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System for manipulating singulated integrated circuit elements

Related applications

5 The present application is one of a group of four applications sharing a priority date and entitled respectively "Supply mechanism for the chuck of an integrated circuit dicing device", "System for manipulating singulated integrated circuit elements", "Net block assembly for an integrated circuit dicing system", and "Quality control system for integrated circuit dicing system".

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Field of the invention

15 The present invention relates to a sawing and sorting system. The system interacts with, or includes, a dicing machine which saws ("dices") a substrate with many integrated circuits formed onto it to form individual integrated circuits. The invention further relates to apparatus for use in such a sawing and sorting system.

Background of Invention

20 Conventionally a plurality of integrated circuits are formed simultaneously on a semiconductor substrate, and the substrate is then diced to form individual integrated circuits. Apparatus is known for feeding substrates into such a dicing machine, and for sorting the diced integrated circuits.

25 One type of integrated circuit which is becoming increasingly popular is one having an array of multiple electrical contacts (typically solder balls, known as a ball grid array packages, and pads in non-leaded packages, known as a Quad Flatpack Non-Leaded (QFN) packages) in an array on one of its major faces. The dicing of a substrate having a ball grid array on one of its surfaces is typically performed with the surface of the substrate carrying the balls

- facing upwards. It is known to perform a limited number of sorting operations on the singulated integrated circuit units to detect abnormal (faulty) units. This is performed using cameras under which the singulated units pass. The level of sophistication of such techniques is presently limited. In particular, it tends to be performed on the basis of a batch of units produced from the same substrate, and that batch of units is rejected as a whole if a fault is identified (e.g. because it is discovered that the alignment of the substrate with the lines cut by the dicing machine is not sufficiently accurate).
- 10 During this process, the units are handled by devices which touch the integrated circuits at the edges of their upper surfaces, at the margins which are outward of the area of the upper surfaces covered by the ball grid array. Contacting the circuits there reduces the risk of damage being done to the array of balls. However, this handling operation is a difficult one, and is becoming increasingly more difficult as the size of the integrated circuits falls and the margin around the ball grid array shrinks.

Summary of the invention

- 20 The present invention aims to provide a new and useful system for manipulating the integrated circuits singulated by a dicing machine.

- It further aims to provide a new and useful dicing system including a dicing machine and a mechanism for manipulating integrated circuits singulated by the dicing machine.

- In general terms, the invention proposes that in a dicing system in which a dicing machine singulates integrated circuits placed upon a chuck and having electrical contacts which face away generally upwardly from the chuck, a

mechanism should be provided for flipping the singulated integrated circuits so that the electrical contacts face generally downwards.

- 5 An advantage of this is that when the singulated units are subsequently supported, by suction from above, their electrical contacts are on the opposite face. Thus, even if the electrical contacts are close to the edges of the integrated circuit (as in modern units they increasingly are) they will not interfere with the support operation, nor be damaged by it.
- 10 As described below, this concept is particularly useful in a system in which the integrated circuits are subject to a quality check which individually sorts integrated circuits, because it means that the speed of picking up individual integrated circuits can be much higher. If the contact (e.g. balls) are facing upward then the sorting speak (with picking up and placing by individual
- 15 pickers) is obstructed by the high density of the ball-count in modern BGA packages. However, if the integrated circuits are flipped to face down, and then the integrated circuits are picked up from the flat moulding area, the picking up and placing does not take so long, and in particular may stop being the process which limits the overall speed of the system.
- 20 Thus, the present invention is particularly useful in, and facilitates, a system which has a higher through-put of integrated circuits than conventional systems. Such a system is described in detail below, in which singulated units are obtained from a sawing process which is has a progression much faster
- 25 than conventional systems. Once the integrated circuits are turned by the flipper so that the balls (or other contacts) face downward, these units can be continuously transferred at high speed. Pls. consider our concept, two chuck base, which means that singulated units came out of the sawing progression is much higher than the existing systems in the market.

The inversion of the singulated units may be performed by depositing the units onto an upwardly-facing inversion surface of a unit (a "flipper block") which is arranged to rotate about an axis (generally a horizontal axis) so that the inversion surface faces downwardly.

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Note that this is usually much more convenient than the alternative possibility of placing the singulated units onto a surface of the flipper unit which faces down (e.g. retaining the singulated units by suction), and inverting them by turning the flipper unit so that this surface faces upwards. The reason for this is that in this case the integrated circuits would contact the flipper unit on their surface which carries the electrical contacts (since these contacts face upwards when the integrated circuits exit the sawing process), and gaps between the balls and the surface of the flipper would tend to break the suction. (Note that this related to the reason that the balls face upwards when they exit the sawing process: the substrates are held on the chuck table by suction, and if the balls faced downwards this suction would be unreliable, making the whole substrate unstable and leading to some offset cut.)

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The flipper block includes a mechanism for retaining the singulated units on the inversion surface during this operation. This mechanism may include a plurality of apertures arranged on the flipper block with at least one of the apertures in register with each of the integrated units. The apertures can be connected to a vacuum source, so apply a suction to retain the singulated units against the inversion surface. The connection to the vacuum surface may be via a conduit extending through the axial section of the flipper block.

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Following the inversion operation, the singulated units are preferably transferred from the flipper block to another member, here referred to as an idle block. The idle block may initially be located beneath the flipper member and includes an upwardly facing surface. The upwardly facing surface of the

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idle block moves vertically upwards relative to the flipper member until the singulated units are proximate to or in contact with it. The singulated units are then transferred from the flipper member to the idle block. This may be by disconnecting the apertures in the flipper member from the vacuum source.

- 5 Optionally, apertures in the idle block in register with the singulated units may be put into communication with a vacuum source, to retain the units on the idle block.

- 10 The idle block is then moved away from the flipper block. This may initially include moving it downwardly relative to the flipper block. The idle block preferably also moves laterally from beneath the flipper block.

- 15 Once removed from beneath the flipper block, the idle block may be moved vertically so that its surface carrying the singulated units is at approximately the same height as the surface of the flipper block at the time that the singulated units were deposited onto it. This facilitates use of the same lifting assembly to move the singulated units onto the flipper block and off the idle block, since conventional lifting assemblies for moving singulated units between processing units generally permit a greater range of movement in a horizontal direction than in the vertical direction.
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- 25 The flipper block may optionally include inversion surfaces on two oppositely facing sides which are both suitable for receiving singulated units. This means that when one inversion surface (currently carrying singulated units) is moved from facing upwardly to facing downwardly, the opposite one of the two inversion faces would move from facing downwardly to facing upwardly. Thus, the flipper unit would be ready to receive a further batch of singulated units even without returning to its previous configuration.

A control system is provided for controlling and co-ordinating the motion of the flipper unit and idle block, and also apparatuses which move singulated units to the flipper unit, and remove singulated units from the idle block.

5 Brief Description of The Figures

Preferred features of the invention will now be described, for the sake of illustration only, with reference to the following figures in which:

Fig. 1(a) is a top view of an integrated circuit sawing and sorting system which is an embodiment of the invention;

10 Fig. 1(b) is a side view of a part of the embodiment of Fig. 1 looking in the direction Y shown in Fig. 1;

Fig. 2, which is composed of Figs. 2(a) to 2(c), shows a loader assembly of the embodiment of Fig. 1;

15 Fig. 3 which is composed of Figs. 3(a) to 3(c), shows a inlet rail assembly of the embodiment of Fig. 1;

Fig. 4, which is composed of Figs. 4(a) and 4(b), shows a section of the embodiment of Fig. 1 including a twin chuck table;

Fig. 5 is a first view of a cleaner unit of the embodiment of Fig. 1;

Fig. 6 is a second view of the cleaner unit of the embodiment of Fig. 1;

20 Fig. 7, which is composed of Figs. 7(a) to 7(c), shows a heating block assembly of the embodiment of Fig. 1;

Fig. 8, which is composed of Figs. 8(a) to 8(c), shows a flipper unit of the embodiment of Fig. 1;

25 Fig. 9, which is composed of Figs. 9(a) to 9(c), shows an idle unit assembly of the embodiment of Fig. 1;

Fig. 10, which is composed of Figs. 10(a) to 10(i), shows a net block assembly of the embodiment of Fig. 1;

Fig. 11, which is composed of Figs. 11(a) to 11(c), shows a lifter assembly of the embodiment of Fig. 1;

Fig. 12, which is composed of Figs. 12(a) to 12(c), shows a tray lifter assembly of the embodiment of Fig. 1;

Fig. 13 is a top view of the tray lifter assembly of Fig. 12, and a normal tray stacking assembly, an abnormal tray stacking assembly and a vacant tray
5 stacking assembly;

Fig. 14, which is composed of Figs. 14(a) and 14(b), shows the normal tray stacking assembly and abnormal tray stacking assembly of Fig. 13; and

Fig. 15 shows the vacant tray stacking assembly of Fig. 13.

10 Detailed Description of the embodiments

Figs. 1(a) shows the overall construction of an integrated circuit sawing and sorting system which is an embodiment of the invention. In Fig. 1(a) the system is viewed from above. It is composed of two sections, a dicing section
15 and a sorting section. Two horizontal directions are marked X and Y.

The sawing and sorting system is for sawing and sorting substrates which include a plurality of integrated circuits. The system is particularly suitable for integrated circuits each of which is provided with an array of contacts on a
20 side of the substrate which is initially facing upwards (however the system may be modified for other sorts of integrated circuits, as described below). The substrates are inserted into the system from cassettes using a loader assembly 1. From the loader assembly 1 the substrates are carried to an inlet rail assembly 2. At this stage the substrates are examined using a first
25 camera 3, mainly to check that the substrates are of a type suitable for use in the sawing and sorting system.

As described in detail below, the substrates pass to a twin chuck table 4, from which they are carried into a dicing machine indicated generally as Z. This

dicing machine Z can be formed according to known designs, and so will not be described here in detail.

5 The diced substrates pass via a brush unit 5 where the singulated units are brushed, and a cleaner unit 6, to a heating block assembly 7. From there, the units pass to a flipper unit 8, where, as described in detail below, the units are turned over so that each ball grid array faces downwards. The singulated units are then received by an idle unit assembly 9, including a second camera. Subsequently, the singulated units pass to a net block assembly 10.

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Fig. 1(b) shows the portions 2 to 10 of this system from the direction marked A in Fig. 1(a). A frame lifter assembly indicated having portions Ay and Ax is shown in two different positions which it successively adopts during the use of the system.

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The singulated units are picked up from the net block assembly 10 by a lifter assembly 11A. They are then inspected by a ball vision inspection camera assembly 11B which examines them from beneath. A computer system uses the data obtained at this step to make a determination of the quality of the units, and accordingly controls the lifter assembly 11A to place them into one of two trays 12d, 12e. A vacant tray is kept at position 12c. Once filled, the trays 12d, 12e are moved (in the direction which is downwards in Fig. 1(a)) respectively into a normal unit tray stacking assembly 13 and an abnormal unit tray stacking assembly 14. A tray lifter assembly 12 moves a vacant tray from position 12c to replace whichever of trays 12d, 12e has been removed. A new vacant tray is moved to position 12c from a vacant tray stacking assembly 15.

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We now discuss the various sections of the embodiment in detail.

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The loader assembly 1 is shown in Fig. 2(a) in top view, in Fig. 2(b) in side view in the direction Y in Fig. 1(a), and in Fig. 2(c) in side view in the direction X in Fig. 1(a). The loader assembly 1 includes a number of cassette magazines 1a in a region 1d of an upper stage 1c of the load assembly 1. The

5 cassette magazines each contain a number of stacked substrates, each including a number of panels 1b (typically each panel is identical, and is designed in view of the uses which are to be made of the singulated integrated circuits; there may be 2, 3, 4 or 5 panels in a single substrate). At least one cassette magazine 1a is fed at a time to the loader assembly 1.

10 Once each magazine 1a has been loaded, it is carried (in the direction towards the right in Fig. 2(c)) towards a magazine gripper 1h, 1i by a wide rubber belt 1e driven by rollers 1f and a motor 1g. The magazine gripper 1h, 1i is composed of a lower gripper 1i and an upper gripper 1h. The magazine gripper 1h, 1i is installed on an up/down linear rail 1j via a gripper block 1L.

15 As soon as the cassette magazine 1a has been transferred to the magazine gripper 1h, 1i, the lower gripper 1i is activated by a cylinder 1k to push the magazine upward. This positions the cassette magazine 1a firmly between the lower gripper 1a and the upper gripper 1h.

20 The magazine gripper 1h, 1j is then lowered along the up/down linear rail 1j, until one of the substrates is in register with a substrate slot 1m. The substrate is pushed into the substrate slot 1m by a pusher 1n. The magazine gripper 1h, 1j is then moved to bring another of the substrates in the cassette magazine

25 1a into register with the substrate slot 1m. In this way, all the substrates in the cassette magazine 1a are sequentially transferred to the slot 1m.

Once the substrate loading is complete, the empty magazine 1a is shifted downward, and the magazine gripper 1h, 1i releases it from the up/down

linear rail 1j. The empty magazines are placed onto a lower stage 1o of the region 1d of the loader assembly 1.

The inlet rail assembly 2 is shown in Fig. 3(a) in top view, in Fig. 3(b) in side view looking in the direction Y in Fig. 1(a), and in Fig. 3(c) in side view looking in the direction opposite to X in Fig. 1(a). The substrate is pushed by the pusher 1n until it is positioned at the roller 2a. At this location, the substrate 1b is inspected by the first camera 3. The image taken by the first camera 3 is analysed by a computer system, to establish that the substrate is the correct package type, to check its alignment and its orientation. If it is detected that the substrate is the wrong type for example, the progression is automatically stopped, then the substrate can be removed from the system (e.g. manually).

After the visual inspection by the first camera 3, the roller 2a is rotated to move the substrate onto a rail supporter 2f until it reaches a stopper 2b. The rail supporter is has a generally rectangular upper surface, and at this time the long axis of the upper surface is in the horizontal direction on Fig. 13(a).

During this process, the spacing of the inlet rails 2c is aligned using a servo-motor 2d and belt 2e. Once a substrate (which in Fig. 3(a) is shown including four panels 1b) is located over the rail supporter 2f, the rail supporter 2f, which is linked with an up/down air cylinder 2g lifts the substrates 1b upwards, out of the horizontal level of the inlet rails. Then a servo motor 2h and belt 2i rotate the rail supporter 2f, and thereby rotate the substrates 1b. The rotation is through 90° or 270° in a horizontal plane, in order that the substrates should be correctly aligned with the twin chuck table discussed below. This rotation means that the substrates can initially have their long axis in the X direction, but are rotated so that their long axis extends in the Y direction, in which the dicing machine Z is arranged to receive them.

Once the substrate is rotated by the frame supporter 2f, the substrate is lifted from the frame supporter 2f by a frame lifter assembly. The frame lifter assembly has two portions labelled (in Fig. 1(b)) respectively as Ay and Ax, which are independently movable in a vertical direction, and horizontally
5 movable together (in the left-right direction as viewed in Fig. 1(b)) by a servomotor Af. The portion Ay includes a frame lifting member Ab, for lifting the substrate supported on the frame supporter 2f, and the portion Ax includes a net lifter member Aa, which is explained below. The frame lifting member Ab is connected via a conduit Ai to a vacuum source for generating a force for
10 retaining the substrate against the frame lifter member Ab. Typically, the frame lifting member Ab includes a number of apertures on its face communicating with the conduit Ai. A switch mechanism (not shown) determines whether the vacuum source is activated (i.e. applies negative pressure to the apertures) or deactivated (e.g. because it is no longer in
15 communication with the apertures).

After the frame lifter member Ab has picked up a first substrate from the frame supporter 2f, the frame supporter 2f returns to its previous orientation and height, so that it can receive a new substrate. The operation of lifting and
20 rotating is then performed for the new substrate.

The frame lifter assembly transfers the substrate to a frame loading position of the twin chuck table 4. The twin chuck table 4 is shown in top view in Fig. 4(a), and in Fig. 4(b) looking in the direction Y of Fig. 1(a). It is arranged to be
25 capable of rotation around a vertical axis, and includes two identical sections 4a, 4b, which are interchanged by the rotation. The frame lifter member Ab of the frame lifter assembly places the substrate at a time into the section 4a on the left side as shown in Fig. 4. There the substrate is retained by suction using apertures in the chuck table which can be put into communication with a
30 vacuum source. The members Aa and Ab each have projections Am, An at

their ends, for entering corresponding apertures 4m, 4n on the chuck table 4, thereby ensuring correct positioning. The twin chuck table 4 is arranged to co-operate with a dicing machine of a known design, which dices the cassette. During the dicing, each substrate 1b is cut into singulated units 7a.

- 5 Following the dicing the chuck table rotates 180^0 about its central vertical axis so as to bring the singulated units 7a to position of the on the right side as shown in Fig. 4 (i.e. the one formerly occupied by the section 4b). The section 4b moves simultaneously into the position formerly occupied by the section 4a.

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- Simultaneously with the operation in which the frame lifter member Ab deposits a new substrate into the section 4a, the net lifter member Aa is lowered to contact the singulated units 7a of a previously diced substrate 1b. The net lifter member Aa contains apertures in its lower surface which are in
15 communication with a vacuum source via a conduit Ah, so that the net lifter member Aa retains the singulated units 7a. The suction on the singulated units from the apertures in the chuck table is turned off. The frame lifter assembly then moves away from the twin chuck table 4, so that the twin
20 chuck table 4 can cooperate with the dicing machine to dice the substrate 1b which has just been deposited. Thus, the time during which the twin chuck table cooperates with the frame lifter assembly is efficiently used, both for the deposition of a new substrate and the removal of one which has already been diced. Thus, the throughput of the dicing machine is optimised, with as little time as possible wasted in loading and unloading a chuck table.

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The net lifter member Aa lifts the singulated units 7a to the brush unit 5 which cleans them by a rubbing motion. The net lifter member Aa then moves the singulated units 7a to a cleaner unit 6, shown in Fig. 5 in a view looking in the direction Y, and in Fig. 6 in a view looking in the direction opposite to X. The

net lifter member Aa lowers until the units enter a cleaning zone 6a. The projections 4n enter respective apertures at the top of the cleaning unit 6.

5 Simultaneously, a frame supporter 6b inside the cleaner unit 6 is raised by pneumatic cylinders 6c and guide posts 6d, until it touches the lower surface of the singulated units 7a. A vacuum source is put into communication via a conduit with apertures in the upper surface of the frame supporter 6b respectively in register with the singulated units 7a, so as to retain the singulated units 7a on the frame supporter 6b. The pneumatic function of the
10 net lifter member Aa is turned off.

The frame supporters 6b then moves down, and water and air jets 6f are initiated to remove dust and debris from the surface of the singulated units 7a which is facing upwardly (recall that this is the surface having the ball
15 contacts).

After the surfaces of the singulated units 7a carrying the balls have been cleaned, the water and/or air jets 6f are deactivated. The frame supporter 6b moves upward again, until the singulated units 7a are again against the net
20 lifter member Aa. The vacuum source is again initiated using the conduit Ah, and the vacuum source of the frame supporter 6b is disconnected. At this point the singulated units 7a are again retained on the lower surface of the net lifter member Aa. The water and air jets 6f are activated again, and clean the other surface of the singulated units 7a (i.e. the side away from the ball grid
25 array).

After the cleaning, the net lifting member Aa lifts the singulated units 7a and moves them to the upper surface of a heating block 7c of the heating block assembly 7. The heating block assembly 7 is shown in top view in Fig. 7(a), in
30 cross-section when viewed from direction A in Fig. 7(b), and in cross-section

when viewed in direction B in Fig. 7(c). At this moment, the net lifting member Aa and the heating block 7c are aligned by the projections An entering apertures 7d, so that the singulated units 7a are properly positioned in predetermined positions on the heating block 7c.

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Once the singulated units 7a are in contact with the heating block 7c, the suction from the conduit Ah is deactivated, and suction is applied via a conduit 7b which is in communication with apertures in the upper surface 7c in register with the singulated units 7a, so as to hold the singulated units 7a on the heating block 7c.

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At this point the frame lifter assembly is not carrying either substrates or singulated units), and the frame lifter assembly returns to its position over the inlet rail assembly 2. The time taken by dicing machine to dice the substrates 1b is preferably at least as great as the time taken by the frame lifter assembly to perform the set of actions: (i) moving from the twin chuck table 4 to the heating block assembly 7, (ii) returning to the inlet rail assembly, and (iii) picking up a new substrate(s) 1b (i.e. all portions of the operation of the lifter assembly except that in which it interacts with the table 4). Provided this is true, then the speed of operation of the dicing machine is not reduced by the time the head lifting assembly takes to interact with the other units.

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Any drops of water on the singulated units 7a are evaporated by heat generated by a cartridge heater 7a of the heating block assembly 7. The system further includes an idle lifter assembly (indicated generally as Az in Fig. 1(b)) which is reciprocated (left-right in Fig. 1(b)) by a servo-motor Ag. This idle lifter assembly includes a nozzle Ad. The idle lifter assembly Az is moved so that the nozzle Ad is directed at the singulated units 7a, and the nozzle Ad blows air at the singulated units 7a to dry the units, especially at the top.

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The idle lifter assembly Az includes an idle lifter Ac which can be raised and lowered, and which includes apertures on its lower surface in communication with a vacuum source via a conduit AL. The idle lifter Ac is lowered over the singulated units 7a, and the vacuum source activated so that the singulated units are retained on the lower surface of the idle lifter Ac. The idle lifter Ac is then raised, moved horizontally (to the right in Fig. 1(b)), and then lowered onto a horizontal surface of a flipper block 8a of the flipper unit 8. The flipper unit 8 is shown in top view in Fig. 8(a), and in Fig. 8(b) looking in the direction X. A portion of the flipper unit is shown in Fig. 8(c) looking in the direction Y. The flipper block 8a is a body having two opposed flat surfaces, each containing apertures in communication with a vacuum source via a conduit 8b. Once the singulated units 7a are placed on the upper surface of the flipper block 8a, the vacuum source of the idle lifter Ac is deactivated, and the vacuum source of the flipper unit 8 activated so that the singulated units 7a become attached to the upper surface of the flipper block 8a.

While this attachment continues, the flipper block 8a is rotated about a horizontal axis 8e through its centre (into the page in Figs. 1(b) and 8(c)) so that the surface of the flipper block 8a which formerly faced upward, now faces downward. The rotation of the flipper block 8a is performed by a servo motor 8c, which is linked to the flipper block by a rubber belt 8d. Note that the ball grid arrays, which until this time have been facing upwards, now face down.

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The next section of the system is the idle block assembly 9 shown in Fig. 9. Fig. 9(a) is a top view, Fig. 9(b) is a view looking opposite to the direction X, and Fig. 9(c) is a view looking in the direction Y. The idle block assembly 9 includes an idle block 9a located beneath the flipper block 8a. After the flipper block 8a has been rotated such that the singulated units 7a face down, the

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idle block 9a is raised, until the singulated units 7a contact its horizontal upper surface. This is performed by an idle block lifting mechanism including up/down cylinders 9d and up/down guide posts 9e. A vacuum source is then applied in communication with apertures in the upper surface of the idle block 9a, to retain the singulated units 7a on the idle block. The vacuum source of the flipper unit 8 is then deactivated. The idle block 9a is then lowered again.

The idle block 9a can also be moved horizontally (in the left-right direction on Fig. 1(b)) by a forward-backward cylinder 9b along a horizontal rail 9c. This is done until the idle block 9a is no longer beneath the flipper block 8a. The idle block 9a passes beneath a second camera Ae. Using data collected by the camera Ae, a computer system analyses the marking status and condition of the singulated units 7a (note that it is seeing the surface of the singulated units 7a opposite the ball grid array), and identifies any units having an abnormal marking status or condition. This data is stored by the computer system for later use (as described below).

The idle block 9a is then raised until its upper surface is approximately at the same height as the upper surface of the flipper unit 8a, so that (as described below) the singulated units 7a can conveniently be picked up again by the idle lifter assembly Az. The idle lifter Ac is lowered over the singulated units, and its vacuum source AL again activated to retain the singulated units 7a. The vacuum source of the idle block 9a is then deactivated. The idle lifter Ac is then used to move the singulated units 7a onto the upper surface of a net block 10a of a net block assembly 10.

Fig. 10(a) shows the net block assembly 10 looking in the direction opposite to direction X, Fig. 10(b) shows the net block assembly looking in direction Y. Fig. 10(c) is a top view of a net block 10a of the net block assembly 10. Fig.

10(d) shows how the net block assembly 10 would appear if the net block 10a were removed.

Fig. 10(e) is an enlarged top view of a portion of Fig. 10(c). Fig. 10(f) is an enlarged view of a portion of Fig. 10(e). Figs. 10(g) and 10(h) show two cross-sections through the net block 10a in respective mutually transverse vertical planes. Fig. 10(i) corresponds to Fig. 10(g), and illustrates the operation of the net block 10a.

10 As shown in Figs 10(a) and 10(b), the net block 10a of the net block assembly 10 is supported on a rectangular plate 10j mounted at the top of a vertical shaft 10m. The shaft 10m can be reciprocated (in the left-right direction in Fig. 10b) by a servo-motor 10b. The shaft 10m can be rotated by a servo motor 10L via a rubber belt 10k.

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As shown in Fig. 10(e), the top surface of the net block 10a has a number of pockets 10d corresponding to the number of singulated units. The pockets 10d are arranged in groups 10c corresponding in number and arrangement to the singulated units 7a obtained from a single one of the substrates 1b. All of the singulated units 7a from one of the substrates 1b are placed into the respective pockets 10d of one of these groups 10c.

The pockets 10d are defined by ridges 10e, 10f, here referred to as "anvils". The anvils 10e are formed by grinding the upper surface of the net block 10a, and all extend in parallel (in the horizontal direction as shown in Fig. 10(f)). The anvils 10f are formed by the upper curved portions of laminar elements 10g which extend through laminar slots in 10j in the net block 10a, as shown in Fig. 10(h). An advantage of this forming the pockets in this way (i.e. rather than providing integral ridges 10e extending over the surface of the net block

10a in both transverse directions) is that it means that the upper net block 10a can be formed by grinding.

Each of the pockets 10d is in register with a respective conduit 10i which can
 5 be put into communication with a vacuum source, so that one of the singulated elements 7a can be retained in the pocket 10d. The connection between the conduits 10i and the vacuum source is via a channel in the shaft 10j and a conduit 10n. After one of the units 7a is placed into the pocket 10d, the negative pressure in the pocket 10d sucks the unit 7a towards the bottom
 10 of the pocket 10a, and the shaping of the anvils 10e, 10f means that the unit 7a becomes properly aligned with respect to the net block 10a. That is, there is a "self-alignment", which reduces the risk of a failure of pickup later. Note that this self-alignment property would be useful even if there were no flipping in the embodiment (i.e. if the flipper unit 8 is omitted), and/or if the singulated
 15 units did not have a ball-grid array.

Once properly in the pockets, the singulated units 7a are moved in the direction Y toward the lifter assembly 11A at the rear portion of the system (i.e. the top of Fig. 1(a)) by a servo motor 10b which drives the net block 10a.
 20 During this time, motor 10L is used to rotate shaft 10m.

The lifter assembly is shown in top view in Fig. 11(a), in Fig. 11(b) looking in the direction opposite to X, and in Fig. 11(c) looking in the direction Y. The lifter assembly 11A includes a number (e.g. at least three) of unit lifter
 25 assemblies 11a, each of which is moved horizontally (left-right in Fig. 1(a)) by a respective linear series actuator 11c. Each unit lifter assembly 11a includes a number (e.g. at least four) of sets of individual unit lifters 11b. Each individual unit lifter 11b is actuated up and down by a respective individual linear motor 11d. Once the servo motor 10b has moved the net block 10a to
 30 the rear of the system, rotation of the net block 10a brings each of the lifter

assemblies 11a into register (in the direction Y) with one of the rows of singulated units 7a. Each individual unit lifter 11b lifts a respective one of the singulated units 7a, and moves the lifted unit in the direction indicated by the arrow 11f to be above a ball vision inspection camera 11e.

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There may be any number of camera(s) 11e, and, like the net block 10a, each of the cameras 11e can be moved in the Y direction. In Fig. 11(a) there is just a single camera 11e, which is shown in three possible positions spaced apart in the Y direction, and movable between these positions, as indicated by the
10 arrow 11g.

Thus, each unit 7a can be photographed from beneath in any 3-dimensional position relative to one of the cameras 11e. Note that the ball grid array is facing downwards. The 2-D images captured by the camera(s) 11e are input
15 to a computer system for inspecting the status, condition, features and patterns of the balls. For example, if any of the balls have become detached from an integrated circuit, this can be determined straightforwardly. Optionally, this may include determining sophisticated parameters of the units, such as their offset relative to a preferred position, their coplanarity and their warpage.

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Based on this determination (and the results from the earlier quality determination based on the output of the camera Ae) a determination is made for each of the units individually whether to move the unit is normal or abnormal. According to the result, the computer system controls the individual
25 unit lifter 11b to place the corresponding unit on the normal unit tray 12d or on the abnormal unit tray 12e.

When a normal unit tray 12d or an abnormal unit tray 12e is filled it is removed from the system, and a vacant tray is inserted from a location 12c
30 into the place of the removed tray. This performed by a tray lifter assembly 12.

Fig. 12(a) is a top view of the tray lifter assembly 12, Fig. 12(b) is a view of the tray lifter assembly 12 looking in the direction X, and Fig. 12(c) is a view of the tray lifter assembly 12 looking in the direction Y.

- 5 While the normal unit tray 12d and abnormal unit tray 12e are being filled, these trays are located at positions along a linear conveyor 12b. The linear conveyor 12b also extends over a location at which a vacant unit tray 12c is positioned. The conveyor 12b carries a tray lifter unit 12a which in turn is capable of lifting a tray.

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The structure of the mechanism for removing the full normal trays is shown in Fig. 13 in top view and Fig. 14(a) in a view looking in the direction X.

- The normal unit tray 12d and abnormal unit tray 12e are located respectively on a normal tray plate 12i and an abnormal tray plate 12j. When the normal
15 tray 12d is filled, the normal tray plate 12i it rests on is conveyed in the direction opposite to Y along a track 13c by a conveyor 13d, to a normal tray stack assembly 13. At the normal tray stack assembly 13, the trays filled with normal units removed from the plate 12i and stacked in a section 13a using a drive system located in a section 13b. Usually, at least 30 trays may be
20 stacked in the assembly 13.

- Similarly, when the abnormal tray 12e is filled, the abnormal tray plate 12j it rests on is conveyed in the direction opposite to Y direction along a track 14c by a conveyor 14d, to an abnormal tray stack unit 14. At the abnormal tray stack
25 assembly 14, the trays filled with abnormal units are removed from the plate 12j and stacked in a section 14a using a drive system located in a section 14b. Usually, at least 30 trays may be stacked at this position. The structure of the mechanism for removing the trays full of abnormal units is shown in Fig. 14(b), and is identical to that of Fig. 14(a) except that the reference numerals

12d, 12i, 13, 13a, 13b, 13c, 13d are replaced by the units 12e, 12j, 14, 14a, 14b, 14c, 14d respectively.

Whenever, as described in one of the preceding paragraphs, a normal tray
5 12d or abnormal tray 12e is removed, the tray lifter unit 12a carries the vacant tray 12c into its place.

The position the vacant tray 12c formerly occupied is filled with a new vacant tray by a vacant tray supply assembly. The vacant tray supply assembly
10 consists of a vacant tray stack unit 15 where vacant trays are stacked in a region 15a under the control of a drive unit located in section 15b (preferably this unit should be capable of storing at least 30 vacant trays), and a linear conveyor 15d which conveys vacant trays along a track 15c from the vacant tray stack unit 15 to the position 12c. The structure of this mechanism is
15 shown in top view in Fig. 13, and in Fig. 15 looking in the direction X.

Note that in other arrangements the number of these trays is varied. For example, in some variants of the embodiment abnormal units 7a may be further classified, according to the type of abnormality they suffer from. The
20 abnormal units may then be placed in one of a number of abnormal unit trays according to the type of abnormality identified.

Although only a single embodiment of the invention has been described in detail many variations are possible within the scope of the invention as will be
25 clear to a skilled reader.

Claims

1. A system for inverting a set of integrated circuit units obtained by singulation of a substrate, the system including:
 - 5 a flipper unit having a retention mechanism for retaining singulated units on an inversion surface of the flipper unit;
a drive mechanism for moving the flipper unit between a first configuration in which the inversion surface of the flipper unit faces upwardly and a second configuration in which the inversion surface faces downwardly;
10 and
a first transport mechanism for locating the singulated units on the inversion surface, and a second transport system for removing the singulated units from the inversion surface;
whereby the first transport mechanism locates the singulated units on
15 the inversion surface of the flipper unit, the flipper unit is moved to invert the inversion surface, and the second transport system removes the singulated units from the inversion surface.
2. A system according to claim 1 in which the flipper unit is mounted for
20 motion between said configurations by rotational motion about an axis.
3. A system according to claim 1 or claim 2 in which the retention mechanism includes a plurality of apertures on the inversion surface and a mechanism for connecting the apertures to a vacuum source, whereby
25 suction can be applied to the singulated units.
4. A system according to claim 1 in which the first transport mechanism is arranged to locate the singulated units on the inversion surface of the flipper unit when the surface is directed upwardly, and the second transport

mechanism is arranged to remove the singulated units from the inversion surface when the surface is directed downwardly.

5. A system according to claim 4 further including an idle block arranged
5 for upward motion relative to the flipper block from beneath the flipper block until the singulated units retained on the flipper block are proximate to or in contact with a transfer surface of the idle block, the retention mechanism being arranged to release the singulated units onto the transfer surface of the idle block.
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6. A system according to claim 5 in which the transfer surface of the idle block includes apertures connectable to a vacuum source.
7. A system according to claim 5 or claim 6 further including an idle block
15 drive mechanism for moving the idle block laterally from beneath the flipper block.
8. A system according to claim 7 in which the idle block drive mechanism is operative to raise the idle block to a height at which the transfer surface is
20 proximate the height of the inversion surface in the first configuration.
9. A system according to claim 7 or claim 8 in which the flipper unit includes a second inversion surface opposite the first surface, and a second retention means for retaining singulated units on the second inversion
25 surface.
10. A substrate dicing and processing system, the system including:
a dicing machine for dicing a substrate located on a chuck to form a plurality of singulated integrated circuit units;

a flipper unit having a retention mechanism for retaining singulated units on an inversion surface of the flipper unit;

a first transport mechanism for moving the singulated units from the chuck to the inversion surface;

5 a drive mechanism for moving the flipper unit between a first configuration in which the inversion surface of the flipper unit faces upwardly and a second configuration in which the inversion surface faces downwardly; and

10 a second transport system for removing the singulated units from the inversion surface;

whereby the first transport mechanism locates the singulated units on the inversion surface of the flipper unit, the flipper unit is moved to invert the inversion surface, and the second transport system removes the singulated units from the inversion surface.

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11. A system according to claim 10 including at least one further transport system for transporting the inverted integrated circuits while retaining them by suction applied to their upper surface.

20 12. A method for inverting a set of integrated circuit units obtained by singulation of a substrate, the method including:

locating the singulated units on a generally horizontal inversion surface of a flipper unit;

25 applying a retention mechanism to retain the singulated units on an inversion surface of the flipper unit;

moving the flipper unit to invert the inversion surface; and
removing the singulated units from the inversion surface.