METHOD FOR FORMING STACKS OF WAFERS TO BE DOPED ONE-SIDED, IN PARTICULAR SOLAR WAFERS, AND HANDLING SYSTEM FOR LOADING A PROCESS BOAT WITH WAFER BATCHES

The invention relates to a method for forming stacks of wafers to be doped one-sided, in particular solar wafers, for loading a process boat with batches of wafers, in which a predetermined even number of wafers is serially provided in reception slots of a transfer carrier to be clamped in a horizontal plane with an upward facing stacking opening.

The invention further relates to a handling system for loading a process boat comprising a plurality of insertion positions with wafer batches, in particular solar wafers, before the doping in a diffusion oven.

A handling system for loading and unloading of a process installation with at least one carrier loadable and unloadable with at least one flat substrate for a vertical transport of the substrate, and a method for operating this handling system are principally known from e.g. DE 10 2004 039 787. According to this a first and a second handling module are provided, whereby at least one substrate handling unit is associated with at least one of the handling modules for a substrate transfer separate from the carrier. The carrier is transferable with the vertically aligned substrate between the process installation and the first handling module, the process installation and the second handling module and between both of the handling modules, and the substrate handling unit is designed as a multi-axis robot, preferably with one or more vacuum grippers.

In connection with the manufacturing of electronic microcircuits or circuit elements from DE 30 51 199 C2 is also known a feeding mechanism for a device for loading dies into a treatment chamber, whereby the dies are provided in cassettes. Hereby a device for lifting and lowering of respectively one of a number of dies arranged standing in the cassette and aligned to each other, relative to the cassette, is provided below the feeding device, whereby an approximately vertically moveable slide that moves through the feeding device and the cassette picks up one die respectively from underneath. Such an individual handling is time consuming, complicated and increases the risk of damage of the dies by increasingly occurring abrasion and thereby causing dust problems.

For the increase of the efficiency of the production processes of solar cells the automation and acceleration of solar wafer handling, specifically the load and unload process of the process boat by which the solar wafers have to be delivered in and out of the diffusion oven, respectively, is an important factor. The diffusion process requires only the diffusion of one side of the wafer. The solar wafers are fed to the diffusion oven in a process boat typically provided with 200 slots inclined by 3° to the vertical. Such an incline effects a pre-alignment of the solar wafers so that they rest against the flanks of the process boat.

It is object of the invention to provide a method and a handling system of the aforementioned type, with which a higher packaging density in the process boat and an increase of the through-put of the diffusion process and a simultaneous reduction of the scrap rate can be obtained.

This object is procedurally solved according to the invention in that one half of the number of the wafers provided serially in the transfer carrier is transferred out of the transfer carrier in the form of a first wafer stack in a mounted standby position located outside of the transfer carrier, that then the other half of the number of wafers serially provided in the transfer carrier is being moved out of the transfer carrier in the form of a second wafer stack and the second wafer stack is being swivelled in a manner that the wafers of the second wafer stack reach a position swivelled by 180° in relation to the position of the wafers of the first wafer stack in its standby position, and that subsequently the second wafer stack is transferred to the standby position of the first wafer stack, is aligned to it and is then joined together as form fitting with the first wafer stack to a form a package-like Back-To-Back wafer batch (BTB wafer batch) by respectively abutting against each other simultaneously and congruently the sides not to be doped of the wafers of the first and the second wafer stack associated to each other, whereupon the BTB wafer batch is picked up as form fitting by a transfer gripper and loaded into the process boat.

Preferably one half of the number of the wafers provided serially in the transfer carrier is lifted by a first lifting comb, which is to be positioned beneath the transfer carrier and to be moved along a first vertical axis and the comb gaps thereof being aligned exactly with the centres of the first half of wafers, as first wafer stack in a first lifting position in which the first wafer stack is picked up by a multi-vacuum gripper which is to be moved in a horizontal direction, swivelled by 180° relative

to its position in the first lifting position and positioned in this swivelled position in a second lifting position associated to a second vertical axis, in which subsequently the other half of the number of wafers serially provided in the transfer carrier is lifted by a second lifting comb, which is to be positioned beneath the transfer carrier and to be moved along the second vertical axis and the comb gaps thereof being aligned exactly with the centres of the second half of the number of wafers, as second wafer stack in a manner that the wafers of the second wafer stack along a servo-controlled movement path are respectively moved past the associated wafers of the first wafer stack positioned swivelled by 180° in the second lifting position until a form fitting congruence and then abutted against them, rear side to rear side, while forming a packet-like Back-To-Back wafer batch (BTB wafer batch), which thereafter is removed form fitting by the transfer gripper out of the second lifting comb and loaded into the process boat.

Advantageously also the first half of the number of the wafers provided serially in the transfer carrier in the form of the first wafer stack may be removed out of the transfer carrier by a multi-vacuum gripper, transferred servo-controlled to a insertion position of the process boat and inserted in the reception slots thereof in the insertion position, whereupon the second half of the number of the wafers serially provided in the transfer carrier is removed by the multi-vacuum gripper out of the transfer carrier in the form of the second wafer stack, swivelled by 180° relative to the position of the first wafer stack in the process boat and positioned offset above in alignment to the wafers located in the insertion position of the

process boat by a distance to this insertion position, which is at least as big as the wafer thickness, whereupon the multi-vacuum gripper inserts the second wafer stack which is swivelled by 180° in the first wafer stack located in the insertion position of the process boat, whereby the wafers of the first and the second wafer stack associated to each other are abutted congruently against each other with the sides not to be doped while forming the package-like BTB wafer batch.

All insertion positions each with 50 reception slots of the process boat are to be loaded successively in the same way, so that through the Back-To-Back principle according to the invention with 400 solar wafers double of the capacity in a current process boat with 200 reception slots typically inclined by 3° to the vertical is to be achieved.

By reception of respectively two wafers of the BTB wafer batch abutted rear side to rear side (Back-To-Back) in a slot of the process boat, the package density therein and hence also the throughput of the diffusion oven is to be doubled.

The object of the invention is achieved according to the invention through the handling system for loading a process boat having a plurality of insertion positions with wafer batches, in particular with solar wafer batches before the doping in a diffusion oven, whereby the handling system is provided
with an automatic transfer unit by which a carrier loaded with a predetermined even number of wafers is to be moved in a horizontal transport plane in a standby position for formation of wafer stacks,

with a clamping module by which the carrier is to be clamped with an upward-facing stacking opening in the standby position in a manner that the centres of the wafers located in the reception slots of the carrier are aligned exactly with the comb gaps of lifting combs moveable in vertical direction of a first and a second vertical-drive module, which respectively are arranged fixed beneath the clamping module in the standby station,

whereby by the lifting comb of the first vertical-drive module the first half of the number of wafers in the carrier held by the clamping module is to be moved upward as the first wafer stack in a first lifting position and is there to be aligned at the lateral edges and with an exact distance of the wafers to each other by a centring module,

with a Back-To-Back module (BTB module) having a multi-vacuum gripper with vacuum-gripping combs and movable in X-Y-Z- and R-direction arranged above the clamping module, the vertical oriented axis of which is to be put in rotation by a servo motor via a downstream play-free gear,

whereby the first wafer stack lifted by the lifting comb of the first vertical-drive module out of the carrier into the first lifting position is to be picked up by the multi-vacuum gripper, to be swivelled by 180° and without any relative movement in relation to the first lifting comb of the first vertical-drive module to be deposited therein again in the position swivelled by 180° in the first lifting position,

whereby subsequently the second half of the number of the wafers located in the reception slots of the carrier is to be lifted by the lifting comb of the second vertical-drive module as the second wafer stack in a second lifting position and is to be aligned therein by the centring module at the lateral edges and with an exact distance of

the wafers to each other, the second wafer stack is to be picked up in the second lifting position by the multi-vacuum gripper of the Back-To-Back module (BTB module) and to be moved without rotation into the first lifting position above the first wafer stack, in which the first wafer stack is to be moved up and is to be inserted in the second wafer stack, with the wafers of the first wafer stack to be moved along a servo-controlled movement path past the associated wafers of the second wafer stack already arranged in the first lifting position and to be abutted back-to-back in the lifting comb while forming a package-like BTB wafer batch with a doubled doping surface, and

with a transfer gripper by which after turning off and relieving of the multi-vacuum gripper the formed BTB wafer batch is to be moved from the standby station to the process boat and is to be deposited at an insertion position of the process boat.

Through the rotary drive of the vertical axis of the BTB module by means of the servo motor via the downstream play-free gear the first wafer stack to be sucked by the multi-vacuum gripper is to be put in rotation with precisely defined start and breaking ramps, whereby jerky swivelling movements are avoided and the scrap rate is reduced. The control of the swivelling movement via a servo motor enables a precise, smooth and hence a stress-free approaching of the desired position for the wafer. The hereby improved possibility of a positioning guarantees a very precise lifting and re-insertion of a wafer stack in a comb, whereby relative movements between wafer and comb are avoided.

The multi-vacuum gripper of the BTB module advantageously comprises an upper part connected to the vertical axis thereof and a bottom part supporting vacuum-gripping combs, whereby the upper part and the bottom part are connected via two ball screw guide elements and are kept by them precisely aligned during a movement and two inductive sensors are provided at the upper part of the multi-vacuum gripper by which upon lowering of the multi-vacuum gripper an abutting of the bottom side of the vacuum-gripping combs upon the upper front faces of the wafers located in the lifting comb is to be detected and a further lowering of the multi-vacuum gripper is to be blocked with minimal delay. By means of the improved reaction time there is only a minor force effect on the solar wafers in case of the abutting.

Preferably there are 100 solar wafers to provide in the carrier, which are to be fed by the lifting comb of the first and the second vertical-drive module in the form of the first and the second wafer stack, respectively, each with 50 wafers, to the BTB module, by which the first and the second wafer stack are to be joined together to a package-like BTB wafer batch with 100 wafers abutted back-to-back, whereby in the process boat consisting of silica preferably 4 loading compartments are provided, in each of which one package-like BTB wafer batch is to be deposited by the transfer gripper.

Preferably the comb walls of the vacuum gripping comb of the multi-vacuum gripper, which define the reception slots of each vacuum gripping comb and engage with the side surfaces of the wafers, are each shaped in the form of a frame-like bezel having fins parallel and horizontal

extending to each other, with respectively one vacuum slot formed therebetween oriented at an angle to the comb wall, whereby the supporting surface of each comb wall engaging with one of the side surfaces of the associated wafer is formed by the outer surface of the frame-like bezel of the fins and the front edges of the fins which lie in the vertical plane, in which the outer surface of the frame-like bezel lies, whereby the contact pressure per unit area of the wafer is minimized.

The invention provides an increase of throughput capacity during the doping process in the diffusion ovens without the need to change their size or design, and a considerable reduction of the total processing time. Furthermore the transport, handling and positioning operations are specified more precisely, which results in a reduction of the damage and/or fracture rate and a decrease of the doping failure rate. A retrofitting of the handling systems according to the invention in conventional installations for loading and unloading of process boats with wafers is readily possible.

The invention is now described by means of the drawings, in which:

Fig. 1 is a perspective view of a provided carrier filled with 2 x 50 wafers above which a fiftyfold vacuum gripper of a BTB module is arranged, and with a laterally arranged side centring,

Fig. 2 is perspective view corresponding to Fig. 1 but with a lifted first wafer stack with 50 wafers,

Fig. 3 is a perspective view corresponding to Fig. 2 but with two laterally arranged side centrings,

Fig. 4 is a perspective view corresponding to Fig. 3 but with the first wafer stack picked up by the vacuum gripper of the BTB module with relieved lifting comb,

Fig. 5 is a perspective view corresponding to Fig. 4 but in process to swivel the first wafer stack by means of the BTB module,

Fig. 6 is a perspective view corresponding to Fig. 4 but after swivelling of the first wafer stack by means of the BTB module by 180° relative to the position of the second wafer stack in the carrier and in standby position of the first wafer stack above the second wafer stack located in the carrier,

Fig. 7 is a perspective view corresponding to Fig. 5 but after lifting of the second wafer stack out of the carrier and joining together with the first wafer stack provided in the lifted position while forming a package-like BTB wafer batch,

Fig. 8 is a perspective illustration of a transfer gripper during pick-up of the package-like BTB wafer batch in the position seen in Fig. 7,

Fig. 9 is a perspective illustration of the transfer gripper above an insertion position of the process boat in which the BTB wafer batch after transfer by the transfer gripper is deposited by the same, and of the emptied carrier with lifting combs arranged beneath the same,

Fig. 10 is a perspective illustration of the BTB module with a multi-vacuum gripper, which is to be put in rotation around its vertical axis by means of a servo motor via a downstream play-free gear,

Fig. 11 is a schematic sectional view of the multi-vacuum gripper of the BTB-module, and

Fig. 12 is a perspective partial sectional view of the vacuum gripping combs of the multi-vacuum gripper in two different embodiments.

As can be taken from Fig. 1 preferably a carrier 2 filled with 2 x 50 solar wafers 1 is aligned and clamped in a clamping module 3 in a manner that the stacking opening 4 thereof is facing upward. Beneath the carrier 2 in vertical direction two moveable lifting combs 5a and 5b are arranged, while above the carrier 2 a fiftyfold vacuum gripper 6 of a Back-To-Back module (BTB module) 7 is arranged, as illustrated separately in figure 10. Two linear moveable centring combs 8 are also positioned above the carrier 2 on the left (Fig. 1) and on the right (Fig. 2) as side centring.

At first, by the right lifting comb 5a in Fig. 2, the comb gaps of which are aligned exactly with the centres of a first half of a number of the wafers 1 provided in carrier 2, fifty of wafers 1 provided in carrier 2 are transferred as first wafer stack 9 in a lifting position, are centred there laterally by the centring combs 8 and subsequently picked up by the fiftyfold vacuum gripping comb 10 of the

vacuum gripper 6 movable in X-Y-Z and R-direction of the BTB module 7, as seen in Fig. 4.

As follows from Fig. 10, the vacuum gripper 6 with vacuum gripping comb 10 of the BTB-module 7 is to be put in rotation around its vertical axis by a servo motor 11 via a downstream play-free gear 12.

According to Fig. 5 therefore the first wafer stack 9 picked up by the 50-fold vacuum-gripping comb 10 of the vacuum gripper 6 is swivelled by rotation of the vacuum gripper 6 by 180° and by this very angle relative to its initial position in carrier 2 and transferred by moving the vacuum gripper 6 in horizontal direction into a standby position above the second half of the 100 wafers 1 still remaining and provided in carrier 2 (Fig. 6).

After that second half of the number of the provided 100 wafers 1 remaining in carrier 2 is lifted as second wafer stack 13 by the second lifting comb 5b, the comb gaps of which are aligned exactly with the centres of the wafers 1 which remained in carrier 2, and moved to the second lifting position, which corresponds to the standby position of the first wafer stack 9. Thereby the wafers 1 of the second wafer stack 13 are moved along a servo-controlled movement path past the associated wafers 1 of the first wafer stack 9 positioned swivelled by 180° in the standby position respectively until form fitting congruence and then abutted against them while forming a package-like Back-To-Back wafer batch (BTB wafer batch) 14, as shown in Fig. 7. The BTB wafer batch 14 formed in such a manner is picked up as form fitting by a transfer gripper 15 from the standby position, transferred to a process boat 16 with

four insertion positions 17 and inserted in one of the insertion positions 17 (Fig. 9).

The process boat 16 is therefore altogether to be loaded with 400 solar wafers for a diffusion process in a diffusion oven.

As can be seen from the detailed sectional view of the vacuum gripper 6 of the BTB module 7 according to Fig. 11, the vacuum gripper 6 comprises an upper part 18 connected with its vertical axis and a bottom part 19 receiving the vacuum gripping comb 10, whereby upper part 18 and bottom part 19 are connected via two ball bearing guide elements 20 and kept precisely aligned by them during a movement. On the upper part 18 there are further provided two sensors 21 by which upon lowering of the vacuum gripper 6 an abutting of the bottom side 22 (Fig. 10) of the vacuum-gripping comb 10 upon the upper front face of the wafers 1 located in the lifting combs 5a, 5b is detected. The employment of the smooth running ball bearing guide elements 20 improves the reaction time considerably, so that in case of an abutting there is a lower force effect on the wafers 1.

From Fig. 12 are following finally two possible embodiments of the vacuum comb geometry, in which the comb walls 23 of the vacuum gripping combs 10 of the multi-vacuum gripper 6 of the BTB module 7, which define the reception slots 24 of each vacuum gripping comb 10 and engage with the side surfaces 25 of wafers 1 respectively have a frame-like bezel 26. In the front embodiment of Fig. 12 the frame-like bezel 26 is advantageously designed with fins 27 which extend parallel and horizontal to each other, between which respectively a vacuum slot 28 oriented at an angle to the

comb wall 23 is formed. Hereby thus the supporting surface of each comb wall 23 engaging with one of the side surfaces 25 of the associated wafer 1 is formed by the outer surface 29 of the frame-like bezel 26 of the fins 27 and the front edges 30 of the fins 27 which lie in the vertical plane in which the outer surface 29 of the frame-like bezel 26 lies. Hereby the contact pressure per unit area of each wafer 1 is minimized which results in a considerable decrease of the damage and fracture rate.

LIST OF REFERENCE NUMBERS

1	Wafer, solar wafer
2	Transfer carrier, carrier
3	Clamping module
4	Stacking opening
5a, 5b	Lifting combs
6	Vacuum gripper, multi-vacuum-gripper
7	Back-To-Back module, BTB module
8	Centring combs
9	First wafer stack
10	Vacuum gripping combs
11	Servo motor
12	Play-free gear
13	Second wafer stack
14	Back-To-Back wafer batch, BTB wafer batch
15	Transfer gripper
16	Process boat
17	Insertion position
18	Upper part of vacuum gripper
19	Bottom part of vacuum gripper
20	Ball bearing guide elements
21	Inductive sensors
22	Bottom side of vacuum-gripping combs
23	Comb walls
24	Reception slots of vacuum-gripping combs
25	Side surfaces of wafers
26	Frame-like bezel
27	Fins
28	Vacuum slots
29	Outer surface of frame-like bezel
30	Front edges of fins

PATENT CLAIMS

AMENDED UNDER ART. 19 PCT

1. A method for forming a package-like Back-to-Back wafer batch (BTB wafer batch) (14) to be positioned in a process boat (16), the Back-to-Back wafer batch consisting of a predetermined even number of serially arranged wafers (1), such as solar wafers, to be doped one-sided, and each side (25) which is not to be doped is abutting congruently against the side (25) not to be doped of the respective adjacent wafer (1), whereby first one half of the predetermined number of the wafers (1) to be doped one-sided is transferred in the form of a first wafer stack (9) into a mounted standby position, subsequently the other half of the predetermined number of the wafers (1) to be doped one-sided in the form of a second wafer stack (13), each wafer (1) of which is offset by 180° with respect to the position of the wafers (1) of the first wafer stack (9) in its standby position, is transferred thereto, is aligned to the first wafer stack (9), and then joined together with the same to form a form fitting, package-like Back-to-Back wafer batch (BTB wafer batch) (14) by respectively abutting against each other, simultaneously and congruently, the sides not to be doped of the wafers (1) of the first and the second wafer stack (9 and 13, respectively) associated to each other, whereupon the BTB wafer batch (14) is picked up as form fitting by a transfer gripper (15) and loaded into the process boat (16), characterized in that the first half as well as the second half of the predetermined even number of wafers (1) for the BTB wafer batch (14) to be formed are serially provided in the reception slots of only one transport carrier (2), which is clamped in a horizontal plane with upward facing stacking openings (4), and are moved out of this only one transport carrier (2) one

after the other in the form of the first wafer stack (9) or the second wafer stack (13), respectively, whereby the second wafer stack (13) lifted out of the transport carrier (2) is picked up by a multi-vacuum gripper (6) to be moved in horizontal direction and is swivelled by the rotation of the same by 180° before the transfer into the standby position of the first wafer stack (9), such that the wafers (1) of the second wafer stack (13) reach the position which is offset by 180° with respect to the position of the wafers (1) of the first wafer stack (9) in its standby position.

2. The method for forming a package-like Back-to-Back wafer batch (BTB wafer batch) (14) to be positioned in a process boat (16), the Back-to-Back wafer batch consisting of a predetermined even number of serially arranged wafers (1), such as solar wafers, to be doped one-sided, and each side (25) which is not to be doped is abutting congruently against the side (25) not to be doped of the respective adjacent wafer (1), whereby first one half of the predetermined number of the wafers (1) to be doped one-sided is transferred in the form of a first wafer stack (9) into a mounted standby position, subsequently the other half of the predetermined number of the wafers (1) to be doped one-sided in the form of a second wafer stack (13), each wafer (1) of which is offset by 180° with respect to the position of the wafers (1) of the first wafer stack (9) in its standby position, is transferred thereto, is aligned to the first wafer stack (9), and then joined together with the same to form a form fitting, package-like Back-to-Back wafer batch (BTB wafer batch) (14) by respectively abutting against each other, simultaneously and congruently, the sides not to be doped of the wafers (1) of the first and the second wafer stack (9 and 13, respectively) associated

to each other, whereupon the BTB wafer batch (14) is picked up as form fitting by a transfer gripper (15) and loaded into the process boat (16), characterized in that the first half as well as the second half of the predetermined even number of wafers (1) for the BTB wafer batch (14) to be formed are serially provided in the reception slots of only one transfer carrier (2) to be clamped in a horizontal plane with upward facing stacking openings (4), that the first half of the number of the wafers (1)provided serially in the transfer carrier (2) is lifted by a first lifting comb (5a), which is to be positioned beneath the transfer carrier (2) and to be moved along a first vertical axis, and the comb gaps thereof being aligned exactly with the centres of the first half of wafers (1), as first wafer stack (9) in a first lifting position in which the first wafer stack (9) is picked up by a multi-vacuum-gripper (6) which is to be moved in a horizontal direction, swivelled by the same by 180° relative to its position in the first lifting position, and positioned in this swivelled position in a second lifting position associated to a second vertical axis and representing the standby position of the first wafer (1), in which subsequently the other half of the number of wafers serially provided in the transfer carrier is to be aligned by a first lifting comb (5a) with an exact distance of the wafers (1) to each other in the first wafer stack (9), and is to be deposited with a transfer gripper (15), by which the formed BTB wafer batch (7) is to be moved from the standby position to the process boat (16) at one of the insertion positions (17) of the process boat (16).

3. A method for forming a package-like Back-to-Back wafer batch (BTB wafer batch) (14) which is positioned in a process boat (16) by means of a transfer gripper (15) and which consists of a predetermined even number of

serially arranged wafers (1), such as solar wafers, to be doped one-sided, and each side (25) which is not to be doped is abutting congruently against the side (25) not to be doped of the respective adjacent wafer (1), whereby first one half of the predetermined number of the wafers (1) to be doped one-sided is transferred in the form of a first wafer stack (9) into a mounted standby position, subsequently the other half of the predetermined number of the wafers (1) to be doped one-sided in the form of a second wafer stack (13), each wafer (1) of which is offset by 180° with respect to the position of the wafers (1) of the first wafer stack (9) in its standby position, is transferred thereto, is aligned to the first wafer stack (9), and is then joined together with the same to form a form fitting, package-like Back-to-Back wafer batch (BTB wafer batch) (14) by respectively abutting against each other, simultaneously and congruently, each of the sides not to be doped of the wafers (1) of the first and the second wafer stack (9 and 13, respectively) associated to each other, characterized in that the first half as well as the second half of the predetermined even number of wafers (1) for the BTB wafer batch (14) to be formed are serially provided in the reception slots of a transfer carrier (2) to be clamped in a horizontal plane with upward facing stacking openings (4), that one half of the number of the wafers (1) provided serially in the transfer carrier (2) is removed in the form of a first wafer stack (9) out of the transfer carrier (2) by the transfer gripper (15) in the form of a multi-vacuum gripper, transferred servo-controlled to an insertion position, representing the standby position of the first wafer stack (9), of the process boat (16) and inserted in the reception slots thereof in the insertion position, that subsequently the other half of the number of wafers (1) provided serially in the

transfer carrier (2) is removed in the form of a second wafer stack (13) out of the transport carrier (2) by the multi-vacuum gripper (6), swivelled by rotation of the multi-vacuum gripper (6) by 180° into the position offset by exactly this angle with respect to the position of the first wafer stack (9) in its standby position, and, by moving the multi-vacuum gripper (6) in horizontal direction above and in alignment to the wafers (1) located in the insertion position of the first wafer stack (9) in the process boat (16), is positioned offset to the insertion position by a distance, which is at least as big as the wafer thickness, whereupon the second wafer stack (13) swivelled by 180° is inserted by the multi-vacuum gripper (15) into the first wafer stack located in the insertion position of the process boat, wherein the wafers (1) associated to one another of the first and the second wafer stack (9 and 13, respectively) are abutted congruently back-to-back forming a package-like BTB wafer batch (14) with a doubled doping surface.

4. A handling system for loading a process boat (16) having a plurality of insertion positions (17) with wafer batches (14) before the doping in a diffusion oven, with an automatic transfer unit by which a carrier (2) loaded with a predetermined even number of wafers (1) is to be moved in a horizontal transport plane in a standby position for formation of wafer stacks, with a clamping module (3) by which the carrier (2) is to be clamped with an upward facing stacking opening in the standby position in such a manner that the centres of the wafers (1) located in the reception slots of the carrier (2) are aligned exactly with the comb gaps of in-vertical-direction moveable lifting combs (5a; 5b) of a first and a second vertical-drive module, each of them arranged

fixed beneath the clamping module (3) in the standby position, whereby by the lifting comb of the first vertical-drive module, the first half of the number of wafers (1) in the carrier (2) held by the clamping module (3) is to be moved upward as the first wafer stack (9) in a first lifting position and is therein to be aligned at the lateral edges and with an exact distance of the wafers (1) in the wafer stack (9) to each other by a centring module (8), and with a transfer gripper (15), by which the formed BTB wafer batch (7) is to be moved from the standby station to the process boat (16) and to be deposited at one of the insertion positions (17) of the process boat (16), characterized in that

a Back-To-Back-module (BTB-module) (7) is provided having a multi-vacuum-gripper (6) which is arranged above the clamping module (3), and which has vacuum gripping combs (10) and is movable in X-Y-Z- and R-direction, the vertical oriented axis of which is to be put in rotation by a servo motor (11) via a downstream play-free gear (12), whereby the first wafer stack (9) lifted by the lifting comb (5a) of the first vertical-drive module out of the carrier (2) into the first lifting position is to be picked up by the multi-vacuum-gripper (6) controlled by means of inductive proximity switches, to be swivelled by 180° and without any relative movement in relation to the first lifting comb (5a) of the first vertical-drive module to be deposited therein again in the position swivelled by 180° in the first lifting position, whereby subsequently the second half of the number of the wafers (1) located in the reception slots of the carrier (2) is to be lifted by the lifting comb (5b) of the second vertical-drive module as the second wafer stack (13) in a second lifting position and is to be aligned therein by the centring module (8) at

the lateral edges and with an exact distance of the wafers (1) to each other, the second wafer stack (13) is to be picked up in the second lifting position by the multi-vacuum-gripper (6) of the Back-To-Back-module (BTB-module) (7) and is to be moved without rotation into the first lifting position which is above the first wafer stack (9), and in which the first wafer stack (9) is to be moved up and is to be inserted in the second wafer stack (13), whereby the wafers (1) of the first wafer stack (9) are to be moved along a servo-controlled movement path past the associated wafers (1) of the second wafer stack (13) already arranged in the first lifting position and are to be abutted back-to-back in the lifting comb while forming a package-like BTB wafer batch (14) with a doubled doping surface.

5. Handling system according to claim 4, **characterized in that** the multi-vacuum-gripper (6) of the BTB-module (7) comprises an upper part (18) connected to the vertical axis thereof and a bottom part (19) supporting vacuum gripping combs (10), that the upper part (18) and the bottom part (19) are connected via two ball screw guide elements (20) and are kept by them precisely aligned during a movement and that two inductive sensors (21) are provided at the upper part (18) of the multi-vacuum-gripper (6) by which upon lowering of the multi-vacuum-gripper (6) an abutting of the bottom side (22) of the vacuum gripping combs (10) upon the upper front faces of the wafers (1) located in the carrier (2) is to be detected and a further lowering of the multi-vacuum-gripper (6) is to be blocked with minimal delay.

6. Handling system according to claim 4 and claim 5, **characterized in that** the carrier (2) comprises 100 reception slots in which 100 solar wafers (1) are to be provided, which are to be fed by the lifting comb (5a; 5b) of the first and the second vertical-drive module in the form of the first and the second wafer stack, respectively (9 and 13, respectively), each with 50 wafers (1), to the Back-To-Back-module (7), by which the first and the second wafer stack (9 and 13, respectively) are to be joint to the BTB-wafer-batch (14) with 100 wafers (1) abutted back-to-back,
and that in process boat (16) 4 insertion positions (17) are provided, in each of which one package-like BTB-wafer-batch (14) with 100 BTB-wafers (1) is to be deposited by the transfer gripper (15).

7. Handling system according to any one of the claims 4 to 6, **characterized in that** the comb walls (23) of the vacuum gripping comb (10) of the multi-vacuum-gripper (6), which define the reception slots (24) of the vacuum gripping comb (10) and engage with the side surfaces (25) of the wafers (1), are each shaped in the form of a frame-like bezel (26) having fins (27) parallel and horizontal extending to each other, with respectively one vacuum slot (28) formed therebetween oriented at an angle to the comb wall (23), and that the supporting surface (29) of each comb wall (23) engaging with one of the side surfaces (25) of the associated wafer (1) is formed by the outer surface (29) of the frame-like bezel (26) of the fins (27) and the front edges (30) of the fins (27) which lie in the vertical plane, in which the outer surface (29) of the

frame-like bezel (26) lies, whereby the contact pressure per unit area of the wafer (1) is minimized.