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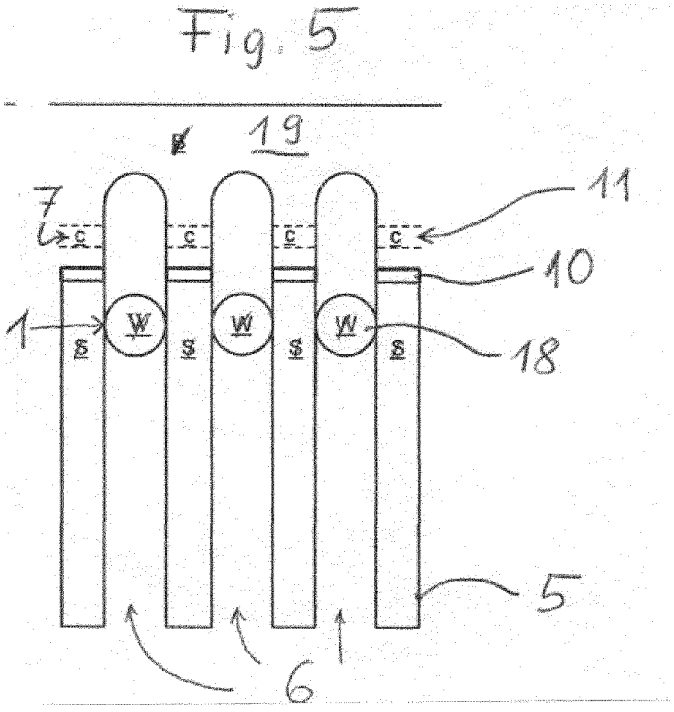
(54) **Method of making wafers**

(57) The invention relates to a method of making wafers (5) from an ingot (4) which is fixed to a beam (19) by means of a gluing layer (10) wherein the beam (19) has at least one internal channel (11), the method comprising the steps of:
- cutting the ingot (4) into a plurality of wafers (5),
- separating the wafers (5) from the beam (19) by introducing a de-gluing fluid to the internal channel (11),

subsequent to the step of cutting the steps of:

- moving the beam (19) with the cut wafers (5) relative to the wire web (18) in a direction opposite to the cutting direction into a de-gluing position in which the wire web (18) is located below the gluing layer (10) in the gaps (6) between the wafers (5),
- holding the beam (19) with the cut wafers (5) relative to the wire web (18) in that de-gluing position while de-gluing fluid (7) is delivered through the internal channel (11) to the gluing layer (10).

Fig. 5



EP 2 711 151 A1

Description

[0001] The invention relates to a method of making wafers from an ingot which is fixed to a beam by means of a gluing layer wherein the beam has at least one internal channel, the method comprising the steps of:

- cutting the ingot into a plurality of wafers in a wire saw by means of moving the ingot in a cutting direction through a wire web of the wire saw and proceeding with cutting until the wire web incises the internal channel of the beam,

- separating the wafers from the beam by introducing a de-gluing fluid to the channel, such that the de-gluing fluid is delivered to the gluing layer.

[0002] Wafers e.g. for use in solar cells are cut from a block (also called brick or ingot) in a wire cutting device employing a metal wire and abrasives. Usually abrasives suspended in a slurry, that are transported by a metal wire, are used. Nowadays, wafers are cut more and more using fixed abrasives, which are directly attached to the metal wire. Such wire is e.g. called a diamond wire. The present invention is not restricted to one of these cutting technologies.

[0003] The ingot to be cut is of poly-crystalline or mono-crystalline semiconductor material, e.g. silicon or other materials such as sapphire. In case, the block is generally referred to as core. The ingot is what is casted. In case of a poly-crystalline material usually a large ingot is casted and bricks are cut from that. In case of a mono-crystalline material a round ingot is made and cut into the typical mono-crystalline wafer shape.

[0004] From prior art containers are known for receiving a wafer already cut into a plurality of individual wafers. When the wafers are still basically in the position they were in before they were cut, the wafers are called a wafer block. The containers are used to clean or otherwise treat the wafers.

[0005] Prior art is further known, where the block to be cut is attached to a glass plate, which in turn is attached to a fixture attachment. The fixture attachment is horizontally inserted between two guide rails (usually L-shaped). The guide rails are part of the cutting device and only used for inserting the workpiece into the machine. As soon as the workpiece is in position, clamps hold the fixture attachment during cutting. When the cutting process is finished, the wafer block (arrangement of a plurality of parallel wafers) is slid out of the cutting device, while the fixture attachment is supported by the two guide rails.

[0006] Due to the fact, that the load is pretty heavy, the relative motion of the guide rails, the fixture attachment and the dirt (slurry) in between produces friction that is irregular and pretty hard to overcome. Moreover, when moving the block into and out of the cutting device or during transportation, the block wobbles (e.g. slip-stick effect). In the case of the inward movement this does not constitute a problem, since the block has not been cut yet. However, when removing said wafer block comprising a plurality of extremely thin wafers, the so called slip-stick effect causes damages to the wafers. The individual wafers tilt easily about the axis formed by the thin attachment zone on the glass plate or the fixture attachment, respectively. This causes adjacent wafers to touch each other. When the wafers however touch each other they may be damaged. Hence the slip-stick effect causes yield loss, resulting in higher costs per wafer.

[0007] EP2110216A1 discloses a wafer cutting and separation method. The ingot to be cut is glued to a holding beam having conduits. The dismounting is accomplished by supplying hot cleaning liquid such as water to the conduits after wafer cleaning has been performed. The hot water de-glues the wafers from the beam so that the wafers are collected in wafer baskets which can be removed, e.g., via a front door in the wire saw. This method has the disadvantage that the heat of the hot water is not efficiently transferred to the gluing layer, such that the de-gluing process becomes time-consuming and unreliable. A large quantity of hot water is required, since the hot water immediately escapes through the gaps between the wafers, i.e. escapes where the lowest flow resistance occurs. To that location most of the heat is transferred. However, a uniform distribution is required for saving energy and time.

[0008] According to the prior art the wafer block is removed from the wire saw and placed in a wafer carrier. The wafer carrier is transported to the next stages in the process. Normally the process consists of the following steps:

- Wafer pre-cleaning and de-gluing: Coarse dirt is removed from the wafers and the wafers are detached from the beam
- Wafer separation (=singulation): After pre-cleaning and de-gluing, the wafers are normally stacked. now they need to be separated to be treated individually
- Wafer cleaning: The now singulated wafers are cleaned to a degree that they can be processed chemically to be turned into a solar cell.

[0009] In short: sawing, pre-cleaning/de-gluing, wafer separation, final wafer cleaning, cell manufacturing

[0010] Also know from prior art it is to do the de-gluing in the wire saw and take out the wafers from between the wire guide rollers:

> JP7153724 A discloses a method of de-gluing the wafers from the beam by means of heating the beam. This is done by heating means which are integrated in the fixture attachment holding the beam

[0011] It is further known to use channels in the beam and/or workpiece holder to clean the wafers, e.g. JP9019921A, WO2010133682A1, DE102010052635

and DE102010050897. When the wire cuts through the beam the channel is incised and cleaning fluid can be delivered to the wafers. WO2011009917A2, WO2011009927A1 and WO2012007381A1 relates to a special design of the cleaning channels.

[0012] DE102004058194A1 discloses a beam having reduced cross-section by bore horizontal holes. However, DE102004058194A1 does not relate to deliver cleaning fluid through the bores.

[0013] Further documents relating to the cleaning to wafers are EP2153960A2, DE19900671C2, JP9207126A.

[0014] The object of the invention is to overcome the disadvantages of the wafer cutting and separating method disclosed in EP2110216A1 and to provide a reliable and time- and cost-effective method of de-gluing the cut wafers from the beam. Economical and energy-saving use of heated fluid should be guaranteed. The de-gluing step, preferably combined with a pre-cleaning step should be applicable in the wire saw (in-situ) in an easy and robust manner.

[0015] Undesired chipping of the wafers (breaking-off of silicon chips from the wafers) can be avoided if the ingot (or brick) is glued to the beam in such a way that the glue completely covers the contact surface between ingot and beam. In that case the gluing surface is large and it is of uppermost importance that the gluing layer is dissolved homogeneously along the entire contact surface. Chipping e.g. caused by application of very hot vapor reduces the energy conversion efficiency of solar cells due to undesired recombination processes. Therefore, the de-gluing step should be preferably performed using not too hot fluid. This can be done if the fluid is homogeneously distributed all over the gluing surface.

[0016] This object is achieved by a method of making wafers from an ingot as mentioned above, wherein the method subsequent to the step of cutting further comprises the steps of:

- moving the beam with the cut wafers relative to the wire web in a direction opposite to the cutting direction into a de-gluing position in which the wire web is located below the gluing layer in the gaps between the wafers,

- holding the beam with the cut wafers relative to the wire web in that de-gluing position while de-gluing fluid is delivered through the channel to the gluing layer, wherein the wire web impedes the de-gluing fluid from escaping through the gaps between the wafers.

[0017] According to the invention de-gluing fluid for reducing the adhesive force of the gluing layer is applied to the gluing layer via the channels after the cutting step such that the wafers are detached from the beam. The de-gluing fluid may be a heated fluid warming up the gluing layer and/or a solvent chemically interacting with the gluing layer.

[0018] The wire web brought in the de-gluing position closes the gaps between the wafers at least partially and impedes or restricts the de-gluing fluid from escaping through the gaps downwards, i.e. in the de-gluing position the wire web constitutes a barrier for the de-gluing fluid. The wire web functions as barrier for the de-gluing fluid and retains the de-gluing fluid in the region of the gluing layer. The interaction time between a fluid particle and gluing layer is efficiently increased. It is not necessary that the wire completely prevents the de-gluing fluid from escaping through the gaps downwards (once the wafers start falling off, the fluid will also flow past the wire). However, the wire allows to control the fluid flow of the de-gluing fluid. The wire between the wafers acts as a valve which may be controlled by the adjustable distance between the wire web and the gluing layer. The wire web held in the wafer gaps allows an uniform distribution of the de-gluing fluid over the entire gluing surface.

[0019] During the step of holding the beam with the cut wafers relative to the wire web in that de-gluing position, the relative movement between beam and wire web is stopped. Preferably, the beam is held still in that de-gluing position until all or at least most of the wafers have detached themselves from the beam upon influence of the de-gluing fluid. Preferably, the beam is held still in that de-gluing position for more than 10 or 30 seconds, preferably at least 1 minute. Depending on the temperature or type of the de-gluing fluid the de-gluing process may take up to 15 - 20 minutes. The fluid is preferably applied then when the wires have been moved out of the beam.

[0020] The inventive solution does not require complicated heaters (that would suffer greatly in the harsh environment in the wire saw) and preferably the de-gluing fluid will simply become part of the used cutting fluid.

[0021] In the case of slurry cutting a de-gluing fluid may be used that dissolves in the slurry.

[0022] Preferably, the internal channel is formed as a distribution network having individual distribution channels for uniformly distributing the de-gluing fluid over the whole beam. The internal channel is connected to a fluid inlet for receiving the heated fluid from e.g. a heated reservoir or other source of hot liquid.

[0023] Preferably, the channels are made on the back of beam, i.e. channels are made on the back surface of the beam that is glued to the work piece holder. The channels may be milled or be moulded. The latter being preferable when the beam is moulded anyway.

[0024] The internal channel or a plurality of distribution channels are incised by the cutting wire, such that openings are formed which face towards the gluing layer. A uniform distribution of de-gluing fluid by means of the channels guarantees that all wafers are separated within the same time; typically within 1 to 15 minutes.

[0025] At the same time a cleaning step may be provided for cleaning the wafers. This cleaning step may be performed prior to bringing the wire web in the de-gluing position. Depending on the gluing layer, the liquid used

for the cleaning may have a lower temperature than used for the de-gluing.

[0026] Preferably, the method subsequent to the step of cutting further comprises a step of cleaning the wafers with a cleaning fluid, wherein the step of cleaning may be performed prior to the step of moving the beam relative to the wire web into the de-gluing position or afterwards to prevent the wires from getting stuck as the beam swells. The beam may be brought relative to the wire into a suitable cleaning position, e.g. where the wires are located near the gluing layer.

[0027] Preferably, the step of cleaning is performed by introducing a cleaning fluid to the channel, such that the cleaning fluid is delivered to the wafers. The cleaning fluid may be e.g. identical with the de-gluing fluid or with the cutting fluid. By using a non-heated fluid, the wafers may be cleaned without de-gluing.

[0028] Preferably, the de-gluing fluid is a heated fluid for transmitting heat to the gluing layer. In this embodiment just the heating up of a fluid is needed. Any fluid may be used which is compatible with the wafer production and the cutting process. Preferably, the de-gluing fluid has a temperature between 45°C and 65°C, more preferably between 50°C and 60°C. Due to the direct delivery through the channel the temperature of the de-gluing fluid when touching the gluing layer does not differ much from the temperature it has when entering the channel through an inlet.

[0029] When the wire web is moved out of the beam and between the wafers into the de-gluing position the delivery of the de-gluing fluid can be started. It is e.g. possible to start with a cold (i.e. unheated) fluid which is continuously heated up during the step of de-gluing up to e.g. 50-60°C. In this way too fast heating is prevented that would induce stress on/in the wafers.

[0030] Preferably, the de-gluing fluid is a solvent for chemically reacting with the gluing layer. Special solvents may be selected according to the used glue. Preferably, the beam is made from a fluid absorbing material swelling under the influence of the de-gluing fluid. Once a wafer is detached from the beam or falls down the incision in the channel effected by the cutting wire closes automatically by the swelling force of the beam material. This helps to prevent that fluid only leaves the beam where the wafers have already dropped off and it thus is not needed any more.In the case of swelling beams, de-gluing fluid is delivered only to that wafers still hanging on the beam. The expansion also facilitates the detachment of the wafers since a shear tension is exerted on the glue.

[0031] If the beam is build up from a swelling material, the timing of the steps may further increase the efficiency of de-gluing. Preferably the wire web is moved out from the beam into its de-gluing position before the beam begins to swell in the region of the incisions. This prevents that the wire web get stuck. Typically the wire has to be removed from the beam within 2 minutes.

[0032] Preferably, the web does not stay in the beam longer than 2 minutes. To prevent swelling the de-gluing fluid may not start running before the wire is retracted from the beam. In order not to produce a thermal shock, the de-gluing fluid may at first be cool.

[0033] Preferably, in the de-gluing position the wire web is located less than 15 mm (millimeter) below the gluing layer, preferably less than 5 mm below the gluing layer, more preferably less than 2 mm below the gluing layer; most preferably the wire web is located less than 0,5 mm below the gluing layer. In this embodiment the lateral gaps are held small such that de-gluing fluid is impeded from escaping in lateral direction.

[0034] Preferably, heat of the cutting wire is efficiently transmitted to the gluing layer (adding heat from the wires). Since the wires are warm themselves during the cutting process, they may be placed just below the gluing layer to be dissolved so that their warmth deteriorates the glue as well (additionally to the effect of the de-gluing fluid).

[0035] Preferably, the diameter of the cutting wire of the wire web is smaller than 200μm, more preferably smaller than 150μm (micrometer), most preferably smaller than 130μm.

[0036] The wavers may have e.g. a thickness between 100 and 200 μm (micrometer).

[0037] Preferably, (clean or used) cutting fluid used for the cutting step to be applied to the wire web or one of its components is also used as de-gluing fluid. Here, cutting fluid is used to de-glue the wafers. In this embodiment no additional fluid has to be provided.

[0038] Preferably, the delivered amount of de-gluing fluid during the step of de-gluing is between 5 and 20 liters/minute.

[0039] The present invention constitutes a method for in-situ (in the wire saw) de-gluing of wafers and comprises: Cutting of wafers until wires cut the beam and its channels; moving the wire from the beam material back into the gap between the wafers (retraction of the wires by a relative movement between beam and wire web); flushing a de-gluing fluid onto the wires so that the fluid is forced towards the glue; moving/having the wafers fall away from the beam as to remove them from the wire saw.

[0040] Further embodiments of the invention are indicated in the figures and in the dependent claims. The list of reference marks forms part of the disclosure. The invention will now be explained in detail by the drawings. In the drawings:

Fig. 1 shows a wire saw for cutting a plurality of wafers from an ingot,

Fig. 2 shows parallel arranged wafers after the cutting process,

Fig. 3 shows wafers after the cutting process with some of the wafers have fallen sideways (prior art),

Fig. 4 shows in a cross section the cut wafers still

hanging on the beam, with the wire web having cut the internal channel,

Fig. 5 shows the cut wafers still hanging on the beam with the wire web being located below the gluing layer in the de-gluing position.

[0041] Fig. 1 shows a wire saw 2 for cutting a plurality of wafers from an ingot 4 (also called brick or core). The wire saw 2 comprises a support base 21 for positioning ingot 4 with respect to a wire web 18 which is formed by a cutting wire. Ingot 4 is by gluing attached to a beam 19 (also called sacrificial substrate), which in turn is attached to a fixture attachment 20 usually made of metal. The beam 19 is mounted to the fixture attachment 20 which in turn is detachably mounted to the support base 21 of the wire saw 2.

[0042] Wire saw 2 further comprises wire guide rollers 14, 16 for forming a field of cutting wire, i.e. wire web 18. A first wire guide roller 14 is rotatable about a first rotational axis 15, a second wire guide roller 16 is rotatable about a second rotational axis 17. The wire web 18 is supported by the wire guide rollers 14, 16.

[0043] After all cuts for separating the wavers 5 have been made (all wafers are cut in parallel, even though they are cut at a slightly different rate), the wafers 5 are still attached to the beam 8 giving the wafer block a comb-like structure.

[0044] During the cutting process, the ingot 4 is pushed through the wire web 18, causing the cutting wire to bend downwards (not shown). Because of this bow of the cutting wire, the top edges of the ingot are cut before the middle part of the ingot is completely cut. It is the purpose of the sacrificial substrate or beam 19 to keep the fixture attachment 20 at a distance of the ingot 4, so that the fixture attachment 20 is not cut. The beam 19 - which is relatively inexpensive - is replaced after each cut.

[0045] Once the wafers have been cut, they have to be cleaned and separated from the beam 19. Ideally, the arrangement of a plurality of wafers 5 still hanging on the beam 19 via a gluing layer 10 corresponds to the drawing of Fig. 2. All wafers 5 are aligned in parallel with a constant spacing between the individual wafers. However, the wafers 5 are very thin and can be easily damaged. One can imagine, that if the fixture attachment 20 is tilted or pushed, the wafers move sideward and stick to each other due to the fluid on their respective surfaces forming the spacing between them. Fig. 3 illustrates this non-ideal situation.

[0046] After the ingot has been cut, the wafers are dirty from the slurry or cutting fluid and the silicon particles that are cut off (swarf). If the wafers are left to dry, the swarf gets stuck to the wafers are very hard to remove. Also the wafers become stains that are not allowable. For both reasons, wafers are cleaned right after they have been cut, not allowing them to dry while dirty.

[0047] Fig. 4 shows the wafer block after the cutting step. The bow of the wire has been built of. Individual wafers 5 are still attached to the beam 19 by the adhesive force of the gluing layer 10. The beam 19 has internal channels 11. As illustrated in Fig. 4 the cutting step is proceeded until the wire web 18 cuts through the channels 11 of the beam 19. Now, fluid which is delivered to the channels 11 may escape through the incisions towards the gluing layer 10. Before the step of separating the wafers 5 from the beam 19 a relative movement between beam 19 and wire web 18 is done: The beam 19 with the cut wafers 5 is moved relative to the wire web 18 in a direction opposite to the cutting direction into a de-gluing position 1 in which the wire web 18 is located below the gluing layer 10 but still in the gaps 6 between the wafers 5. The de-gluing position 1 of the wire web 18 is preferably located less than 1.5 cm below the gluing layer 10, preferably less than 0.5 cm below the gluing layer 10. Ideally the wires are held as close to the gluing layer as possible.

[0048] However, it is also possible to use the wire web as a valve controlling the flow of the de-gluing fluid. Typically a discharge of 5 to 20 liters per minute is used. The wire web may be controlled to keep this rate.

[0049] Now, the beam 19 with the cut wafers 5 is held relative to the wire web 18 in that de-gluing position 1 while de-gluing fluid 7 is delivered through the channels 11 to the gluing layer 10. The wire web 18 prevents that the de-gluing fluid 7 escapes (runs downwardly) through the gaps 6 between the wafers 5.

[0050] The de-gluing fluid 7 which is delivered during the separation step is a heated fluid and transmits its heat to the gluing layer 10 thereby destroying the adhesive force of the de-gluing layer 10 by melting it.

[0051] In an alternate embodiment the de-gluing fluid 7 may be a solvent for chemically reacting with the gluing layer 10 thereby reducing the adhesive force of the de-gluing layer 10. Here, also an elevated temperature may facilitate the degluing.

[0052] Preferably, the beam 19 is made from a fluid absorbing material swelling under the influence of the de-gluing fluid 7.

[0053] As an example the de-gluing fluid 7 may be a heated cutting fluid also used for/during the cutting step to wet the wire web 18.

[0054] In the following the method is described: As can be seen from Figs. 4 and 5 the cutting wires of the wire web 18 penetrate through the beam 19 after the cutting step (Fig. 4). Once the channel 11 is open (and the cut completed) fluid 7 is guided through the channels 11 towards the wafers 5 for cleaning and de-gluing purposes. At this stage, the wafers 5 are still attached to the beam 19 with glue.

[0055] According to the invention, after the cutting step, the wires are moved back into the gap 6 between the wafers 5. In this de-gluing position 1, the wires function as to stop for the de-gluing fluid 7 coming from above or from the channels 11 from moving downwards. Instead the fluid 7 can only leave the gap sideways (perpendicular to the drawing). In this way the fluid 7 is forced to flow

past the glue which it has to melt or for destroying its adhesive power by chemical reactions. Once the wafers are detached they drop (e.g. approximately 3 mm) into a wafer carrier and are taken out of the wire saw 2 between the wire guide rollers 14, 16.

[0056] The invention is not restricted to these embodiments. Other variants will be obvious for the person skilled in the art and are considered to lie within the scope of the invention as formulated in the following claims.

List of reference marks

[0057]

1	de-gluing position of the wire web 18
2	wire saw
4	ingot
5	wafers
6	gaps between wafers 5
10	gluing layer
14	first wire guide roller
15	rotational axis of the first wire guide roller
16	second wire guide roller
17	rotational axis of the second wire guide roller
18	wire web
19	beam
20	fixture attachment
21	support base

Claims

1. Method of making wafers (5) from an ingot (4) which is fixed to a beam (19) by means of a gluing layer (10) wherein the beam (19) has at least one internal channel (11), the method comprising the steps of:

- cutting the ingot (4) into a plurality of wafers (5) in a wire saw (2) by means of moving the ingot (4) in a cutting direction through a wire web (18) of the wire saw (2) and proceeding with cutting until the wire web (18) incises the channel (11) of the beam (19),
- separating the wafers (5) from the beam (19) by introducing a de-gluing fluid to the channel (11), such that the de-gluing fluid (7) is delivered to the gluing layer (10),

characterized in that the method subsequent to the step of cutting further comprises the steps of:

- moving the beam (19) with the cut wafers (5) relative to the wire web (18) in a direction opposite to the cutting direction into a de-gluing position (1) in which the wire web (18) is located below the gluing layer (10) in the gaps (6) between the wafers (5),
- holding the beam (19) with the cut wafers (5) relative to the wire web (18) **in that** de-gluing position (1) while de-gluing fluid (7) is delivered through the channel (11) to the gluing layer (10), wherein the wire web (18) impedes the de-gluing fluid (7) from escaping through the gaps (6) between the wafers (5).

2. Method according to claim 1, **wherein** the de-gluing fluid (7) is a heated fluid for transmitting heat to the gluing layer (10).

3. Method according to claim 1 or 2, **wherein** the de-gluing fluid (7) is a solvent for chemically reacting with the gluing layer (10).

4. Method according to one of the claims 1 to 3, **wherein** the beam (19) is made from a fluid absorbing material swelling under the influence of the de-gluing fluid (7).

5. Method according to one of the claims 1 to 4, **wherein** in the de-gluing position (1) the wire web (18) is located less than 15 mm below the gluing layer (10), preferably less than 5 mm below the gluing layer (10), more preferably less than 1 mm below the gluing layer (10).

6. Method according to one of the claims 1 to 5, **wherein** cutting fluid used for the cutting step to be applied to the wire web is also used as de-gluing fluid (7).

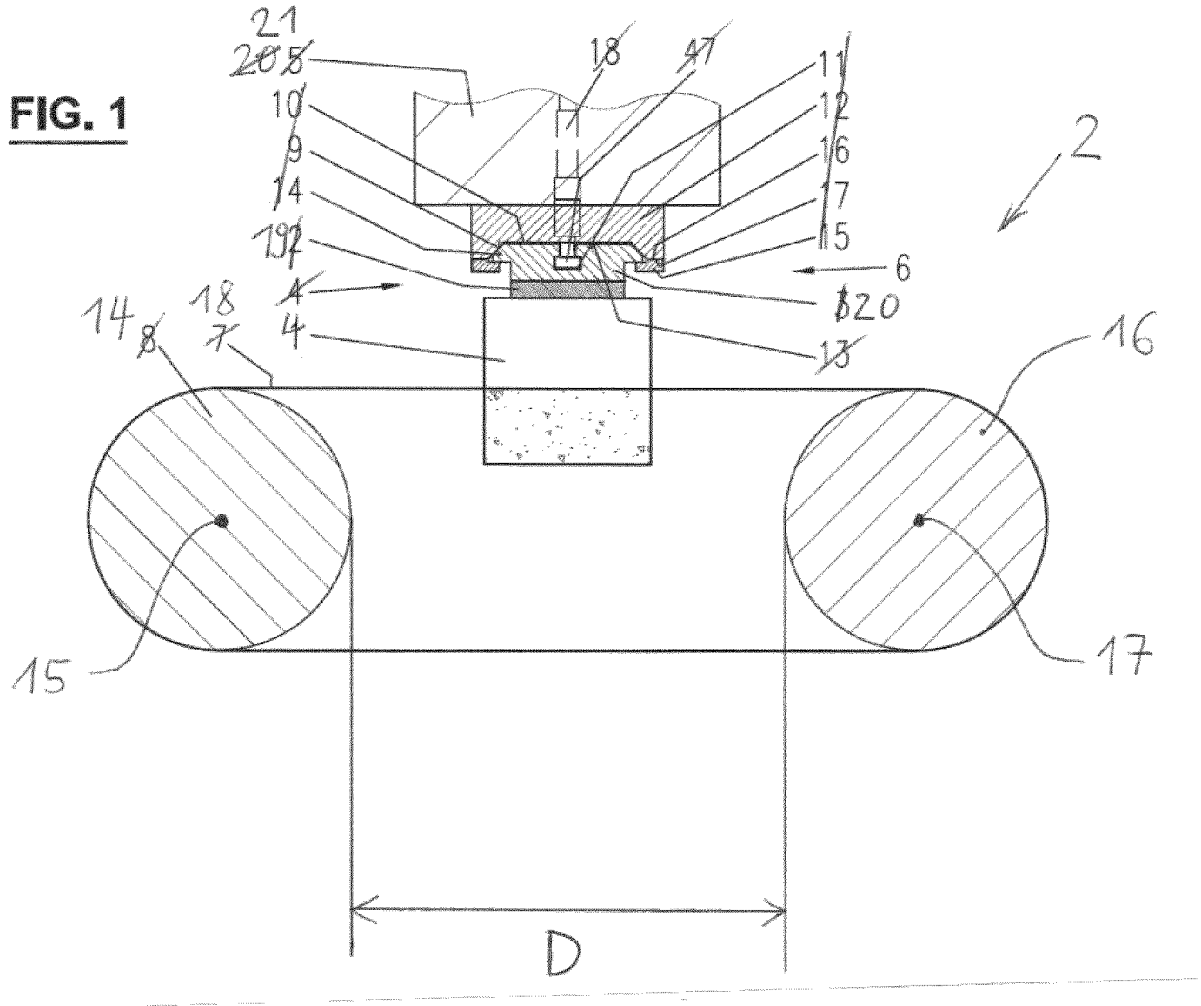
7. Method according to one of the claims 1 to 6, **wherein** prior to the step of moving the beam (19) relative to the wire web (18) into the de-gluing position (1), the beam (19) is moved relative to the wire web (18) into a heat transfer position in which the wire web (19) is at least partially arranged close to the gluing layer (10), preferably within the gluing layer (10), to transfer the heat of the wire web (19) generated during the step of cutting to the gluing layer (10).

8. Method according to one of the preceding claims, wherein the method subsequent to the step of cutting further comprises a step of cleaning the wafers (5) with a cleaning fluid.

9. Method according to claim 8, wherein the step of cleaning is performed prior to the step of moving the beam (19) relative to the wire web (18) into the de-gluing position (1).

10. Method according to claim 8 or 9, wherein the step of cleaning is performed by introducing a cleaning fluid to the channel (11), such that the cleaning fluid (7) is delivered to the wafers (5).

FIG. 1



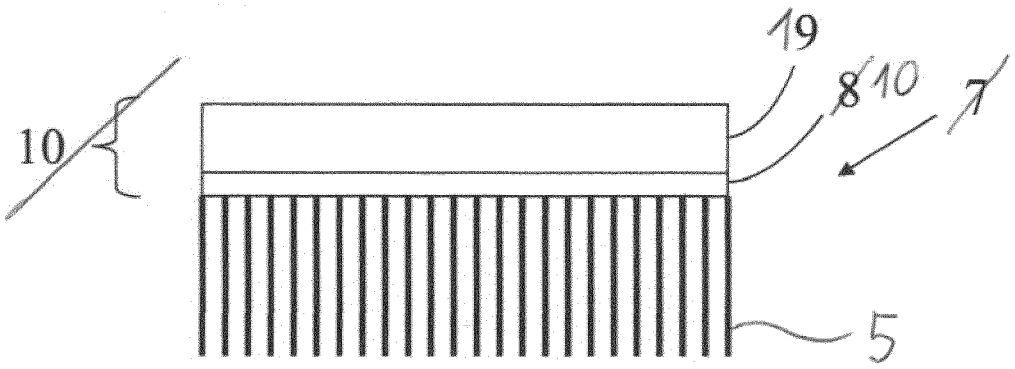


Fig. 2

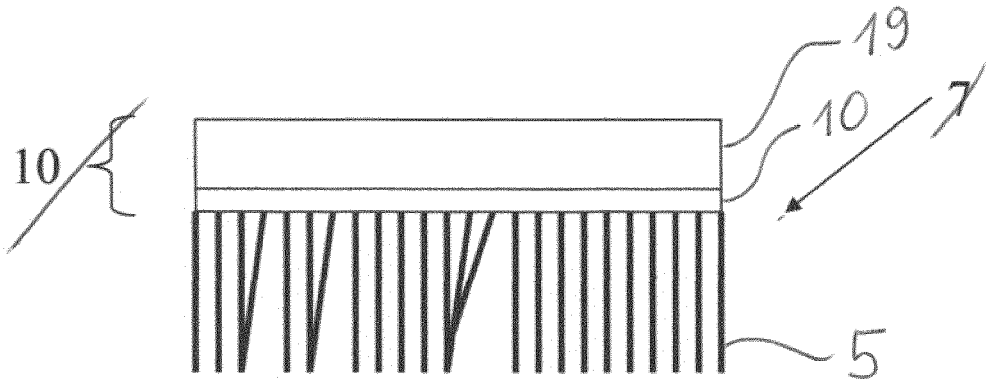


Fig. 3

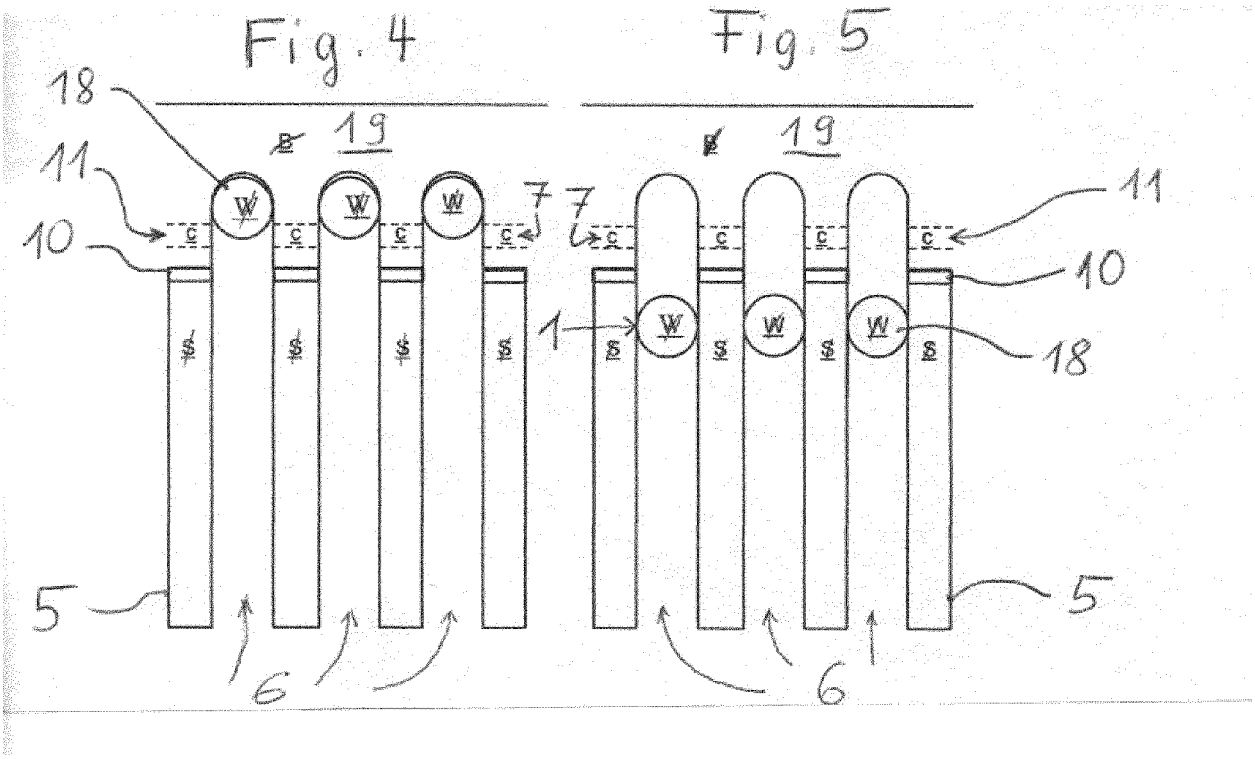


Fig. 4
Fig. 5
18
11
10
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C
W
S

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 12 18 5757

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2005 028112 A1 (SCHMID TECHNOLOGY SYSTEMS GMBH [DE]) 21 December 2006 (2006-12-21) * claim 1; figures *	1-10	INV. B28D5/00
A,D	EP 2 110 216 A1 (APPLIED MATERIALS INC [US]) 21 October 2009 (2009-10-21) * paragraphs [0048], [0060]; claim 13 *	1-10	
A,D	DE 199 00 671 C2 (FRAUNHOFER GES FORSCHUNG [DE]) 25 April 2002 (2002-04-25) * column 6, lines 42-61; figures 6,7 *	1-10	
A,D	JP 7 153724 A (SHARP KK) 16 June 1995 (1995-06-16) * abstract; figures *	1-10	

TECHNICAL FIELDS SEARCHED (IPC)
B28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 February 2013	Popma, Ronald

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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