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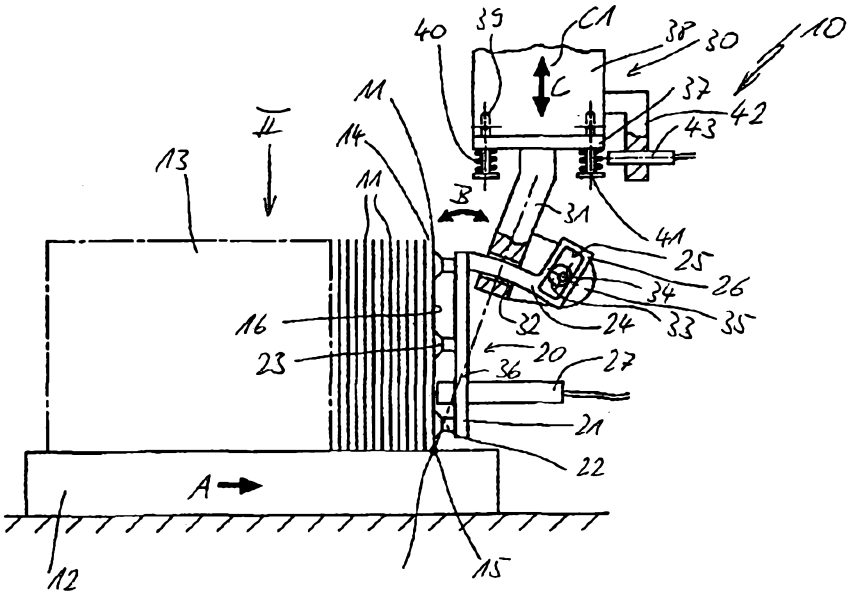
[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD AND DEVICE FOR ISOLATING PLATE-LIKE SUBSTRATES

(54) Bezeichnung: VERFAHREN UND EINRICHTUNG ZUM VEREINZELN VON SCHEIBENFÖRMIGEN SUBSTRATEN



(57) Abstract: The invention relates to a method for isolating and detaching thin, fragile, plate-like substrates (11). Said plate-like substrates (11) are cut from a substrate block (13), which is preferably mounted on a baseplate (12) by means of adhesive, are gripped at evenly distributed points on the free outer surface thereof (16) and are displaced in an oscillating manner, such that the plate-like substrates (11) are automatically and individually removed free of damage from the sawn substrate block and from the layer of adhesive.

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A Method and a Device for Isolating and Detaching Plate-Like Substrates

Specification

The present invention relates to a method for isolating and detaching thin, fragile, plate-like substrates which have been cut from a substrate block mounted fixed preferably by means of adhesive on a baseplate, in accordance with the preamble of Claim 1 and/or with that of Claim 10.

In the manufacture of plate-like substrates, such as are used for solar cells for example, use is made of substrate blocks or substrate columns made of silicon, for example, which are sawn into thin plates. For this purpose, the substrate block or the substrate column is glued onto a baseplate and fixed there by that means. After sawing, the lower face of each plate-like substrate still adheres by means of the line or seam of adhesive to the baseplate, the upper portion of which normally comprises glass and will also have been given a cut with the saw. After the substrate block or the substrate column has been completely divided up, a comb-like formation is thus produced, from which the very fragile, plate-like substrates are broken off by hand at the adhesive joint. Since plate-like substrates of this kind are very thin, for example in the region of 0.3 mm, and the saw slit is likewise hardly any larger, many plates are damaged or broken in this operation of detachment by hand. Furthermore, the expenditure of time for this purpose is also substantial as a function of the care taken when detaching.

The problem of the present invention is to provide a method and a device, respectively, of the kind mentioned above, by which and with which, respectively, thin, fragile, plate-like

substrates of this kind may be automatically and individually removed, free of damage from the process, from the sawn substrate block and from the seam of adhesive.

The features specified in Claim 1 are provided in a method of the aforementioned kind and the features specified in Claim 10 in a device of the aforementioned kind in order to solve this problem.

The method according to the invention makes it possible to take hold of the thin, fragile, plate-like substrates in portions over a substantial surface area and to loosen them from the adhesive seam by vibration and thereby to remove them safely. A preferred embodiment of the oscillating movement is provided thereby in accordance with the features of Claim 2 and with those of Claim 11. An oscillating pivoting movement about the seam of adhesive or line of adhesive is produced in this manner, which results in a fatigue fracture of the said seam of adhesive. Furthermore, the exertion of force on the plate-like substrate itself is limited to a minimum as a result.

A preferred embodiment of the gripping apparatus emerges from the features of Claim 12.

The features according to Claim 3 and respectively those according to Claim 13 are provided in order to be able to record the time at which complete removal and lifting of the plate-like substrate from the baseplate and from the broken seam of adhesive is achieved. The time at which the seam of adhesive is sufficiently brittle can rapidly and easily be recorded and/or detected by means of the bias exerted upon the plate-like substrate in the direction of lift-away from the baseplate, the magnitude of the bias being selected to prevent breakage of the plate-like substrate. The plate-like substrate may then be removed safely for further processing and/or storage.

Advantageous embodiments of the gripping apparatus emerge from the features of one or more of Claims 14 to 16.

It is achieved with the features of Claim 4 and of Claim 17, respectively, that adjacent plate-like substrates may still be isolated and consequently detached from the baseplate when they adhere at least partially to one another on account of humidity which is unavoidable for process-engineering reasons, and/or when in inclined state.

Advantageous embodiments to this effect emerge from the features of one or more of Claims 5, 6 and 18. The features according to Claim 7 and Claim 19, respectively, are provided in order to be able to isolate and detach plate-like substrates of different surface area or different shape and size. It is possible in this manner not only to handle different format sizes, but also to detach and remove remnants of broken-off plate-like substrates. The equivalent holds good for plates detached when sawing the substrate block or substrate column.

Advantageous embodiments to this effect emerge from the features of Claim 20 and/or 21.

With the features according to one or more of Claims 8, 9 and respectively 22, 23, it is achieved, in an operationally advantageous manner, that the plate-like substrates may be delivered to the gripping apparatus and safely gripped by the gripping apparatus on account of the isolation which occurs at the same time. In this connection, delivery to the gripping apparatus of the plate-like substrate which is to be gripped is recorded in a precise manner by a position sensor.

Further details of the invention are to be taken from the following description, in which the invention is more closely described and explained with reference to the embodiment represented by way of example in the drawing, in which

Figure 1 is a device, in diagrammatic, partially exploded and sectioned side view, for isolating and detaching plate-like substrates from a cut substrate block in accordance with a preferred embodiment of the present invention which is given by way of example,

Figure 2 is a partial plan view according to Arrow II in Fig. 1,

Figure 3 is a front view of the gripping apparatus with suction-cup matrix according to Arrow III in Fig. 2, in accordance with a variant, and

Figure 4 is a circuit diagram for the suction-cup matrix according to Fig. 3.

The device 10 represented in the drawing serves to isolate and detach thin, fragile, plate-like substrates 11 which have been cut from a substrate block 13 mounted fixed on a baseplate 12. An example of a substrate block of this kind is a silicon block, produced from polycrystalline silicon, which is cemented, for example with the aid of a two-component adhesive, onto a glass pane portion of the baseplate 12. With the aid of parallel cutting wires with accompanying supply of a liquid cutting means, the silicon block is cut into individual silicon plates, serving as solar wafers for example. This cutting or sawing of the substrate block 13 into individual, thin, plate-like substrates or wafers is effected right into the glass pane portion, supported on a steel plate portion, of the baseplate 12. The bottom edge of all plate-like substrates 11 is then held fixed on the baseplate 12 or respectively on the glass pane portion thereof by means of a seam of adhesive 15 indicted in Fig. 1. The individual plate-like

substrates 11 are disposed in relation to one another, in particular in the region of the seam of adhesive 15, at a spacing corresponding to the width of the saw cut 14. On account of using the liquid cutting means, it is possible, for example, for individual, adjacent, plate-like substrates 11 to adhere to one another in parallel or inclined position. As semiconductor wafers, the plate-like substrates 11 have a thickness of about 0.7 to 0.8 mm, and, as solar wafers, a thickness in the region of from 0.2 to 0.3 mm, substrate plate thickness in the region of 0.15 mm also being possible. The purpose of the device 10 according to the invention is to isolate thin, plate-like substrates 11 of this kind from the adjacent plate-like substrate, and to detach them by automatic means, unbroken and also otherwise undamaged, in an easy manner from the baseplate 12 and to deliver them for further storage and/or processing.

The device 10 has a gripping apparatus 20, which is driven to pivot and oscillate back and forward in the direction of the double-arrow B and which serves, on the one hand to detach the plate-like substrates 11 from the baseplate 12 and on the other hand, to remove and deliver the plate-like substrates 11 onwards. The gripping apparatus is fastened to a gripper mounting 30 for this purpose and in order to provide a bias in the direction of Arrow C1.

The gripping apparatus 20 has a gripper plate 21, from which gripper arms 22 protrude perpendicularly in a matrix-like arrangement. A matrix-like arrangement of the gripper arms 22 is revealed, for example, in a variation from Fig. 1 shown in Fig. 3. The gripper arms 22 are disposed over the gripper plate 21, whose plane measurement approximately corresponds to the plane measurement of the plate-like substrates 11, in such a way that they are distributed in sections or point-by-point over substantially the entire outer surface 16 of a plate-like substrate 11 to be gripped. The gripper arms have suction cups 23 at their free ends opposite to the gripper plate 21, which suction cups, as will be described below, are joined to a vacuum apparatus 50. The gripper plate 21 is joined, at its top end opposite to the baseplate 12 and at its rear face opposite to the gripper arms 22, to an arcuate slide 24 which is held in a receiver

32 of a holder 31 of the gripper mounting 30 for guidance in the direction of Double Arrow B. The rear end 26 of the slide 24 has a connecting-link opening 25, in which is inserted an eccentric disc 33 which is mounted on a flange 35 attached protrudingly on the holder 31 and which is driven to rotate by means of a motor which is not represented. The slide 24 is moved by the rotational movement of the eccentric disc 33 to oscillate arcuately backward and forward in the direction of Double Arrow B, by which means the gripper plate with the gripper arms 22 is pivoted oscillatingly. The holder 31 is aligned in such a way that the imaginary extension of its central axis 36 intersects with the seam of adhesive 15. In this manner, the gripper plate 21 is pivoted with the aid of the eccentric drive 33, 34 to oscillate about the seam of adhesive 15 between plate-like substrate 11 and baseplate 12.

The holder 31 is fastened onto a holder plate 37, which can be moved linearly in relation to a mounting cross-member 38 in accordance with Double Arrow C. For this purpose, the mounting cross-member 38 is joined permanently to bolts 39 disposed at a spacing, which bolts penetrate the holder plate 37 in axially movable form and which have a bearing plate 41 at their end. Compression springs 40 are disposed between the bearing plate 41 and the under side of the holder plate 37. The mounting cross-member 38 can be moved upward or lifted in the direction of Arrow C1 by means which are not represented, which lifting movement may or may not be followed, as will be described below, by the holder plate 37 joined to the holder 31. The mounting cross-member 38 is joined to a laterally protruding angle bracket 42, to the downward-projecting end of which is attached a motion recording sensor 43 which is disposed opposite to a region between holder plate 37 and bearing plate 41 of the bolt 39.

According to Figures 1 and 2, the gripping apparatus 20 is provided with a positioning sensor 27, which is disposed opposite to the plate-like substrate 11 respectively being gripped. Furthermore, a spray nozzle 45 is disposed fixed in a lateral region of the baseplate 12 at a height just above the seam of adhesive 15 between plate-like substrate 11 and baseplate 12,

which spray nozzle is joined in a manner not shown to a pressure reservoir for liquids and whose slit-like nozzle opening 46 is directed into the region of the saw cut 14 between two adjoining plate-like substrates 11. As opposed to this, the baseplate 12 with the cut substrate block 13 can be moved in the direction of Arrow A and thus in the direction of the gripping apparatus 20 which can be pivoted to oscillate.

The operation or the method for isolating and detaching thin, fragile, plate-like substrates 11 from one another and respectively from a substrate block 13, mounted fixed by adhesive on the baseplate 12, which has been cut into the plate-like substrates 11, proceeds as follows.

The baseplate 12 is moved in the direction of Arrow A until the positioning sensor 27 has detected the correct position for connecting the foremost plate-like substrate 11 to the gripping apparatus 20, this positioning sensor 27 being provided in a lower region not far from the seam of adhesive 15. The spray nozzle apparatus 45 is activated at the same time, so that a fan jet of liquid is brought through the slit opening 46 into the saw cut 14 between the foremost and the succeeding plate-like substrate 11, the jet of liquid causing a possible adhesion of the succeeding plate-like substrate 11 to dissolve, and/or causing the plate-like substrate being gripped to stand up (vertically). On turning on the vacuum apparatus 50, the foremost plate-like substrate 11 to be gripped is taken hold of by the suction cups 23 attached to the gripper arms 22.

The eccentric apparatus 33, 34 is then put into operation, by which means an oscillating pivoting movement of the gripping apparatus is produced. The pivoting oscillation has a low amplitude in the region of between 2 and 6°, preferably one of 3°, at a frequency range of about 5 to 10 Hz. This pivoting oscillation is transferred to the plate-like substrate 11 gripped by the gripping apparatus 20. The pivoting oscillation of the plate-like substrate 11 is effected

until tears are produced in the seam of adhesive 15 between the plate-like substrate 11 and the baseplate 12 to such an extent as to enable a damage-free lifting of the plate-like substrate 11. Before or during the pivoting oscillation, but after the plate-like substrate 11 in question has been gripped by the gripping apparatus 20, the mounting cross-member 38 of the gripper mounting 30 is moved somewhat upwards in the direction of Arrow C1, the holder plate 37, which is permanently joined to the gripping apparatus 20, remaining in its position. This causes a bias force, corresponding to the spring tension of the gripper mounting 30 in the direction of Arrow C1, so that a tensile load is produced within the seam of adhesive 15, the load being chosen to have a magnitude such as still to guarantee damage-free handling of the plate-like substrate 11. The relative movement between mounting cross-member and holder plate 37 acts upon the compression springs 40 in the direction of Arrow C1, and the movement of the spring windings and/or that of the bearing plate 41 is recorded by the motion recording sensor 43.

Under this tensile load, the oscillating pivoting or vibrating movement of the plate-like substrate 11 is continued until the seam of adhesive 15 is sufficiently torn or worn out for the plate-like substrate 11 to be detached and lifted off the baseplate 12 in the direction of Arrow C1 under the aforementioned bias or tensile force. The holder plate 37 is moved upward in the direction of Arrow C1 and the compression springs 40 are released, this being detected by the motion recording sensor 43.

The isolated and detached plate-like substrate 11 can then be delivered in a manner which is not shown to a store or for further processing.

According to Figures 3 and 4, the matrix arrangement of the gripper arms 22 and of their suction cups 23 is wired in a certain manner. All suction cups 23 are permanently connected to

a vacuum generator 51, for example in the form of an ejector nozzle. In addition to the n ejector nozzles associated with the n suction cups 23, n transducers 52 are provided with which it is possible to evaluate whether and which suction cups 23 have gripped a corresponding surface of the associated plate-like substrate 11. Conclusions can be drawn from this as to whether the plate-like substrate 11 in question is present in its entirety or only in fragmentary form. This also permits sorting of the good from the bad, for example.

In accordance with Fig. 3, the suction cups 23 are combined into two (or more) format-dependent circuits 53, 54 and are correspondingly wired. In this manner, plate-like substrates 11 of different outer surface and/or formats 16', 16", 16"', 16"" may be handled and also taken hold of. It is possible to apply vacuum differently to these format-dependent circuits, so that it is also possible to take hold of and remove fragments of plate-like substrates.

According to an embodiment by way of example which is not shown, it is also possible to fit the gripping apparatus with only one and possibly a larger-surfaced suction cup.

Claims

1. A method for isolating and detaching thin, fragile, plate-like substrates which have been cut from a substrate block mounted fixed, preferably by means of adhesive on a baseplate, **characterised in that** the plate-like substrate is gripped at one or more points of its free outer surface which are spaced apart and is caused to oscillate.

2. A method according to Claim 1, characterised in that the plate-like substrate is pivoted to oscillate about an axis contained within the substrate's seat on the baseplate and approximately parallel to the seating surface.

3. A method according to Claim 1 or 2, characterised in that, during its oscillating movement, the plate-like substrate is held biased in a direction away from the baseplate.

4. A method according to at least one of Claims 1 to 3, characterised in that adjacent plate-like substrates are isolated, preferably in the region thereof that faces the baseplate, by means of a pressure jet.

5. A method according to Claim 4, characterised in that the isolation of adjacent plate-like substrates is carried out between the plate-like substrate to be gripped and the succeeding substrate.

6. A method according to Claim 4 or 5, characterised in that a fan jet of liquid is directed into the cut slit between two adjacent plate-like substrates.

7. A method according to at least one of the preceding claims, characterised in that the plate-like substrate is gripped by suction in a format-dependent matrix.

8. A method according to at least one of Claims 4 to 7, characterised in that the isolation of adjacent plate-like substrates and the gripping of the appropriate substrate by suction is effected at the same time.

9. A method according to at least one of the preceding claims, characterised in that the baseplate provided with the cut substrate block is displaced by steps in order to grip the respective plate-like substrate.

10. A device (10) for isolating and detaching thin, fragile, plate-like substrates (11) which have been cut from a substrate block (13) mounted fixed, preferably by means of adhesive, on a baseplate (12), characterised in that a gripping apparatus (20) having several gripper arms (22) is provided, by means of which the plate-like substrate (11) can be gripped at adjacent points of its free outer surface (16), and in that the gripping apparatus (20) or the gripper arms (22) is or respectively are driveable to move oscillatingly.

11. A device according to Claim 10, characterised in that the gripper arms (22) protrude rigidly from a gripper plate (21) of the gripping apparatus (2) and in that the gripper plate (21) can be pivoted to oscillate about an axis (15) which is approximately parallel to the outer surface (16) of the gripped plate-like substrate (11) and extends within the seating region of the plate-like substrate (11) on the baseplate (12).

12. A device according to Claim 11, characterised in that the gripper plate (21) has an arcuate slide (24) guided in a recess (32), which slide can be moved backward and forward by a rotatingly driven eccentric apparatus (33, 34).

13. A device according to at least one of Claims 10 to 12, characterised in that the gripping apparatus (20) is joined to a gripper mounting (30) in such a way that the gripping

apparatus (20) is biased in a direction lifting the plate-like substrate (11) off the baseplate (12).

14. A device according to Claim 13, characterised in that the gripper mounting (30) has a tension element (38) joined to a lifting drive, and a holding plate (37) which is relatively moveable by spring bias in opposition to the tension element (38) and on which the gripping apparatus (20) is mounted.

15. A device according to Claims 12 and 14, characterised in that a lever arm (31) is fastened to the relatively moveable holding plate (37), which lever arm has a recess (32) for guidance of the arcuate slide (24) of the gripping apparatus (20).

16. A device according to at least one of Claims 13 to 15, characterised in that a sensor (43) is provided on the gripper mounting (30) for the purpose of recording the relative movement between the tension element (38) and the holding plate (37).

17. A device according to at least one of the preceding claims, characterised in that a pressure-jet nozzle (45) is provided disposed on one side of the baseplate (12) adjacent to the seat (15) of the plate-like substrate (11) on the baseplate (12) and directed between two adjoining plate-like substrates (11), the pressure-jet nozzle (45) and the baseplate (12) being displaceable in relation to one another along the substrate block (13).

18. A device according to Claim 17, characterised in that the pressure-jet nozzle (45) has a slit-like outlet (46).

19. A device according to at least one of the preceding claims, characterised in that the gripper arms (22) of the gripping apparatus (20) are provided with suction cups (23) which are arranged in a matrix and can be controlled as a function of format.

20. A device according to Claim 19, characterised in that the suction-cup matrix is subdivided into several switching circuits.

21. An apparatus according to Claim 19 or 20, characterised in that a vacuum generator (51) and a transducer (52) to record the applied vacuum is associated with each suction cup (23).

22. An apparatus according to at least one of the preceding claims, characterised in that the pressure-jet nozzle (45) is stationary and the baseplate (12) can be displaced stepwise towards the gripping apparatus (20).

23. An apparatus according to at least one of the preceding claims, characterised in that a positioning sensor (27) for the substrate block (13) is provided in the region of the gripping apparatus (20).