor wafer which has two flat-ground sides and a rounded edge by cutting the semiconductor wafer from a single crystal and by grinding the sides and the edge of the semiconductor wafer, the semiconductor wafer being fixed on a support of a wafer holder, and the grinding of the sides comprising a coarse grinding and a fine grinding, wherein the semiconductor wafer is fixed on a wafer holder having a soft support during the coarse grinding of the sides and is fixed on a
20 wafer holder having a hard support during the fine grinding of the sides.