Improved Net Block Assembly

Field of the invention

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 singulate individual integrated circuits. The invention further relates to apparatus for use in such a sawing and sorting system.

Background of Invention

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.

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).

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

The present invention aims to provide a new and useful system for positioning integrated circuit units obtained by singulating a substrate.

In a first aspect, the invention provides a system for positioning integrated circuits singulated from a substrate, the system comprising a net block having a surface for receiving the integrated circuits; said surface at least partially covered by a two dimensional array of alternating first and second elements arranged in a chequer pattern; each first element adapted to receive an integrated circuit and each second element projecting from the surface; a transport means for transporting the integrated circuits to the net block and positioning a first quantity of the singulated integrated circuits in register with respective first elements; and urging means for urging the portion of integrated circuits into the respective first elements.

In a second aspect, the invention provides a substrate dicing system comprising a dicing machine for dicing a substrate to form singulated integrated circuits; a net block having a surface for receiving the integrated circuits; said surface at least partially covered by a two dimensional array of alternating first and second elements arranged in a chequer pattern; each first

element adapted to receive an integrated circuit and each second element projecting from the surface; a transport means for transporting the integrated circuits to the net block and positioning a first quantity of the singulated integrated circuits in register with respective first elements; and urging means for urging the portion of integrated circuits into the respective first elements.

In a third aspect, the invention provides a method of handling integrated circuits singulated from a substrate, the method comprising the steps of transporting the integrated circuits to a net block having a surface for receiving the integrated circuits; said surface at least partially covered by a two dimensional array of alternating first and second elements arranged in a chequer pattern; each first element adapted to receive an integrated circuit and each second element projecting from the surface; and urging the integrated circuits into the respective first elements using urging means.

In a fourth aspect, the invention provides a method for manipulating a plurality of singulated integrated circuits comprising the steps of at a first position, urging a first quantity of the integrated circuits onto a net block having a surface for receiving the integrated circuits; said surface at least partially covered by a two dimensional array of alternating first and second elements arranged in a chequer pattern; each first element adapted to receive an integrated circuit and each second element projecting from the surface; moving the net block to a second position; displacing the first quantity from the net block; rotating the net block 180° within a plane defined by the surface of the net block; moving the net block in the rotated orientation back to the first position; urging a second quantity of the integrated circuits onto the net block; moving the net block to the second position, and; displacing the second quantity from the net block.

In a fifth aspect, the invention provides a unit lifter assembly for lifting a singulated integrated circuit, comprising a body having an engagement end; A first biasing means for resiliently moving the body from a first position to an engagement position; vacuum communication means capable of placing a vacuum source in communication with the engagement end of the body, such that the body engages the singulated integrated circuit at the engagement end through suction; a second biasing means for moving the body from the engagement position to the first position, and consequently lifting the singulated integrated circuit.

In a sixth aspect, the invention provides a method for lifting a singulated integrated circuit comprising the steps of resiliently biasing a body from a first position to an engagement position using a first biasing means; engaging the singulated integrated circuit at an engagement end of the body using a vacuum means; biasing the body from the engagement position to the first position with the singulated integrated circuit attached using a second biasing means.

In general terms, the present invention proposes that a portion of integrated circuits obtained from a singulation process are placed onto a net block having a square array of first and second elements. Each integrated circuit within the portion is inserted into a respective first element, the second element adapted to prevent integrated circuits being inserted.

Each first element may include at least one aperture which can be put into communication with a vacuum source to urge the respective integrated circuit unit into the first element. Furthermore, the net block preferably faces upwards so that gravity helps to urge the integrated circuits into the pocket.

The net block may be arranged to be moved by a drive means to a section of the system in which an inspection process is carried out on the singulated units.

The net block is particularly suitable for positioning integrated circuits having electrical contacts (such as solder balls or non-leaded pads) on one face, and which are laid onto the net block with the electrical contacts facing towards the net block. However, the net block is not limited to such integrated circuits having solder balls, and may indeed be useful even in the case that the integrated circuits are laid onto it with the electrical contacts facing away from the net block.

Brief Description of The Figures

It will be convenient to further describe the present invention with respect to the accompanying drawings which illustrate possible arrangements of the invention. Other arrangements of the invention are possible, and consequently the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

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

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;

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;

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;

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(d), shows a net block assembly of the embodiment of Fig. 1;

Fig. 11, which is composed of Figs. 11(a) to 11(e), 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 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.

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 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 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 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.

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.

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.

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.

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

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 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. 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.

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.

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 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 movable together (in the left-right direction as viewed in Fig. 1(b)) by a servo-motor 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 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 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 pervious orientation and height, so that it can receive a new substrate. The operation of lifting and 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 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 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. Following the dicing the chuck table rotates 180^0 about its central vertical axis so as to bring the singulated units 7a into position 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.

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 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 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.

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.

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 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 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 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 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 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.

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.

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.

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.

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 bock 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.

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 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.

As shown in Figs 10(a) to 10(d), 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.

As shown in Fig. 10(b), the top surface of the net block 10a has a number of first elements, in this case, recesses 10d corresponding to the number of singulated units. The recesses 10d are arranged in a chequer pattern, with interstitial second elements, in this case, raised portions corresponding in number and arrangement to half the singulated units 7a obtained from a single one of the substrates 1b. Half of the singulated units 7a from one of the

substrates 1b are placed into the respective recesses 10d in the first step of this process.

Figure 10(b) shows a detailed view of the surface of the net block 10a, and in particular the chequer pattern comprising the recesses 10d for receiving the singulated integrated circuits and the raised portions 10e located between the recesses 10d.

To assist in the placement of the integrated circuits 7a into the recesses 10d, the raised portions 10e may further have inclined side walls 10f. If an integrated circuit should not align correctly with its respective recess 10d, it will contact the side wall and tend to slide toward the recess 10d through gravity.

In an embodiment were the sides are not inclined, the raised portions will, in any event cause the integrated to "stand" in an inclined position due to the differential in top surfaces between the raised portion 10e and the recesses 10d. This inclined arrangement, being unstable, will urge the integrated circuit downwards, to slide into the recess 10d. Whilst less efficient that an inclined wall 10f, the effect of the differential height of the surfaces is still an effective means to urge the integrated circuit into place.

Each of the recesses 10d is in register with a respective conduit 10i which can be put into communication with a vacuum source, so that one of the singulated elements 7a can be retained in the recesses 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 recesses 10d, the negative pressure in the recesses 10d sucks the unit 7a towards the

bottom of the recesses 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 units did not have a ball-grid array.

The principle behind the chequer pattern of the net block can be seen from Figure 10(c). The required tolerance to place an entire supply of integrated circuits from a diced substrate would be extremely small. For instance, the alignment of adjacent integrated circuits amount to 0.3 to 0.5 mm, being equal to the margin of adjacent integrated circuits. Instead by using a chequer pattern, with interstitial raised portions, the tolerance is equivalent to the full width of the integrated circuits. Consequently, the ease of manufacture improves considerably.

The process shown in Figures 10(c) and 10(d) demonstrate the effect of the chequer pattern. A substrate 1b is diced into a plurality of singulated integrated circuits 7a. Rather than to be processed as a single group, the process according to the present invention divides the total number into two groups, in this embodiment, two halves 10q and 10s.

As shown particularly in Figure 10(d), the net picker holds the singulated integrated circuits. The net picker selectively places the first group of integrated circuits 10q into the recesses 10d of the net block 10a. The net block delivers 10t the first group 10q to a pick up zone 10u, where the first group 10q are removed. The net block 10a is then rotated 180° 10v and returned 10w to the position beneath the net picker. However, in the rotated position, the recesses 10d are now directly aligned with the second group of integrated circuits 10r. Accordingly, the second group 10r are placed in the vacated recesses 10d, and the second group delivered to the pick up zone.

It is clear that, while this embodiment describes a single net block, in fact, other arrangements embodying the present invention may be contemplated, including multiple net blocks so as to emulate a continuous process, rather than for a single net block to be used for the two groups of singulated integrated circuits.

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 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 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.

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 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 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 co-planarity and their warpage.

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 unit lifter 11b to place the corresponding unit on the normal unit tray 12d or on the abnormal unit tray 12e.

Considering the lifter assemblies in detail, attention is drawn to Figures 11(d) and 11(e). Here the lifter assembly 11a comprises a plurality of unit lifter assemblies 11b, each adapted to contact and engage an individual singulated integrated circuit 7a. The unit lifter assembly 11b comprises a body 11s mounted to a frame 11r. Through the centre of the body 11s is a bore 11t which acts as a conduit to provide a negative pressure generated by a vacuum source (not shown) to the engagement end 11h of the body. The vacuum pressure is used to engage the integrated circuit 7a, when the body 11b is brought into contact or proximate to the integrated circuit whilst on the net block 10a.

The mounting of the body 11b to the frame 11r involves a linear bearing, and a rack and pinion 11k, 11m arrangement. This arrangement is used to lock

the body into the upper position, as well as raise 11p the body 11b following pick up of the integrated circuit 7a.

The process of lowering the body involves a resilient member, in this case a spring 11l, which is held in compression when the body is locked in the upper position. On selective release of the rack and pinion 11k, 11m lock, the spring is permitted to release, and so lower 11h to place the engagement end 11h in contact with, or proximate to, the integrated circuit 7a. The lowering process 11n, whilst driven by the spring 11i, may be controlled by a damping device, to avoid excessive energy being imparted to the integrated circuit 7a by the energy of the spring 11i.

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 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.

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.

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 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 stacked in the assembly 13.

Similarly, when the abnormal tray 12e is filled, the normal 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 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 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 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 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 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 clear to a skilled reader.

Claims

1. A unit lifter assembly for lifting singulated integrated circuits, comprising at least one unit lifter assembly, the at least one lifter assembly comprising :

A body having an engagement end;

A first biasing means for resiliently moving the body from a first position to an engagement position;

Vacuum communication means capable of placing a vacuum source in communication with the engagement end of the body, such that the body engages the singulated integrated circuit at the engagement end through suction;

A second biasing means for moving the body from the engagement position to the first position, and consequently lifting the singulated integrated circuit; wherein the second biasing means locks the body in the first position until releasing means disengage the second biasing means, permitting the first biasing means to move the body.

2. The lifter assembly according to claim 1, wherein the first biasing means includes a resilient member for resiliently moving the body.

3. The lifter assembly according to claim 2, wherein the resilient member includes a spring mounted between the body and a contact portion of the lifter assembly.

4. The lifter assembly according to any one of claims 1 to 3, wherein the vacuum communication means includes a conduit to communicate negative pressure between the vacuum source and the engagement end.

5. The lifter assembly according to claim 4, wherein the conduit includes a bore within the body.

6. The lifter assembly according to any one of claims 1 to 5, wherein the second biasing means includes a rack and pinion arrangement

7. The lifter assembly according to claim 6, wherein the rack is attached to the body, and the pinion attached to a locking portion of the lifter assembly such that the pinion drives the body from the engagement position to the first position.

8. The lifter assembly according to any one of claims 1 to 7 wherein the lifter assembly comprises a plurality of unit lifter assemblies.

9. A method for lifting a singulated integrated circuit comprising the steps of :

resiliently biasing a body from a first position to an engagement position using a first biasing means;

engaging the singulated integrated circuit at an engagement end of the body using a vacuum means;

biasing the body from the engagement position to the first position with the singulated integrated circuit attached using a second biasing means, and locking the body in the first position using the second biasing means.

10. The method according to claim 9, further including the first step of releasing the second biasing means so as to permit resilient biasing of the body by the first biasing means.