

Method for singulating stacked, plate-like elements,
and singulating device

- 5 The invention relates to a method for singulating stacked, plate-like elements, and to a singulating device.

In many production processes it is necessary to separate from one another identical elements present in stacked form
10 and to feed them singly for further processing. In this case each uppermost element is generally removed from the stack. In many production processes, in particular those in which the stacked plate-like elements are fragile, a person who removes each first element from a stack manually is
15 used. "Plate-like" is understood to mean elements the thickness of which is significantly less than their dimensions in length and width. The plate-like elements are not necessarily round but may have any peripheral contour.

20 It is further known to effect the removal of each first element by means of a vacuum arrangement. In this case a suction device is placed on the surface of the first element, the intervening space is evacuated and the respective first element of the stack is thus lifted away.

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Both procedures have considerable disadvantages. For example, in the case of manual singulation of the elements from a stack it is disadvantageous that the performance of an operative declines in the course of a working day. This
30 can cause the number of singulated elements to fall in the course of a working day, or the rejection rate to increase. In addition, high fixed personnel costs arise.

With the removal of each first element by means of a suction device it is disadvantageous that considerable complexity or considerable suction power is required for relatively large or not completely flat elements, in order
5 to seal the suction bell with respect to the element and to ensure secure handling of the element. In the event that such an apparatus is to be used for light elements having high surface quality, it is disadvantageous that the performance of such a machine far exceeds the requirements
10 and that the correspondingly high costs cannot therefore be justified.

In the case of brittle materials there is additionally a considerable risk that elements fracture while adhesion
15 forces are overcome. The removal of the fragments and cleaning of the apparatus then cause production down-time.

It is therefore the object of the invention to provide a singulating device and a method for singulating plate-like
20 elements from a stack which make possible automated singulation in a simple manner and with high reliability and high constancy.

This object is achieved by the method according to claim 1
25 and by the singulating device according to claim 11.

In the method according to the invention a stack of plate-like elements is first supplied to an acceleration device. The stack consists of stacked, plate-like elements. Each
30 first element of the stack is lifted away from the stack by increasing its transport velocity. In order to increase the transport velocity, the element is accelerated away from

the stack in the direction of the axis of the stack by a part of its peripheral edge. The element thus lifted from the stack is deposited on a transport device and then conveyed away by the transport device. Through the
5 acceleration of the element at a part of its peripheral edge, complicated vacuum technology can be dispensed with.

For this purpose the singulating device comprises, in addition to a feed device for feeding the stack, an
10 acceleration device with which each first element of the stack is subjected to an acceleration force on a part of its peripheral edge. The accelerated element is conveyed away by a transport device and is thus moved increasingly away from the rest of the stack. The acceleration at the
15 part of the peripheral edge of the first element is effected, for each element of the stack, with a constant force, resulting in constant singulation with regard both to the quality and to the time interval of the singulated elements.

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The dependent claims relate to advantageous developments of the inventive singulating device and of the inventive method.

25 It is advantageous, in particular, to effect the acceleration by means of a conveying element. In this case, a conveying element moves at an increased velocity with respect to the axial velocity of the peripheral edge of the first element of the stack. When the peripheral edge of the
30 first element impinges on the conveying element of the acceleration device, this part of the peripheral edge is

entrained by the conveying element and accelerated away from the stack in the direction of the axis of the stack.

According to a further preferred embodiment of the method and of the inventive singulating device, the acceleration of the part of the peripheral edge of the first element is effected in at least two acceleration stages. This has the advantage that the acceleration forces and the bending moments which act on the element through the impingement of the acceleration force on one side are low. The element to be singulated is first moved a short distance away on one side before a further acceleration is effected on the same peripheral side in the second step. However, the further acceleration acts on the already detached element, so that effects, such as adhesion, between the individual elements of the stack no longer play any part at this point.

Furthermore, the acceleration of the element by a part of its peripheral edge has the advantage that, through the acceleration on one side, a rotational movement of the element to be singulated is initiated. If the stack is being fed, for example, with its axis in a horizontal direction, because of the rotational movement the element to be singulated is laid down in the horizontal plane. The rotational movement is induced solely because of the one-sided acceleration of the element, so that the upper peripheral edge of the first element located opposite the accelerated lower peripheral edge trails behind through inertia, and the singulated element is laid down, for example, on a conveyor belt.

Depending on the thickness of the plate-like elements to be singulated, it is advantageous to carry out the feeding of the stack to the acceleration device in a pulsed manner. Such pulsed feeding ensures that the element first detached
5 from the stack is already far enough away from the stack not to collide with the next element upon singulation of the latter.

In order to prevent the following element of the stack from
10 being inadvertently lifted from the stack together with the element accelerated by its peripheral edge, as a result of adhesion, it is advantageous to provide a braking device with which at least the element adjacent to the first element to be lifted is subjected to a restraining force
15 directed oppositely to the acceleration force.

Considerable adhesion forces can arise between the individual elements of the stack. These forces may have the result that the force exerted on the peripheral edge of the
20 first element is not sufficient to lift away the first element. According to a preferred embodiment, therefore, a jet of fluid begins to be blown or sprayed into the region of a contact face between the first element to be lifted away and the element adjacent thereto, shortly before the
25 start of the acceleration. For this purpose one or more nozzles arranged around the stack are provided, which each direct at least one fluid jet on to the stack, the fluid jet impinging on the stack at the contact face between the first element and the element adjacent thereto at least
30 directly prior to the acceleration of the peripheral edge of the first element. Such a fluid jet may also be directed at the stack from different directions by one or more

nozzles, and the jets may be disposed at an angle deviating from 90° from the axis of the stack.

To prevent surface damage to the adjacent element occurring through the sliding thereon of the edge of the first element opposite the accelerated peripheral edge, a fluid cushion is generated between the slightly lifted first element and the stack by, again, at least one fluid jet, by which the fluid cushion is produced in the gap between the first element and the stack, on which fluid cushion the first element slides down. In this way, contact between the peripheral edge of the first element located opposite the accelerated peripheral edge, and the adjacent element of the stack, is prevented or minimised.

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A preferred embodiment of the inventive singulating device and of the inventive method is represented in the drawings and is explained in detail in the following description. In the drawings:

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Fig. 1 is a perspective representation of a singulating device according to the invention at a first time point;

25 Fig. 2 is a perspective representation of the singulating device according to the invention at a second time point;

Fig. 3 is a perspective representation of the singulating device according to the invention at a third time point;

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- Fig. 4 is a perspective representation of the singulating device according to the invention at a fourth time point;
- 5 Fig. 5 shows a detail of the singulating device according to the invention;
- Fig. 6 shows a detail of an exemplary embodiment with a braking device;
- 10 Fig. 7 is an enlarged representation of the transfer zone according to a second exemplary embodiment;
- Fig. 8 shows further exemplary embodiments for configuring the transfer zone, and
- 15 Fig. 9 is a representation of an alternative feed device.
- 20 Fig. 1 shows a singulating device 1 according to the invention in a perspective view. The representation in Fig. 1 shows the inventive singulating device 1 at a first time point, at which a first element 3 has been slightly lifted from a stack 2. The stack 2 consists of a multiplicity of
- 25 elements 3, 3', ..., which each have the same dimensions. Stacks comprising elements of different sizes may also be used, in which case the singulation may be combined with a sorting process. Such elements 3, 3', 3'', ..., may be, for example, silicon wafers for the manufacture of photovoltaic
- 30 installations. Silicon wafers typically have a thickness of approximately 50 μm to 300 μm . However, the inventive singulating device 1, and the corresponding singulation

method, are not restricted to such thin elements 3, 3', 3'',... . For example, the singulating device may also be used for singulating stacked circuit boards or other elements to be singulated.

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In order to lift each first element 3 away from the stack 2, the stack 2 is first transported in the direction of an acceleration device 5 by a feed device 4. For this purpose the feed device 4 has, in the exemplary embodiment

10 illustrated, a first pair of transport belts consisting of a first transport belt 6a and a second transport belt 6b. The first and second transport belts 6a and 6b together form a conveying element of the feed device 4. The first transport belt 6a and the second transport belt 6b are

15 guided via a first pair of rollers 7a, 7b and a second pair of rollers 8a, 8b, only the roller 8b of the second pair of rollers 8a, 8b being seen in Fig. 1. The drive of the transport belts 6a and 6b is effected, for example, via a drive axle rigidly connected to the rollers 7a, 7b and

20 shown between the rollers 7a, 7b.

The plate-like elements 3 forming the stack 2 have a peripheral edge 9 which in the exemplary embodiment illustrated is identical for all the elements 3, 3',... of

25 the stack 2 and which delimits said elements 3, 3',... in a right-angled manner in the exemplary embodiment illustrated. Singulation of the elements can also be carried out in the case of elements which are delimited by peripheral edges which deviate geometrically from one

30 another. The lower peripheral edges 9' of each of the elements 3, 3', 3'' of the stack 2 rest on the transport belts 6a, 6b of the feed device 4 and are therefore

conveyed through the feed device 4 in the direction indicated by an arrow in Fig. 1.

As a result of this feed movement the first element 3 of the stack 2 in Fig. 1 is conveyed so far to the right at a given time point that its lower peripheral edge 9' loses contact with the conveyor belts 6a, 6b. For this purpose, as will be explained in detail with reference to Fig. 5, in the exemplary embodiment illustrated the transport belts 6a, 6b of the feed device 4, and the further transport belts, are disposed at different levels. In a simpler embodiment the levels may be identical. The acceleration of the first element 3 is effected by a further conveying element. The further conveying element consists of a third transport belt 11a and a fourth transport belt 11b which cooperate as a third pair of transport belts. The third and fourth transport belts 11a, 11b move, on the side in contact with the lower peripheral edge 9' of the first element 3, at a velocity in the direction of the arrow which is greater than the feed velocity of the stack 2 and which is therefore greater than the axial velocity of the elements 3, 3', 3'', ... of the stack 2 in the direction of the axis 10 of the stack 2. The lower peripheral edge 9' of the first element 3 is thereby accelerated in the direction of the arrow by the second pair of transport belts 11a, 11b and is moved increasingly away from the adjacent element 3' of the stack 2. In this case the second pair of transport belts 11a, 11b forms a first conveying element of the acceleration device 5.

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The second pair of transport belts 11a, 11b is located substantially in axial prolongation with respect to the

first pair of transport belts 6a, 6b. As a result of the higher conveying velocity, the lower peripheral edge 9' of the first element 3 is accelerated with respect to the lower peripheral edges of the remaining elements of the stack 2 in a first acceleration stage. In the preferred exemplary embodiment illustrated in Fig. 1, a third pair of transport belts 12a, 12b follows on from the second pair of transport belts 11a, 11b as a further conveying element, which again has an increased conveying velocity as compared to the second pair of transport belts 11a, 11b. As a result of this second acceleration stage, the lower peripheral edge 9' of the first element 3 is further accelerated.

The second pair of transport belts 11a, 11b and the third pair of transport belts 12a, 12b run, like the first pair of transport belts 6a, 6b, on corresponding pairs of rollers 14 to 17; corresponding letters a, b appended to the reference numerals indicate the sides occupied by the respective rollers (some of which rollers are concealed in the Figures). The first pair of rollers 14a, 14b of the second pair of transport belts 11a, 11b, and the second pair of rollers 8a, 8b of the first pair of transport belts 6a, 6b, are arranged in pairs on a common axle. In order to enable different conveying velocities of the first pair of transport belts 6a, 6b and the second pair of transport belts 11a, 11b, the rollers are mounted rotatably with respect to one another. In a corresponding manner the second pair of rollers 15a, 15b of the second pair of transport belts 11a, 11b and the first pair of rollers 16a, 16b of the third pair of transport belts 12a, 12b, are each arranged in pairs on a common axle.

Through the acceleration of the lower peripheral edge 9' of the first element 3 a rotational movement about the part of the peripheral edge 9' of the first element 3 is initiated. In comparison to the accelerated lower peripheral edge 9',
5 an opposite peripheral edge 9'' is left behind and slides through gravity down the surface of the element 3' adjacent to the first element 3.

Once the lower peripheral edge 9' of the first element 3
10 has been moved far enough away from the rest of the stack 2 by the second pair of transport belts 11a, 11b and the third pair of transport belts 12a, 12b, the surface of the first element 3 which had originally faced towards the stack 2, the first element 3 being now rotated to a
15 horizontal position, lies flat on the transport belts. In addition, the already singulated element 3 is fed by the third pair of transport belts 12a, 12b to a transport arrangement 32, which consists of a fourth pair of transport belts 13a, 13b. The transport belts 13a and 13b
20 are in turn guided by two pairs of rollers 18a, 18b and 19a, 19b. At the end of the fourth pair of transport belts 13a, 13b the element 3 thus singulated may - in the case of silicon wafers, for example - either be placed singly in a cassette or transferred directly to a further processing
25 operation. Unlike the case in the embodiment illustrated, the second acceleration stage may be configured at the same time as a transport device.

While the stack 2 is being fed through the feed device 4,
30 the stack 2 is retained on at least two sides of the feed device 4 by guide elements extending in the axial

direction. For clarity, the guide elements are not shown in the Figures.

As was explained in the introduction, the singulating
5 device 1 illustrated is especially suitable for singulating
silicon wafers. Such silicon wafers exist in various
versions. With regard to singulation, a main distinction
must be made here between two types of wafer. On the one
hand, there are so-called drawn wafers, the surfaces of
10 which have slight undulations. These drawn wafers must be
distinguished from monocrystalline or multicrystalline
wafers, between which, in stacked formation, considerable
adhesion forces arise on account of their smooth surfaces.
For this reason, further measures are required or possible
15 in order to enable detachment of the respective first
element 3 from the stack 2, in addition to the acceleration
of the lower peripheral edge 9' of the first element 3.

According to the invention, detachment of the first element
20 3 from the stack 2 is effected in that a plurality of fluid
nozzles 27a, 27b, 27c are arranged laterally in a transfer
zone from the feed device 4 to the acceleration device 5,
by means of which fluid nozzles 27a, 27b, 27c a plurality
of fluid jets 21a, 21b and 21c are directed at the stack 2.
25 Shortly before the acceleration of the lower peripheral
edges 9' begins, the peripheral edge 9 of the first element
3 has passed the fluid jets 21a, 21b and 21c. The fluid is
blown or injected through the fluid nozzles 27a, 27b, 27c
into the region of a contact face between the first element
30 3 and the adjacent element 3' and thus causes slight
separation of the wafers "sticking" to one another.

The fluid nozzles 27a, 27b and 27c are preferably arranged movably. The movable arrangement makes possible either a linear movement in and opposite to the transport direction of the stack 2, or a rotation of the fluid nozzles 27a, 27b, 27c. With a rotatable arrangement, the angle at which the fluid impinges on the element 3 to be singulated from the stack 2 changes. To improve singulation, the fluid nozzles 27a, 27b, 27c are subjected to a common oscillating movement, so that fanning out of the elements of the stack 2 takes place in stages. In this case the fluid may either be supplied continuously through the fluid nozzles 27a, 27b, 27c, or in a pulsed manner, the fluid stream preferably being interrupted, in the case of a pulsed supply of fluid, for a movement of the fluid nozzles 27a, 27b, 27c oppositely to the feed direction of the stack 2.

In the simplest case, air is used as the fluid. However, a higher integration into a manufacturing process is made possible by using a fluid adapted to a processing operation. In particular, it is possible to use a cleaning liquid as the fluid. The blowing-in or injection of the fluid may begin before the stack 2 enters the transfer zone. In this way, in the ideal case, the stack 2 is already loosened continuously while being fed.

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In the Figures an especially preferred embodiment is represented in which there is provided on either side of the stack 2 and on the underside of the stack 2 a respective fluid nozzle 27a, 27b, 27c, which each effect lifting away of the first element 3 by a respective sharp jet 21a, 21b, 21c. The geometry of each of the jets 21a, 21b, 21c corresponds substantially to a segment of a

circle, the extension being sharply delimited in the direction of the axis 10 of the stack 2. Good results can also be achieved with a cylindrical jet, which is preferably sharply delimited. In the Figures it is shown
 5 that the direction of the jet is disposed approximately vertically on the axis 10 of the stack 2. However, it may also be advantageous to guide the fluid jets 21a, b, c slightly in the direction of the conveying direction, in order to favour the lifting away of the first element 3 by
 10 the fluid jets 21a to 21c.

Fig. 2 shows the inventive singulating device 1 at a later time point. While the first element 3 has already been laid down almost completely on the third pair of transport belts
 15 12a, 12b, the adjacent element 3' has already been accelerated by its lower peripheral edge and its rotational movement has been initiated. The further element 3'', by contrast, is still in contact with the first pair of transport belts 6a, 6b, so that its lower peripheral edge
 20 has not yet been subjected to any accelerating force. For greater clarity, the further elements of the stack 2 are not shown in Fig. 2.

As already explained, an especially gentle method of
 25 singulation is provided, in which, in particular, the surface of the respective adjacent element - in the example illustrated, the surfaces of the adjacent elements 3', 3'' - is not damaged by the upper peripheral edge 9'', if the rotational movement of the first element 3 is effected with
 30 the support of a fluid cushion. For this purpose further fluid nozzles 23 to 26 are provided, with which a fluid cushion is created on the sides of the rotating elements 3,

3' oriented towards the stack 2. Said fluid cushion supports the rotating elements 3, 3', so that the respective upper peripheral edges of the rotating elements 3, 3' do not come into contact with the surface of the
5 respective following elements 3', 3'' of the stack 2.

The individual fluid nozzles 23 to 27 may also be operated with different fluid media. In particular, a mixture of different fluid media may be used in some or all of the
10 fluid nozzles 23 to 27. For example, a cleaning liquid may be blown together with air as a spray through the fluid nozzles 23 to 27.

The first fluid nozzle 23 of the fluid cushion is arranged
15 shortly after or in the transfer zone from the feed device 4 to the acceleration device 5, in the region of the first pair of transport belts 11a, 11b. The fluid blown in or injected from the first fluid nozzle 23, to generate the fluid cushion flows into the gap forming in the region of
20 the lower peripheral edge 9' of the first element 3 between the first element 3 and the adjacent element 3', or, at the time point of Fig. 2, between the adjacent element 3' and the further element 3''. Through the use of different fluid nozzles 23 to 26 and fluid media, the singulating device 1
25 can be simply adjusted to different stack elements 3, 3', 3'', In particular, it is thereby made possible to adjust the singulating device 1 in a simple manner to different wafer thicknesses, for example. Moreover, it is advantageous to adapt the geometry and/or the strength of
30 the fluid jets 28 to 31 generated by the fluid nozzles 23 to 26 in a manner corresponding to the increasingly large exposed area as the rotational movements of the elements 3,

3', 3'' progress. In the embodiment illustrated, in which the acceleration device 5 and the transport device 32 each comprise a pair of transport belts 11a, 11b, 12a, 12b and 13 a, b guided in parallel, for two acceleration stages and 5 for conveying away the elements 3, 3', 3'',..., the fluid nozzles 23 to 26 are preferably arranged in a gap formed between the respective pairs of transport belts.

Fig. 3 shows the singulating device 1 again at a later time point. In this case the further adjacent element 3'' has also been accelerated by its lower peripheral edge and the first element 3 is already lying in a horizontal plane on the transport belts 13a, 13b of the transport device 32. A device for monitoring correct singulation may be integrated 15 at this point. A weight detection means or an optical thickness control, for example, is also possible here. The integration may also include automatic sorting of the elements or other devices. In the case of incorrect singulation, the incorrectly singulated element or elements 20 is/are extracted from further transportation and returned to the singulation process. In the case of the adjacent element 3', its rotational movement has almost been completed.

25 During the acceleration through the acceleration device 5 it must be ensured that sufficient distance exists between the respective lower peripheral edge 9' of the successive elements 3, 3', 3'', in order to prevent overlapping when the successively deposited elements 3, 3', 3'' are 30 transported away. For this purpose it is possible, in the case of especially thin elements 3, 3', 3'', for example, to operate the feed device 4 in a pulsed manner. Through

appropriate pulsing of the feed device 4 it is effected that contact between the lower peripheral edge 9' of the adjacent element 3', or of the further adjacent element 3'', and the transport belts 11a, 11b of the acceleration
5 device 5 takes place only when the lower peripheral edge of the preceding element 3 or 3' is already at a sufficient distance. However, such a pulsed feed device 4 may be dispensed with if, for example, comparatively thick elements are being singulated. Such thick elements are, for
10 example, stacked circuit boards. Because of the inherent thickness of the circuit boards, given a suitably chosen, constant feed velocity, contact with the transport belts 6a, 6b of the feed device 4 continues long enough, before acceleration occurs, for the lower peripheral edge 9' of
15 the preceding first element 3 to have already been transported sufficiently far.

Finally, Fig. 4 shows how three elements 3, 3' and 3'' of the stack 2 are arranged for further processing singly and
20 successively on the fourth pair of transport belts 13a, 13b, which form a conveying element of the transport device 32. Further elements are not illustrated, so that the preferred arrangement of the fluid nozzles 27 and 23-26 can again be clearly seen.

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Fig. 5 shows once more an enlarged representation of the transfer zone from the feed device 4 to the acceleration device 5. It can be seen that the lower peripheral edges 9' of the elements 3, 3', 3'', etc., of the stack 2 rest on
30 the pair of transport belts 6a, 6b, only the second transport belt 6b of the feed device 4 being visible in the side view. Because of the abutment of the lower peripheral

edge 9' of the individual elements 3, 3', 3'' of the stack 2 on the pair of transport belts 6a, 6b, a first distance d_1 is produced between the transport belt 6b and the axis 10 of the stack 2. In contrast, a second distance d_2 from the transport belts 11a, 11b of the second pair of transport belts 11a, 11b is increased, as compared to the first distance d_1 . An increase in the distance of the second pair of transport belts 11a, 11b can be achieved, for example, by reduction of the diameter of the rollers 14a, 14b as compared to the diameter of the rollers 8a, 8b of the first pair of transport belts 6a, 6b, which are arranged on the same pair of axles 20.

Fig. 5 illustrates an especially advantageous embodiment in which the second distance d_2 is increased with respect to the first distance d_1 . Equally, it is possible during the feeding of the stack 2 to move the first element 3 towards the acceleration device 5, the first pair of transport belts 11a, 11b of the acceleration device 5 being at a reduced distance d_2 with respect to the first distance d_1 of the transport belts 6a, 6b of the feed device 4. In this case the stack 2 with the first element 3 is moved towards the second pair of transport belts 11a, 11b, whereupon the lower peripheral edge 9' of the first element 3 also has contact with the faster-running transport belts 11a, 11b at a defined time point.

In addition, the position of the contact face 22 between the first element 3 and its adjacent element 3' is again shown clearly in Fig. 5.

Fig. 6 again shows a detail of the inventive singulating device. An example of a braking device 33 is shown in the transfer zone between the feed device 4 and the acceleration device 5. In this case the first elements of a stack 2 transported in the direction of the arrow by the transport belts 6a, 6b of the feed device 4 reach the braking device 33. For greater clarity, only the transport belts and rollers denoted with the suffix "a" are shown in each case. On its side oriented towards the stack 2 to be transported, the braking device 3 has on one side an elevated portion 34 arranged in the conveying direction, towards which the stack 2 to be transported is conveyed by the feed device 4. Instead of the curved contour of the side of the braking device 33 oriented towards the stack 2 illustrated in Fig. 6, a wedge-shaped geometry, for example, of the braking device 33 may alternatively be chosen. During transportation in the direction of the arrow, the distance of the braking device 33 with respect to the axis 10 of the stack diminishes. The braking device 33 is so arranged in the conveying direction that a rear edge 35 is reached by the first element 3 of the stack 2 at a time point at which further contact with the transport belts 6a, 6b of the feed device 4 no longer takes place. Instead, the respective first element 3 of the stack 2, as it moves beyond the rear edge 35 of the braking device 33, slides off same at a defined time point and is accelerated at its lower peripheral edge 9' by the transport belt 11a of the acceleration device 5.

It can also be seen in Fig. 6 that, in contrast to the exemplary embodiments of Figs. 1 to 5, an enlarged transfer zone may be formed in which the respective axles 20 of the

rollers 14a, and 20' of the roller 8a, are arranged offset to one another in the conveying direction. As has already been explained in detail with reference to the exemplary embodiment of Fig. 5, in the exemplary embodiment of Fig. 6 the pair of transport belts 11a, 11b is arranged at an increased distance d_2 from the axis 10 of the stack 2, as compared to the first distance d_1 of the first pair of transport belts 6a, 6b.

- 10 In the Figures, two transport belts in each case jointly form a conveying element of the feed device 4, the acceleration device 5 and the transport device 32. The use of other conveying elements is also possible.
- 15 Fig. 7 is an enlarged representation of a transfer zone between the feed device 4 and the acceleration device 5. As in the preceding examples, the levels with respect to the stack axis are different in the feed device 4 and in the acceleration device 5. To improve the detachment of the
- 20 respective first element 3 of a stack 2, a toothed wheel 36 is additionally provided. In the exemplary embodiment shown in Fig. 7, the toothed wheel 36 is in the form of a gear wheel. However, flank geometries deviating there from may be required in order to adapt the toothed wheel 36 to the
- 25 thickness of the elements 3 to be singulated. The toothed wheel 36 preferably has an external diameter which is greater than the diameter of the rollers of the second pair of rollers 8a, 8b plus twice the thickness of the first or second transport belt 6a, 6b. As can be seen in Fig. 7,
- 30 this has the result that a movement of the stack 2 in the direction of the arrow brings the first element 3 of the stack 2 into contact with the rotating toothed wheel 36

even before said first element 3 has reached the end of the feed device 4. By means of the toothed wheel 36, therefore, each first element 3 of the stack 2 is impinged upon at its lower peripheral edge 9' and is lifted away from the stack.

5 As this happens, because of the slightly greater diameter of the toothed wheel 36, a lifting movement is executed with the element 3.

As has already been explained, the geometry of the teeth of
10 the toothed wheel 36 is coordinated with the thickness of the elements 3 to be singulated, so that one element 3 is transported securely by each two successive teeth of the toothed wheel 36 in the direction of the acceleration device 5. The respective lower peripheral edge 9' of the
15 transported element 3 is transported by the toothed wheel 36 until said lower peripheral edge 9' comes into contact with the third and fourth transport belts 11a, 11b. At this time point the third and fourth transport belts 11a, 11b take over the further transportation of the lower
20 peripheral edge 9', whereby the successively singulated elements of the stack 2 are deposited in the manner already described.

In the exemplary embodiment represented in the drawing, the
25 toothed wheel 36 preferably rotates at the same angular velocity as the first pair of rollers 14a, 14b of the second pair of transport belts 11a, 11b, whereby an acceleration of the lower peripheral edge 9' is achieved. In deviation from the embodiment shown in Fig. 7, however,
30 the toothed wheel 36 may have its own drive, so that, in particular, the first pair of rollers 14a, 14b of the second pair of transport belts 11a, 11b can be mounted

rotatably on their own axle. Even with the use of a toothed wheel 36 for detaching each first element from the stack 2, it is possible for the level of the third and fourth transport belts 11a, 11b to be higher than the level of the first and second transport belts 6a, 6b, and for the resulting height difference to be compensated by lifting of the first element by means of the toothed wheel 36.

Especially if the elements 3 to be singulated are silicon wafers, wheels of plastics material are preferably used as toothed wheels 36. A further possibility is to use aluminium gear wheels, at least the surfaces of the aluminium gear wheels in contact with the elements 3 to be singulated being coated. Anodisation is preferably used to form the coating of the contact faces of the aluminium gear wheels.

Fig. 8 again shows the transfer zone from the feed device 4 to the acceleration device 5 for three alternative exemplary embodiments, in which the arrangement of the toothed wheel or wheels 36, 36a, and 36b is different. In the simplest exemplary embodiment, shown in Fig. 8a), a single toothed wheel 36 is used which is arranged centrally between the first rollers 14a, 14b of the second pair of transport belts 11a, 11b. Unlike the case with the preceding exemplary embodiments, in order to be able to dispense with a separate drive for the toothed wheel 36 the toothed wheel 36 is arranged on a drive shaft 20' which is arranged between the rollers 14a, 14b of the first pair of rollers of the second pair of transport belts 11a, 11b. This drive shaft 20' is connected non-rotatably to at least one of the two rollers 14a, 14b and thus transmits a drive

torque to the toothed wheel 36. The arrangement shown in Fig. 8a) makes it possible to integrate an additional toothed wheel 36 retrospectively in existing plants, since the distance between and disposition of the first pair of transport belts 6a, 6b and the second pair of transport belts 11a, 11b remain unchanged.

A further possible arrangement is shown in Fig. 8b). In order to make possible secure impingement upon the respective first element without producing a tilting moment in the case of a non-central position of the stack 2 being fed, a respective toothed wheel 36a, 36b is associated with each of the rollers of the first pair of rollers 14a, 14b of the second pair of transport belts 11a, 11b, unlike the case with the first exemplary embodiment of Fig. 8a). In this case the toothed wheels 36a and 36b may be connected directly to the first pair of rollers 14a and 14b respectively, so that an indirect drive is produced by the second pair of transport belts 11a, 11b. In this case the common axle 20 may be fixed, the second pair of rollers 8a, 8b of the first pair of transport belts 6a, 6b, and the first pair of rollers 14a, 14b together with the pair of toothed wheels 36a, 36b, rotating independently of one another on the common axle 20.

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Fig. 8c) shows a further exemplary embodiment in which the elements 3 to be singulated are gripped and separated still further towards the outer edge of their respective lower peripheral edges 9' by the toothed wheels 36a, 36b. For this purpose the toothed wheels 36a, 36b are again connected to the first pair of rollers 14a, 14b of the second pair of transport belts 11a, 11b. In contrast to the

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exemplary embodiment shown in Fig. 8b), however, the toothed wheels 36a, 36b are now arranged between the second pair of rollers 8a, 8b of the first pair of transport belts 6a, 6b and the first pair of rollers 14a, 14b of the second pair of transport belts 11a, 11b. In this way the transport belts of the second pair 11a, 11b are offset further towards the centre.

An alternative feed device 4' is shown in a side view in Fig. 9. Instead of the first transport belts 6a, 6b, the alternative feed device 4' has a stack holder 37 by means of which a stack 2 is conveyed towards the acceleration device 5. The stack holder 37 is arranged slidingly on a slide rail 38 and can be displaced on the slide rail 38 in the direction of the arrow by means of a drive element 39. The stack holder 37 has a support element 40 on which an abutment face 41 is formed. The last element of a stack 2, which is supported on a support face 42 of the stack holder 35, rests against the abutment face 41. Transportation of the stack 2 is therefore not effected via the first pair of transport belts, as in the preceding exemplary embodiments, but by means of the stack holder 37.

The support element 40 consists preferably of two elements arranged parallel to one another, the front sides of which together form the abutment face 41. In a prolongation of the abutment face 41 in an approximately horizontal direction towards the acceleration device 5, the abutment face 41 adjoins the support face 42, which also consists of two parallel elements. As a result of its forked configuration, the support face 42 extends so far into the region of the acceleration device 5 that even the last

elements of the stack 2 can be impinged upon at their respective lower peripheral edges 9' by the acceleration device 5. In this configuration the fork-shaped support face 42 is positioned in the gaps between the transport belts 111, 11b and 12a, 12b of the acceleration device 5.

Provided opposite the abutment face 41 is a restraining nozzle 43 which applies to the respective front element 3 of the stack 2 a loading towards the abutment face 41 by means of a fluid jet. The individual elements of the stack 2 are thereby held in abutment with the abutment face 41 with a force adjustable by the fluid jet, preventing the elements 3 from tipping over upon a movement of the stack holder 37. For reasons of clarity the fluid nozzles 27a, 27b, 27c are not represented in Fig. 9. Instead of the movable nozzles already described, the nozzles may also be fixed, a relative movement between the fluid jet and the stack 2 being generated by an oscillating motion of the stack holder 37. A pulsed supply of fluid via the fluid nozzles 27a to 27c may again preferably take place. The lateral alignment of the stack 2 on the stack holder 37 is effected by a stop face 48 which is mounted in a fixed position on a support 49.

Also visible in Fig. 9 is a guide element 45 which is arranged on both sides of the acceleration device 5 and the vertical walls of which effect precise orientation of the individual elements 3 on the transport belts of the acceleration device 5. The distance between the two walls of the guide element 45 decreases in the transport direction. Also shown in the side view are two bearing

blocks 46, 47 in which the axles or shafts for receiving the rollers of the acceleration device 5 are provided.

The invention is not restricted to the preferred exemplary embodiment illustrated. Rather, the individual features of the exemplary embodiment can be combined with one another in any desired manner.

Claims

1. Method for singulating stacked, plate-like elements
(3, 3', 3'') from a stack (2), comprising the
5 following steps:
 - feeding a stack (2) of plate-like elements (3,
3', 3'') to an acceleration device (5);
 - increasing a feed velocity of a first element (3)
of the stack (2) by acceleration of the element (3) at
10 a part of its peripheral edge (9') in the direction of
an axis (10) of the stack (2) by the acceleration
device (5);
 - depositing the element (3) on a transport device
(32), and
 - 15 - conveying away the deposited first element (3).
2. Method according to claim 1, characterised in that the
axis (10) of the stack (2) is oriented approximately
horizontally and the first element (3) is accelerated
20 at a lower part of its peripheral edge (9').
3. Method according to claim 1 or 2, characterised in
that the acceleration is effected by a conveying
element (11a, 11b) of the acceleration device (5)
25 which is moved at an increased relative velocity with
respect to the axial velocity of the peripheral edge
(9') of the element (3).
4. Method according to any one of claims 1 to 3,
30 characterised in that an acceleration of the part of
the peripheral edge (9') of the element (3) is
executed in at least two acceleration stages.

5. Method according to any one of claims 1 to 4,
characterised in that through the acceleration of the
respective first element (3) at a part of its
peripheral edge (9') a rotational movement of the
first element (9) is initiated, with which rotational
movement the element (3) is deposited on the transport
device (32).
6. Method according to any one of claims 1 to 5,
characterised in that a part of the peripheral edge
(9') of the respective first element (3) of the stack
(2) is brought into contact with the acceleration
device (5) by a relative movement of the stack (2)
with respect to the acceleration device (5).
7. Method according to claim 6, characterised in that the
relative movement of the stack (2) with respect to the
acceleration device (5) is pulsed.
8. Method according to any one of claims 1 to 7,
characterised in that an element (3') of the stack (2)
adjacent to the first element (3) is subjected to a
restraining force by a braking device.
9. Method according to any one of claims 1 to 8,
characterised in that at least one fluid jet (27a,
27b, 27c) is blown or injected into a region of a
contact face (22) between the first element (3) and an
adjacent element (3') of the stack (2) at least before
the start of the acceleration.

10. Method according to any one of claims 1 to 9,
characterised in that a fluid cushion for the element
(3, 3') to be deposited is generated by at least one
further fluid jet (28, 29, 30, 31) and the element (3,
5 3') to be deposited is guided by the fluid cushion
past an adjacent element (3', 3'') without contact or
with only slight contact during its rotational
movement.
- 10 11. Method according to any one of claims 1 to 10,
characterised in that the respective first element (3)
is lifted away from the stack by a toothed wheel (36,
36', 36'').
- 15 12. Singulating device for singulating stacked, plate-like
elements (3, 3', 3'') from a stack (2), comprising a
feed device (4, 4') and an acceleration device (5) for
increasing the feed velocity of a first element (3) of
the stack (2) by acceleration of a part of a
20 peripheral edge (9') of the first element (3), and
comprising a transport device (32) for conveying away
the element (3).
13. Singulating device according to claim 12,
25 characterised in that the stack (2) is transportable
with an approximately horizontally-oriented axis (10)
in direction to the acceleration device (5) by a
conveying element (6a, 6b) or a stack holder (37) of
the feed device (4, 4').
- 30 14. Singulating device according to claim 12 or 13,
characterised in that the acceleration device (5) has

as an acceleration element at least one conveying element (11a, 11b) having an increased axial velocity component with respect to the axial velocity of a peripheral edge (9) of the first element (3), and
5 in that the conveying element (11a, 11b) of the acceleration device is arranged substantially in axial prolongation of the conveying element (6a, b) of the feed device (4) or of a support face (42) of the stack holder (37).

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15. Singulating device according to claim 14, characterised in that the conveying element (11a, 11b) of the acceleration device (5) is disposed at a greater or lesser distance (d_2) from an axis (10) of
15 the stack (2) with respect to the conveying element (6a, 6b) or to the support face (42) of the stack holder (37).

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16. Singulating device according to any one of claims 13 to 15, characterised in that the conveying element (6a, b) of the feed device (4) and/or the conveying element (11a, b) of the acceleration device (5) comprise pairs of transport belts in each case.

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17. Singulating device according to any one of claims 12 to 16, characterised in that the singulating device (1) has a braking device.

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18. Singulating device according to any one of claims 12 to 17, characterised in that the singulating device (1) has at least one fluid nozzle (27a, 27b, 27c) for injecting or blowing in at least one fluid jet (21a,

b, c) in a transfer zone from the feed device (4) to the acceleration device (5).

19. Singulating device according to claim 18,
5 characterised in that in a region of the acceleration device (5) adjoining the transfer zone there is arranged at least one further fluid nozzle (23, 24, 25, 26) which loads the first element (3) against gravity with at least one fluid jet (28, 29, 29, 30).

C 10 20. Singulating device according to any one of claims 12 to 19, characterised in that at least one toothed wheel (36, 36', 36'') for lifting away the respective first element (3) of the stack (2) is arranged in a
15 transfer zone from the feed device (4) to the acceleration device (5).

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