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(54) DEVICE AND METHOD FOR CUTTING A SOLID SUBSTRATE

(57) The invention pertains to a device for cutting a solid substrate, preferably a solid semiconductor substrate for use as wafer material, comprising at least two guiding rollers and a cutting wire guided by the at least two guiding rollers forming a wire web between them, and comprising moving means for effecting a relative movement between a solid substrate and the guiding rollers to introduce the solid substrate into the wire web for cutting the solid substrate into a multitude of substrate slices, wherein the wire web is of sufficient size to allow cutting of a solid substrate with a cross section extension of at least 25 cm, wherein the device comprises at least three guiding rollers arranged preferably in triangular form wherein the cutting wire is guided by the at least three guiding rollers and the solid substrate can be introduced by the moving means into the wire web between a first guiding roller and a second guiding roller of the at least three guiding rollers for cutting, and wherein the device comprises pivoting means for alternately pivoting the solid substrate about a longitudinal axis of the solid substrate during cutting and/or for alternately pivoting the guiding rollers about a common axis parallel to their longitudinal axes during cutting. The invention further pertains to a corresponding method.

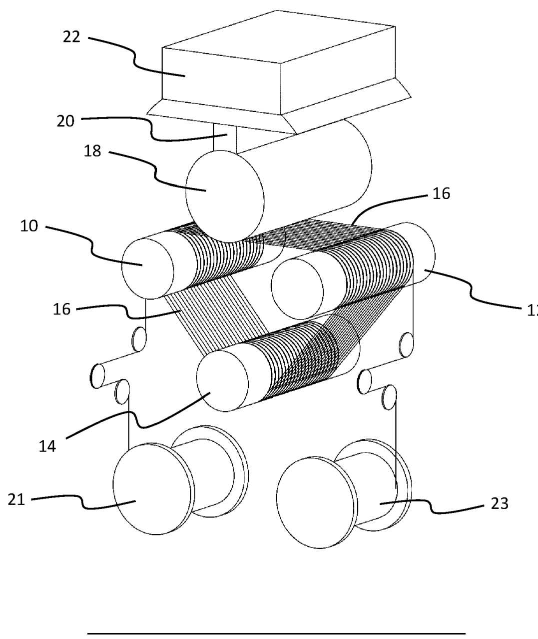


Fig. 1

EP 4 029 670 A1

Description

[0001] The invention pertains to a device for cutting a solid substrate, preferably a solid semiconductor substrate for use as wafer material, comprising at least two guiding rollers and a cutting wire guided by the at least two guiding rollers forming a wire web between them, and comprising moving means for effecting a relative movement between a solid substrate and the guiding rollers to introduce the solid substrate into the wire web for cutting the solid substrate into a multitude of substrate slices, wherein the wire web is of sufficient size to allow cutting of a solid substrate with a cross section extension of at least 25 cm, preferably more than 29 cm, more preferably more than 30 cm.

[0002] The invention also pertains to a method for cutting a solid substrate, preferably a solid semiconductor substrate for use as wafer material, by providing guiding rollers guiding a cutting wire, thereby forming a wire web between them, and effecting a relative movement between the solid substrate and the guiding rollers to introduce the solid substrate into the wire web for cutting the solid substrate into a multitude of substrate slices, wherein the solid substrate has a cross section extension of at least 25 cm, preferably more than 29 cm, more preferably more than 30 cm.

[0003] With such devices and methods solid substrates, like semiconductor substrates, for example ingots, can be cut into a multitude of substrate slices, for example semiconductor wafers, in one cutting step. To this end a cutting wire is wound numerous times around guiding rollers thus forming a wire web between the guiding rollers. The solid substrate is moved relative to the guiding rollers and the wire web and is thereby introduced into the wire web. The guiding rollers can be rotated during the introduction of the solid substrate into the wire web, for example back and forth in the so-called pilgrim mode. In this manner, the solid substrate is cut into a multitude of substrate slices similar to a conventional sawing process. In the cutting process, the solid substrate is fully moved through the wire web. A device and method for such cutting is for example known from WO 2014/087340 A2.

[0004] The added value chain for microchips starts in the provision of resources and ends in a marketable product, like for example a smart phone, a solid-state drive (SSD hard drive), and so forth. In the production chain, intermediate goods have been established which are traded between market participants. One of these intermediate goods are polished wafers. Electronic components are subsequently applied to the surface of such wafers. The surface quality is an essential quality feature of wafers. After the cutting process, the substrate slices to be used as wafers are usually subjected to further processing steps, such as grinding, lapping and polishing, to improve the evenness of the surface, in particular minimize roughness. The surface quality attainable in these process steps also depends on the cutting process.

[0005] Previously, especially when cutting larger solid substrates with a diameter of over 30 cm (12-inch substrates), a plain cutting wire has been used in combination with an abrasive slurry sprayed onto the cutting wire during cutting. Such devices and methods for cutting solid substrates with a wire web and a slurry are described in WO 2018/149631 A1, WO 2019/130806 A1, WO 2019/220820 A1 and DE 11 2018 001 068 T5. WO 2018/149631 A1 describes a device and method for cutting a rod into discs with a structured saw wire and a slurry. In order to reduce wear and the risk of a wire failure the grooves of wire guide rollers have a specific curvature radius. WO 2019/130806 A1 also describes a method and device for cutting a rod with a cutting wire and a slurry to produce wafers. A mechanism for adjusting the degree of parallelism of the axes of wire guides forming the cutting wire is provided to improve wafer quality. WO 2019/220820 A1 describes an ingot cutting method and device with a cutting wire and a slurry, wherein the slurry is individually temperature controlled. DE 11 2018 001 068 T5 describes a further method and device for cutting an ingot with a wire web and a slurry, wherein a curvature of the ingot obtained through cutting shall be compensated by adjusting the cutting parameters.

[0006] While the cutting with a wire web and simultaneously provided slurry generally leads to higher quality surfaces of the substrate slices, in particular the wafers, inter alia due to cost, production speed and environmental impact, fixed abrasive wires with an abrasive material fixed to the wire, such as diamond wires, are used more and more. This has led to additional issues with regard to the surface quality of the substrate slices, especially for larger workpieces with a cross section extension of more than 30 cm, for example to produce 12-inch wafers. The quality requirements for such high-end products with regard to the surface evenness and planarity, in particular the local surface topography, the so-called nano topography, have recently been increased further. While these high requirements can be met with the conventional plain wire process with an additional abrasive slurry, it has been difficult to meet the requirements with fixed abrasive wires, such as diamond wires.

[0007] DE 10 2018 221 900 A1 suggests incorporating the solid substrate before cutting in a rectangular lost body together with which the solid substrate is introduced into the wire web. This shall lead to the engagement length of the cutting wire remaining constant over the whole cutting process. To address the same issue, it is suggested in DE 10 2018 221 921 A1 to measure the position of cutting grooves before and/or during moving the solid substrate into the wire web. If a deviation of the cutting grooves from a preferred position is detected the solid substrate is moved in longitudinal direction for compensation. These known processes are, however, complex, leading to higher costs and more elaborate production processes.

[0008] Starting from the discussed prior art, it is therefore an objective of the present invention to provide a device and method of the above indicated type for cutting solid substrates with large cross-section extensions in a simple and cost-efficient manner while providing surface qualities meeting the high requirements for the substrate slices.

[0009] The invention solves the above objective with a device according to claim 1 and a method according to claim 10. Preferred embodiments are found in the dependent claims, the specification and the drawings.

[0010] For a device of the above explained type, the invention solves the objective in that the device comprises at least three guiding rollers arranged preferably in triangular form wherein the cutting wire is guided by the at least three guiding rollers and the solid substrate can be introduced by the moving means into the wire web between a first guiding roller and a second guiding roller of the at least three guiding rollers for cutting, and in that the device comprises pivoting means for alternately pivoting the solid substrate about a longitudinal axis of the solid substrate during cutting and/or for alternately pivoting the guiding rollers about a common axis parallel to their longitudinal axes during cutting.

[0011] For a method of the above discussed type the invention solves the objective in that the cutting wire is guided by at least three guiding rollers arranged preferably in triangular form and the solid substrate is introduced into the wire web between a first guiding roller and a second guiding roller of the at least three guiding rollers for cutting, and in that the solid substrate is alternately pivoted about a longitudinal axis of the solid substrate during cutting and/or the guiding rollers are alternately pivoted about a common axis parallel to their longitudinal axes during cutting.

[0012] The solid substrate to be cut according to the invention can be a semiconductor substrate such as a silicon substrate. It can be present for example in form of an ingot. The substrate slices obtained by cutting the solid substrate can for example be wafers. As explained above, cutting wire is wound many times around the guiding rollers thus forming a wire web between the guiding rollers for simultaneously cutting the solid substrate into a multitude of substrate slices upon moving the solid substrate into and through the wire web. During the cutting process the guiding rollers can be rotated, for example forward over a certain distance and backward over a certain, usually smaller distance, in an alternating fashion, the so-called pilgrim mode. If an alternating rotation of the guiding rollers is carried out the guiding rollers will usually be rotated about a multitude of full rotations in each direction before being rotated in the opposite direction. The guiding rollers may have grooves on their surface for guiding the cutting wire and thus defining the wire web. The cutting wire is guided in those grooves. The pitch of the grooves, i.e. the distance over which the groove pattern repeats itself, together with the wire diameter of the cutting wire will determine the thickness of the sawn substrate slices. The substrate slices may for example have a thickness of 1 mm or less than 1 mm.

[0013] Moving means are provided for relatively moving the solid substrate with regard to the guiding rollers and the wire web, thereby introducing the solid substrate into the wire web and through the wire web for cutting the solid substrate into a multitude of substrate slices. The moving means can for example move the solid substrate into the wire web. According to the invention the solid substrate to be cut has a (largest) cross-section extension of more than 25 cm, for example at least 30 cm, in particular more than 30 cm. For example, the solid substrate may have a cylindrical shape with a diameter of 12 inches (30.48 cm). In this manner, 12-inch slices, in particular 12-inch wafers, can be produced by cutting the solid substrate. The cross-section extension can accordingly be the diameter of the solid substrate.

[0014] According to the invention at least three guiding rollers are arranged such that they preferably form the corners of a triangle. The guiding rollers are arranged with parallel longitudinal axes, wherein the axes can be arranged at the corners of the triangle. An arrangement of three guiding rollers is known per se for example from JP 2000/158436A. The cutting wire is guided around all three guiding rollers, thus forming a triangular shaped wire web. The cutting is, however, only effected by wire web between two of the guiding rollers. These first and second guiding rollers can for example be arranged at the same height, thus spanning a horizontal wire web between them. A third guiding roller can be arranged below the first and second guiding roller, preferably centrally below the wire web spanned between the first and second guiding rollers. The lower guiding roller provides the necessary vertical space for fully moving the solid substrate through the wire web. The configuration with three guiding rollers allows for a particularly short free wire length between the guiding rollers, specifically a shorter free wire length than if using only two guiding rollers. The reason is specifically that when using three guiding rollers in the triangular form the diameter of each of the guiding rollers can be considerably smaller than if only using two guiding rollers. This is due to the fact that the solid substrate needs to be fully moved through the wire web for the cutting process. When using only two guiding rollers this necessitates a guiding roller diameter larger than the solid substrate diameter to provide the necessary space between the two parallel planes of wire web formed between only two guiding rollers. By providing a third guiding roller below the first and second guiding roller the vertical space for moving the solid substrate is increased. This allows guiding rollers with shorter diameter and thus a shorter free wire length. A shorter free wire length between the guiding rollers leads to a more stable wire web and thus an improved surface quality. Advantages can be achieved with regard to the interrelated parameters of process time and surface quality.

[0015] However, experiments have shown that using the three-guiding-roller configuration by itself may still not be sufficient to achieve a surface quality meeting the particularly high requirements for larger solid substrates with more than 25 cm cross-section extension, in particular with regard to the nano topography of substrate slices obtained during the cutting process. This is true even more when using a fixed abrasive wire instead of a slurry-based process.

[0016] The invention therefore combines the cutting of large solid substrates with a cross-section extension of more than 25 cm, for example at least 30 cm, and with three guiding rollers, further with a so-called rocking movement during the cutting process. To this end, pivoting means are provided for alternately pivoting the solid substrate about its longitudinal axis and/or the guiding rollers about a common axis parallel to their longitudinal axes during cutting. The pivoting means comprise a mechanism for pivoting or rotating for example the solid substrate back and forth about its own axis during the cutting process. Alternatively to pivoting the substrate, also the guiding rollers can be pivoted back and forth about a common axis which is parallel to their longitudinal axes. The spatial relation between the guiding rollers may thereby remain fixed. During the pivoting the guiding rollers are rotated each about their longitudinal axis for moving the wire web for the desired cutting action. This rotation of the guiding rollers is independent of a possible pivoting movement of the guiding rollers about a common pivoting axis. Such a pivoting movement of the substrate or the guiding rollers is also called rocking movement. While such rocking movement is known per se from WO 2010/009881 A1, it is suggested there for reusing wire material to save costs. However, the current inventors have surprisingly found that applying the rocking movement in combination with cutting the substrate in a wire web spanned by three guiding rollers leads to major improvements in the nano topography of the substrate slices, as will be shown in more detail below with reference to experiments.

[0017] According to the invention, of course also more than three guiding rollers can be provided wherein the cutting wire is guided by the more than three guiding rollers, for example four guiding rollers. For example, four guiding rollers could be arranged in trapezoid shape or rectangular shape.

[0018] With the inventive combination of at least three guiding rollers and the rocking process it is in a surprising manner possible to cut solid substrates with large cross-section extensions or diameters in a simple and cost-efficient manner while meeting the high requirements for surface quality, in particular the nano topography. The above explained complex and expensive measures taken in the prior art are thus not necessary. Generally, the inventive teaching improves surface quality, in particular nano topography for both cutting processes with a slurry provided during cutting, and cutting processes without providing a slurry during cutting, in particular with a fixed abrasive cutting wire, such as a diamond wire. In the latter case, however, the advantageous impact of the inventive teaching is even greater since such a process generally has more issues with regard to the surface quality. In fact, in processes without providing a slurry during cutting with a fixed abrasive cutting wire it is the inventive teaching which enables a cutting process achieving the high requirements with regard to surface planarity in particular for larger workpieces. In processes with a slurry provided during cutting, for example a glycol or oil with silicon carbide powder, the impact of the inventive teaching is smaller, but allows significant improvements also.

[0019] It is the applicant's understanding that the combination of three guiding rollers with the rocking process leads to a constant engagement length of the cutting wire in the solid substrate during cutting. Through controlling the cutting length in this manner, and in combination with the three-roller configuration, a highly homogeneous vertical force per wire segment is achieved. The rocking movement thereby helps specifically to reduce surface waviness, thus leading to superior nano topography. As explained, the nano topography is an indicator for the local evenness or planarity of the slice surface. Ideally, deviations in surface height should be nor more than a few nanometers. This can be achieved according to the invention.

[0020] Of course, the substrate slices, for example wafers, produced by the inventive cutting process can be subjected to further process steps subsequently, for example grinding, lapping and/or polishing. Subsequent to the processing of the substrate slices, for example the wafers, electronic components can be implemented on the surface of the substrate slices, for example the wafers. Also, of course the moving means and the pivoting means can be integrated into combined moving and pivoting means.

[0021] According to a preferred embodiment, the solid substrate may have a cylindrical shape, for example a circular cylindrical shape. In particular, semiconductor ingots for the production of wafers are often of cylindrical shape.

[0022] According to a further embodiment, the pivoting means may be designed to alternately pivot the solid substrate about its cylinder axis during cutting.

[0023] According to a further embodiment, the pivoting means may be designed to alternately pivot the solid substrate and/or the guiding rollers about a pivoting angle in each direction of less than 90°, preferably less than 45°, for example less than 20°. In particular, the pivoting during the rocking movement may be a pivoting about less than a full revolution of 360° or more. Rather, it has proven particularly efficient for the surface quality if the pivoting movement is carried out over a smaller circumferential angle.

[0024] As already explained, the guiding rollers may be arranged in triangular form. According to a further embodiment leading to a particularly even spanning of the wire web between the guiding rollers, and consequently a particularly even cutting process, the three guiding rollers may be arranged in equilateral triangular form.

[0025] According to a further embodiment, a distance between the first and second guiding rollers may be more than 25 cm, preferably more than 29 cm, more preferably more than 30 cm, and a distance between the wire web formed between the first and second guiding rollers and a third guiding roller of the three guiding rollers may be more than 25 cm, preferably more than 29 cm, more preferably more than 30 cm,. The distance means the shortest distance between the respective parts, in particular the clearance. The solid substrate needs to pass fully between the first and second guiding rollers and it needs to pass fully through the wire web for the cutting process. To this end, the explained clearances are provided. The distance between the first and second guiding rollers may be measured in particular in a plane spanned by the longitudinal axes of the first and second guiding rollers. The wire web between the first and second guiding rollers may be arranged in a horizontal plane. The distance to a third guiding rollers may thus in particular be measured in a vertical direction.

[0026] As already explained, the three-roller configuration makes it possible to have a diameter of the guiding rollers smaller than a cross section extension of the solid substrate. All guiding rollers may have the same diameter such that they may be rotated with the same rotational speed during cutting. However, the guiding rollers may also have different diameters. For example, the lower guiding roller may have a smaller diameter than the upper guiding rollers. In this case, all guiding rollers may still have a diameter smaller than a cross section extension of the solid substrate. The diameter of the guiding rollers, for example of the smallest guiding roller, if the guiding rollers have different diameters, can for example be no more than 50% of the cross-section extension, for example the diameter of the solid substrate, possibly less than 50%. Such a particularly small guiding roller diameter leads to a particularly short free cutting wire length and thus a particularly stable wire web. Of course, other diameters are also possible.

[0027] According to a further embodiment, the moving means may be designed to effect a relative movement between the solid substrate and the guiding rollers such that the solid substrate is alternately moved relative to the guiding rollers in a direction into the wire web and in a direction out of the wire web during cutting. In such an adaptive feed the solid substrate is successively moved through the wire web in an alternating forward and backward movement. The distance covered by the substrate during the forward movement is greater than the distance covered by the substrate during the backward movement to eventually move the substrate fully through the wire web. The engagement length of the cutting wire of the wire web and the solid substrate is most constant when applying such adaptive feed. This further improves the surface properties of the substrate slices, in particular the nano topography.

[0028] As further already explained, the cutting wire may be a fixed abrasive wire, preferably a diamond wire. As explained above, in such fixed abrasive wires, abrasives are fixed to the wire, thus not necessitating the separate provision of an abrasive slurry. Such a fixed abrasive wire is preferred with regard to costs, production speed and impact on the environment. However, as explained it is also possible that the cutting wire is not a fixed abrasive wire, and that a slurry is provided to the cutting wire during cutting.

[0029] The inventive method may be carried out with the inventive device. Accordingly, the inventive device may be designed to carry out the inventive method. The invention will subsequently be explained in more detail with reference to a preferred embodiment. The drawings show schematically:

Fig. 1	an inventive device in a perspective view,
Fig. 2	the device of Figure 1 in a front view,
Fig. 3	the device shown in Figure 2 in a first operational state,
Fig. 4	the device shown in Figure 2 in a second operational state,
Fig. 5	the device shown in Figure 2 in a third operational state,
Fig. 6	the device shown in Figure 2 in a fourth operational state,
Fig. 7	a visualisation of a measurement of the nano topography of substrate slices produced according to the invention,
Fig. 8	a diagram showing results of a nano topography measurement for a first cutting process,
Fig. 9	a diagram showing results of a nano topography measurement for a second, inventive cutting process, and
Fig. 10	a comparison of nano performances for different cutting processes.

[0030] In the drawings, the same reference numerals shall denote the same components.

[0031] The inventive device shown in the drawings comprises three guiding rollers 10, 12, 14. In the example shown the guiding rollers 10, 12, 14 are of equal diameter and arranged with parallel longitudinal axes. However, the diameters could also differ. Further, in the example shown the guiding rollers 10, 12, 14 form the corners of an equilateral triangle. Again, the triangle need not be equilateral. A cutting wire, in particular a fixed abrasive cutting wire, such as a diamond wire, is wound around the guiding rollers 10, 12, 14 such that a wire web 16 is formed between the guiding rollers 10, 12, 14. The guiding rollers 10, 12, 14 can be rotated about their longitudinal axes by a suitable rotational drive. The wire web 16 is spooled onto and off spooling rollers 21, 23 in the usual manner. For simplification the spooling rollers 21, 23 are not shown in the further drawings.

[0032] A solid substrate 18, in the example shown a right circular cylindrical solid substrate 18, for example a semiconductor solid substrate 18, like a silicon substrate 18, is held via a holding bar 20 on combined moving and pivoting means 22. The moving and pivoting means 22 serve on the one hand for moving the solid substrate 18 such that it is introduced into the wire web 16 formed between a first guiding roller 10 and a second guiding roller 12, in Fig. 2 downwards, as indicated by arrow 24. The solid substrate 18 is thereby moved fully through the wire web 16 between the first and second guiding rollers 10, 12 whereby it is cut by the wire web 16 into a multitude of substrate slices, in particular wafers. The position of the solid substrate 18 after the cutting process is shown in Fig. 2 in dotted lines for visualization purposes.

[0033] The solid substrate 18, and thus also the substrate slices, has a diameter of more than 30 cm, for example 12 inch (30.49 cm). As can be seen in Fig. 2 the distance between the first and second guiding rollers 10, 12 as well as the distance between the wire web 16 formed between the first and second guiding rollers 10, 12 and the third guiding roller 14 is sufficient for the substrate 18 to be fully moved through the wire web 16 between the first and second guiding roller 10, 12. In particular, the third guiding roller 14 is arranged centrally below the first and second guiding rollers 10, 12, thus providing the necessary vertical space to introduce the solid substrate 18. As can also be seen in Fig. 2, the diameter of the guiding rollers 10, 12, 14 is considerably smaller than the diameter of the solid substrate 18.

[0034] In Fig. 3 to 6 the solid substrate 18 is shown in two differently far introduced states in the wire web 16. In dotted lines and by arrows 26 it is visualized in Fig. 3 to 6 that the solid substrate 18 is pivoted by the moving and pivoting means 22 alternately about its longitudinal axes during cutting. The pivoting angle in each direction may be smaller than 90°, preferably smaller than 45°, for example be in the area >0° to 20°. This pivoting movement, also called rocking movement, is carried out during the movement of the solid substrate 18 through the wire web 16. Furthermore, the moving and pivoting means 22 move the solid substrate 18 relative to the guiding rollers 10, 12, 14 and thus relative to the wire web 16, alternately in a direction into the wire web 16 and in a direction out of the wire web 16 during the cutting process, thus successively moving the solid substrate 18 through the wire web 16 in an adaptive feed. This is visualized in Fig. 3 to 6 by arrow 28.

[0035] While it has been explained that adaptive feed may be implemented in the above described embodiment of the invention, it should be noted that it would also be possible to carry out the invention without adaptive feed.

[0036] With regard to Fig. 7 to 10, the influence of the invention on the surface quality of the substrate slices shall be explained. Fig. 7 shows a measurement position 30 on the surface of a substrate slice 32 obtained by the cutting process shown in Fig. 3 to 6. Arrow 34 in Fig. 7 denotes the measurement direction of a line scan, in this example in Y-direction.

[0037] Fig. 8 shows a profile of such a line scan along arrow 34 in measurement position 30, wherein the surface height is plotted on the Y-axis of the diagram in arbitrary units, in particular in the single digit μm range, over the measurement length in Y-direction in Fig. 7 along arrow 34 on the X-axis in arbitrary units, in particular in the single digit mm range. Fig. 8 shows this Y-profile for a substrate slice obtained in a cutting process as shown in Fig. 3 to 6, however without the pivoting rocking movement. The result is a considerable waviness of the surface.

[0038] Fig. 9 shows the same diagram as Fig. 8, in particular the same scale on the Y-Axis and the X-Axis, for a substrate slice 32 obtained with the inventive method as shown in Fig. 3 to 6, in particular also with the pivoting rocking movement. In particular, apart from the additional rocking movement in Fig. 9 the process parameters were identical to Fig. 8. As can be seen from a comparison of Fig. 8 and 9, the amplitude of the surface profile is considerably smaller in the profile according to Fig. 9, than in Fig. 8.

[0039] Generally, the substrate slices 32 are subjected to further process steps after the cutting, namely a grinding, lapping and polishing. Target is a most even slice surface. One criterion is the so-called warp value which refers to the evenness of the whole surface. The other value, which is significantly influenced by the invention, is the so-called nano topography, which refers to a local evenness.

[0040] To determine the nano topography the maximum height difference was measured on a limited surface such as 2x2 mm and 10x10 mm. This maximum height difference should only be a few nanometers. Fig. 10 shows this maximum height difference measured for substrate slices 32 for two measurement surfaces, namely 10x10 mm (THA1010) and 2x2 mm (THA22) for four different cutting processes. Namely, for both measurement surfaces, for a process as shown in Fig. 3 to 6, with a diamond wire, however without the rocking movement ("DW"), for an inventive process as shown in Fig. 3 to 6, with a diamond wire, including the rocking movement ("DW rocking"), for a process according to Fig. 3 to 6, but without the rocking movement, and using, instead of a diamond wire, a plain wire with an abrasive slurry sprayed onto the cutting wire during cutting ("Slurry"), and for an inventive process according to Fig. 3 to 6, with the rocking movement, and using, instead of a diamond wire, a plain wire with an abrasive slurry sprayed onto the cutting wire during cutting ("Slurry rocking"). It is noted that the nano topography is only measured on the final polished wafers. But the topography produced by the cutting process also affects the achievable surface quality in all other processing steps, in particular also intermediate processing steps.

[0041] On the vertical Y-axis in the two diagrams in Fig. 10, the maximum height difference in nanometers is plotted. As can be seen, the inventive process with diamond wire and rocking movement ("DW rocking") leads to a very low maximum height difference, similar to the slurry process without rocking ("Slurry"), while the process with diamond wire, but without the rocking movement ("DW"), leads to a considerably higher maximum height difference. The slurry process with rocking movement ("Slurry rocking") leads to the lowest maximum height difference. It is noted that the values for the process "Slurry rocking" are still under investigation and therefore shown in dotted lines in Fig. 10.

Reference numerals

[0042]

10	first guiding roller
12	second guiding roller
14	third guiding roller
16	wire web
18	solid substrate
20	holding bar
21, 23	spooling rollers
22	moving and pivoting means
24	arrow
26	arrow
28	arrow
30	measurement position
32	substrate slice

Claims

1. Device for cutting a solid substrate, preferably a solid semiconductor substrate for use as wafer material, comprising at least two guiding rollers (10, 12, 14) and a cutting wire guided by the at least two guiding rollers (10, 12, 14) forming a wire web (16) between them, and comprising moving means (22) for effecting a relative movement between a solid substrate (18) and the guiding rollers (10, 12, 14) to introduce the solid substrate (18) into the wire web (16) for cutting the solid substrate (18) into a multitude of substrate slices (32), wherein the wire web (16) is of sufficient size to allow cutting of a solid substrate (18) with a cross section extension of at least 25 cm,

- **characterized in that** the device comprises at least three guiding rollers (10, 12, 14) arranged preferably in triangular form wherein the cutting wire is guided by the at least three guiding rollers (10, 12, 14) and the solid substrate (18) can be introduced by the moving means (22) into the wire web between a first guiding roller (10) and a second guiding roller (12) of the at least three guiding rollers (10, 12, 14) for cutting, and
- **in that** the device comprises pivoting means (22) for alternately pivoting the solid substrate (18) about a longitudinal axis of the solid substrate (18) during cutting and/or for alternately pivoting the guiding rollers (10, 12, 14) about a common axis parallel to their longitudinal axes during cutting.

2. Device according to claim 1, **characterized in that** the solid substrate (18) is a cylindrical solid substrate (18).

3. Device according to claim 2, **characterized in that** the pivoting means (22) are designed to alternately pivot the solid substrate (18) about its cylinder axis during cutting.

4. Device according to one of the preceding claims, **characterized in that** the pivoting means (22) are designed to alternately pivot the solid substrate (18) and/or the guiding rollers (10, 12, 14) about a pivoting angle of less than 90°, preferably less than 45°.

5. Device according to one of the preceding claims, **characterized in that** the at least three guiding rollers (10, 12, 14) are arranged in equilateral triangular form.

6. Device according to one of the preceding claims, **characterized in that** the distance between the first and second guiding rollers (10, 12) is more than 25 cm and that a distance between the wire web (16) formed between the first and second guiding rollers (10, 12) and a third guiding roller (14) of the at least three guiding rollers (10, 12, 14) is more than 25 cm.

7. Device according to one of the preceding claims, **characterized in that** a diameter of the guiding rollers (10, 12, 14) is smaller than the cross section extension of the solid substrate.

8. Device according to one of the preceding claims, **characterized in that** the moving means (22) are designed to effect a relative movement between the solid substrate (18) and the guiding rollers (10, 12, 14) such that the solid substrate (18) is alternately moved relative to the guiding rollers (10, 12, 14) in a direction into the wire web (16) and in a direction out of the wire web (16) during cutting.

9. Device according to one of the preceding claims, **characterized in that** the cutting wire is a fixed abrasive wire, preferably a diamond wire.

10. Method for cutting a solid substrate (18), preferably a solid semiconductor substrate (18) for use as wafer material, by providing guiding rollers (10, 12, 14) guiding a cutting wire, thereby forming a wire web

(16) between them, and effecting a relative movement between the solid substrate (18) and the guiding rollers (10, 12, 14) to introduce the solid substrate (18) into the wire web (16) for cutting the solid substrate (18) into a multitude of substrate slices (32), wherein the solid substrate (18) has a cross section extension of at least 25 cm,

- **characterized in that** the cutting wire is guided by at least three guiding rollers (10, 12, 14) arranged preferably in triangular form and the solid substrate (18) is introduced into the wire web (16) between a first guiding roller (10) and a second guiding roller (12) of the at least three guiding rollers (10, 12, 14) for cutting, and
- **in that** the solid substrate (18) is alternately pivoted about a longitudinal axis of the solid substrate (18) during cutting and/or the guiding rollers (18) are alternately pivoted about a common axis parallel to their longitudinal axes during cutting.

11. Method according to claim 10, **characterized in that** the solid substrate (18) is a cylindrical solid substrate (18).

12. Method according to claim 11, **characterized in that** the solid substrate (18) is pivoted alternately about its cylinder axis during cutting.

13. Method according to one of claims 10 to 12, **characterized in that** the solid substrate (18) and/or the guiding rollers (10, 12, 14) are pivoted about a pivoting angle of less than 90°, preferably less than 45°.

14. Method according to one of claims 10 to 13, **characterized in that** a relative movement between the solid substrate (18) and the guiding rollers (10, 12, 14) is effected such that the solid substrate (18) is alternately moved relative to the guiding rollers (10, 12, 14) in a direction into the wire web (16) and in a direction out of the wire web (16) during cutting.

15. Method according to one of claims 10 to 14, **characterized in that** the method is carried out with a device according to one of claims 1 to 9.

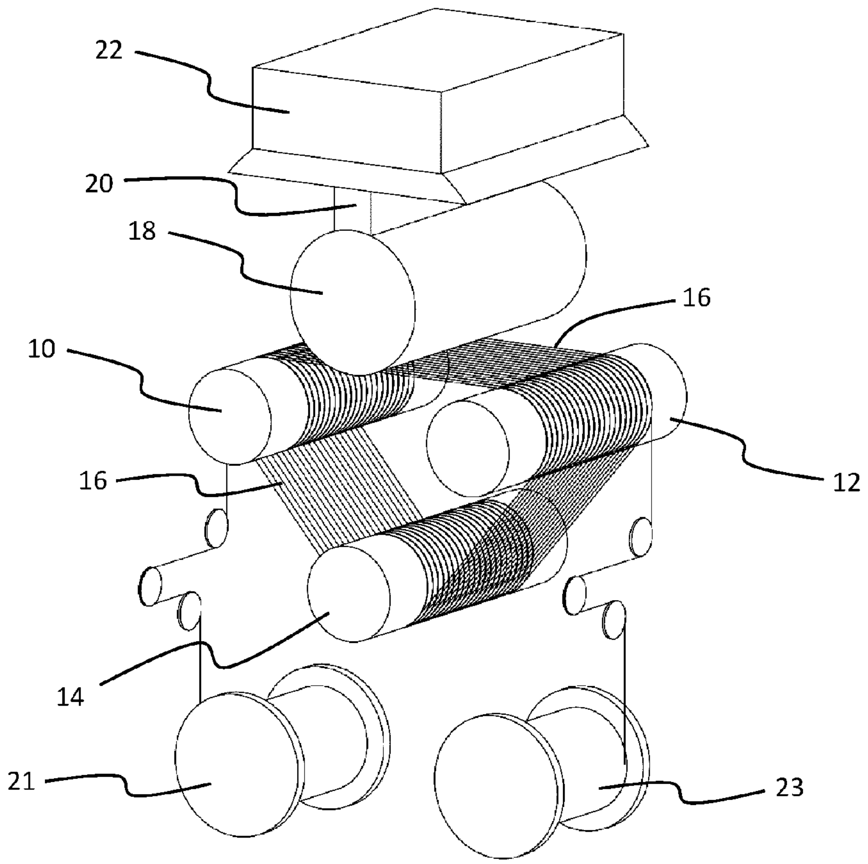


Fig. 1

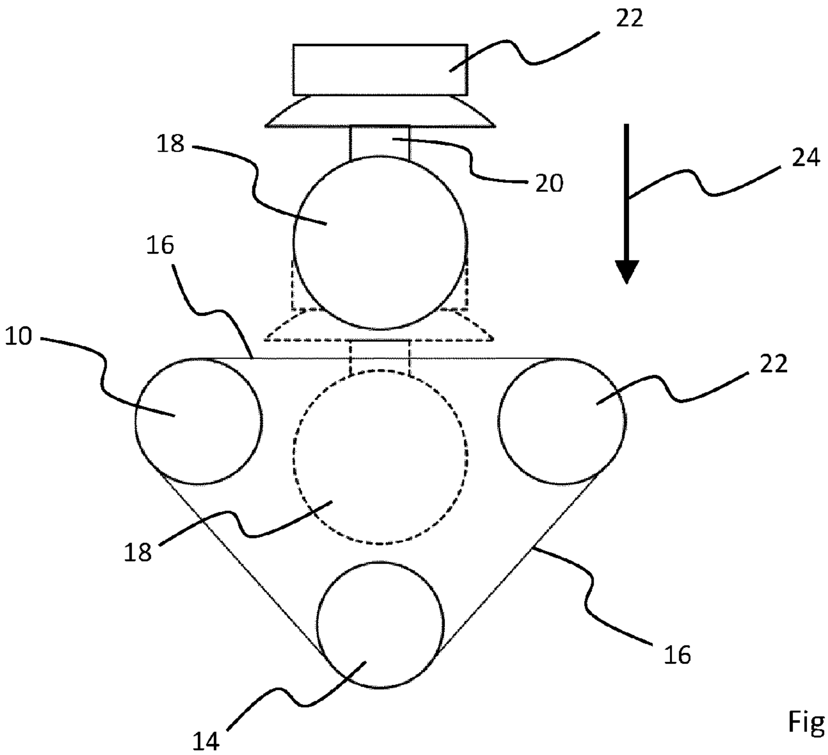
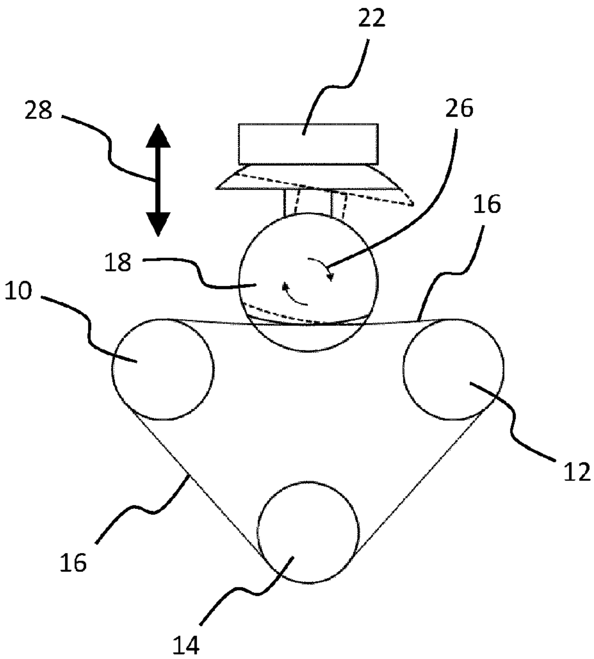


Fig. 2



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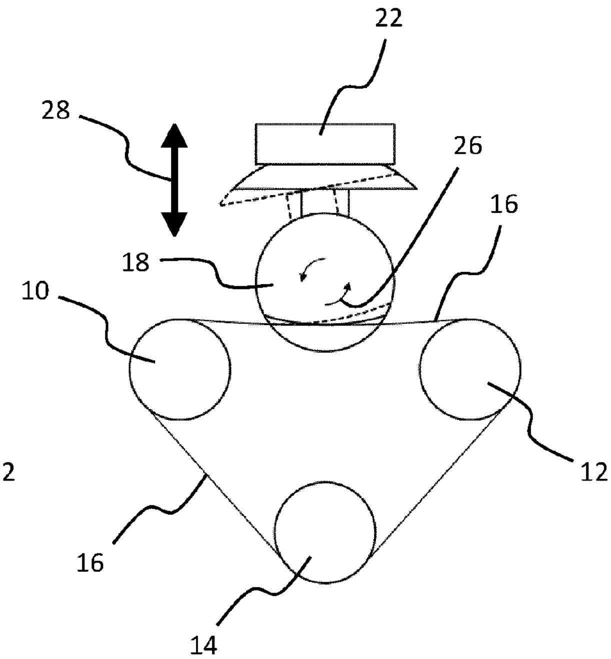

Fig. 4

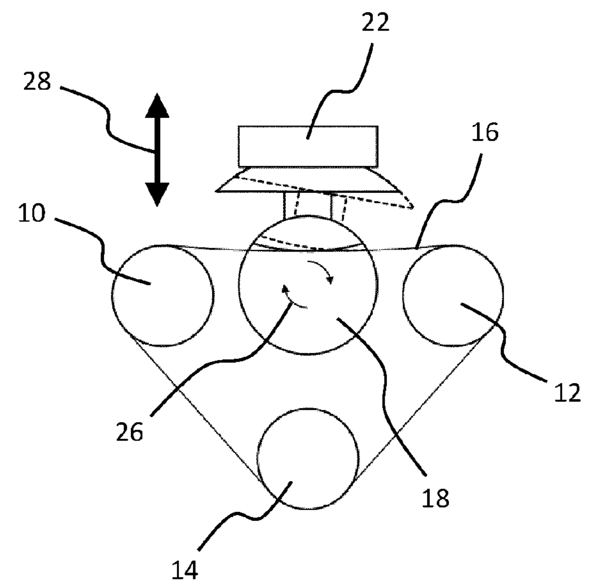

Fig. 5

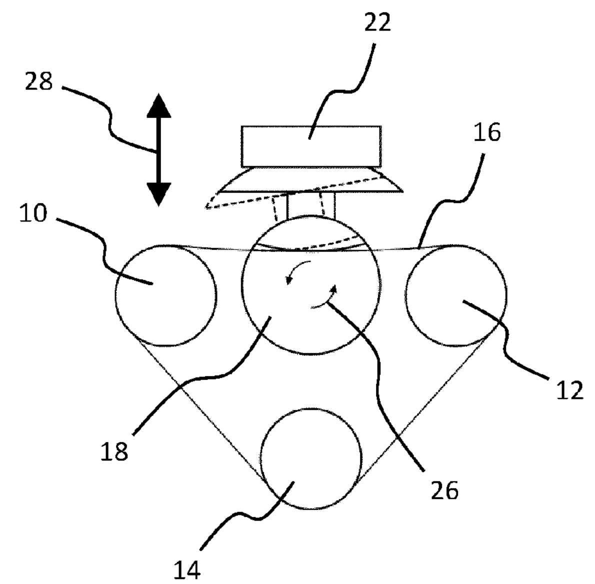

Fig. 6

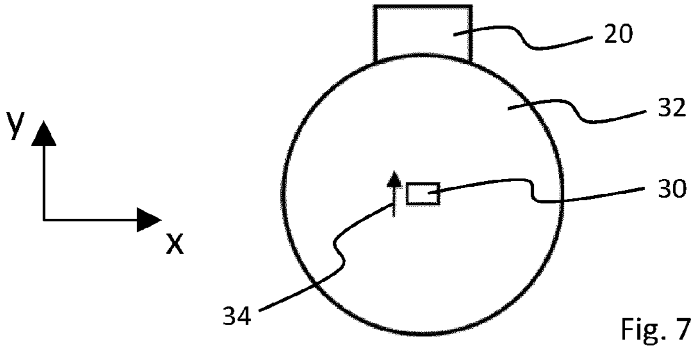

Fig. 7

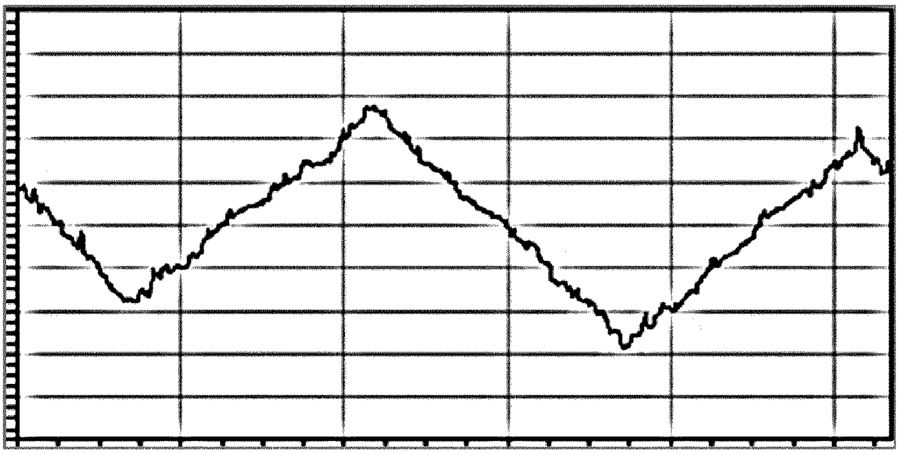

Fig. 8

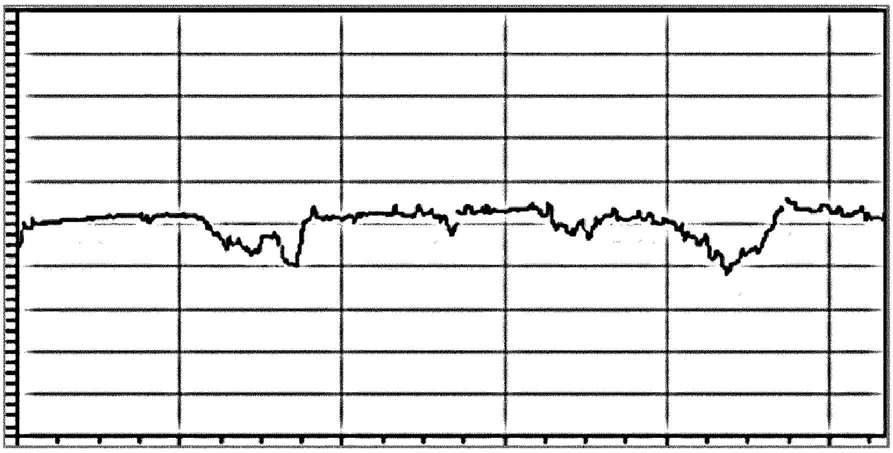

Fig. 9

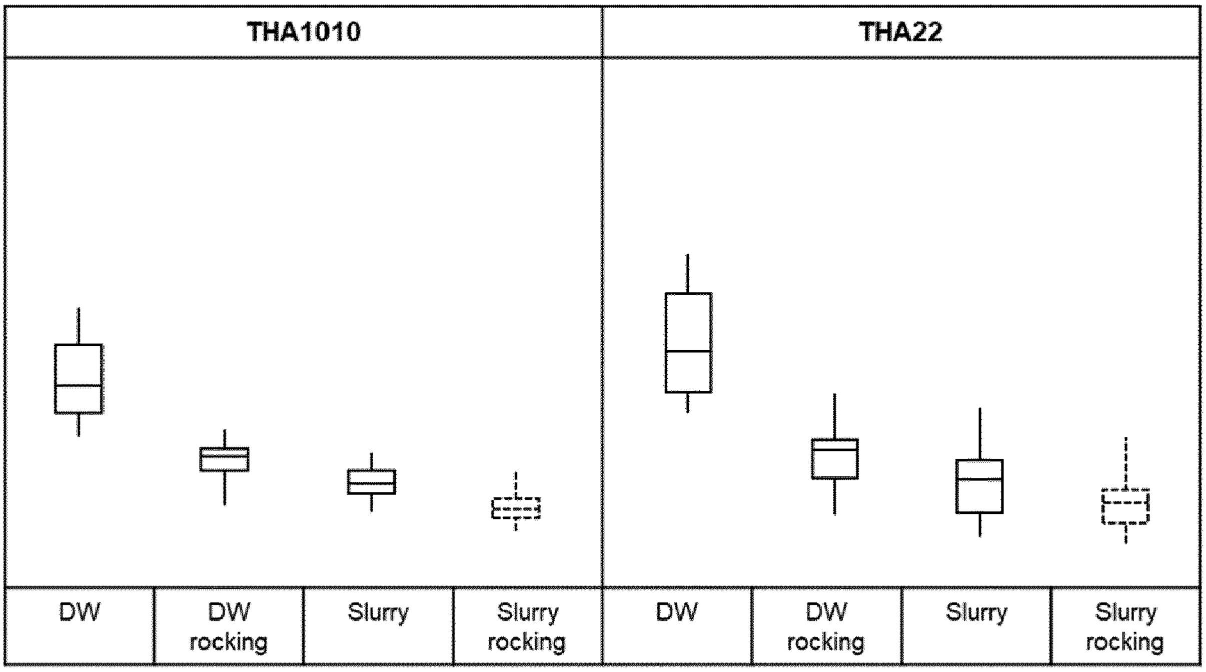
THA1010
THA22
DW
DW rocking
Slurry
Slurry rocking
DW
DW rocking
Slurry
Slurry rocking

Fig. 10

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EUROPEAN SEARCH REPORT

Application Number
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3

Place of search	Date of completion of the search	Examiner
The Hague	2 July 2021	Popma, Ronald

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