

SYSTEM AND METHOD FOR THE SORTING OF IC UNITS

Field of Invention

- 5 The invention relates to the processing of integrated circuit units and in particular, downstream methods and apparatus for the sorting of singulated IC units for detecting defects and packaging for shipment.

Background of the Invention

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The economics involved in the processing of integrated circuit units are influenced by two major factors. Firstly, to maximize the rate of units processed, measured in units per hour (UPH). Secondly, to minimize the footprint of machinery, designed to achieve these rates, and so maximize factory floor space.

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Summary of Invention

- In a first aspect, the invention provides a method for processing a plurality of IC units comprising the steps of: inspecting said units at a first inspection station; moving said
- 20 IC units along a linearly defined path to a second inspection station; inspecting the units at said second inspection station; flipping said units; inspecting the units at said third inspection station, and; sorting said units into pre-defined categories.

In a second aspect, the invention provides a system for processing a plurality of IC units comprising a first inspection station for inspecting said units; a first engagement device for engaging said units, said engagement device arranged to move said IC units along a linearly defined path to a second inspection station, said second inspection station for
5 further inspecting said units; a flipping assembly for inverting said units; a third inspection station for further inspecting said units, and; a sorting station for receiving said units according to the pre-defined categories based on results from the first, second and third inspection stations.

10 By arranging the critical process steps into a linearly arranged path, the IC units being processed don't "back track" but maintain a unidirectional path. Accordingly, mechanisms designed to rotate platforms, or having hubs to deliver and return IC units is avoided, leading to a considerable saving in size. Further, the simplicity of the system also reduces time, such as accelerating and decelerating the IC unit, as well as multiple
15 processes involved in the movement of said units.

In a preferred embodiment, movement along the linear path may include engaging said units using a vacuum associated with a picker assembly. In a more preferred embodiment, movement upstream and downstream of the flipping assembly may
20 include two separate picker assemblies. In a still further embodiment, the flipping step may be achieved by the interaction of the two separate picker assemblies. Thus, instead of having a table rotating about a horizontal axis, two picker assemblies may partially rotate 90 degrees about a horizontal axis and transfer the IC units directly between the assemblies, and so further saving on time and equipment cost.

Thus, in a preferred embodiment, the process of flipping the IC units may include the steps of rotating a first picker assembly from a vertical to horizontal orientation, disengaging the units from the first picker assembly, engaging the units with the second
5 picker assembly also in horizontal orientation, and rotating second picker assembly to the vertical orientation.

The system includes a plurality of inspection stations to ensure the required quality of the end product. In a preferred embodiment, the first inspection station is arranged to
10 inspect the units for any one or a combination of: alignment, unit type and orientation. Further, the second inspection station may inspect the units for the location and alignment of fiduciary marks. Further still, the third inspection station may inspect the units for defects in balls or pads of said units.

15 An arrangement to achieve the linearly defined path may include mounting one or both picker assemblies to a rail, such that the pickers engage the units and move along the rail. On depositing the units at the next respective station, the picker assemblies can then return to the previous station to engage further units. Thus, the units are continually moving forward along the linear path, and not "back tracking" to previous stations.

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In an alternative arrangement, to further enhance the rate of processing, the system may include a second parallel rail having respective first and second picker assemblies mounted thereto. Thus, the rate of processing may be doubled by duplicating the

movement and possibly flipping steps so as to move a greater number of units from the first inspection station to the sorting station as quickly as possible.

In a preferred embodiment, said first and/or second picker assembly may be mounted to the rail in a manner that prevents lateral movement and only permitting longitudinal movement along the rail. Accordingly, in order for said picker assemblies to gain access to IC units at the periphery of the wafer frame or alternatively, to place IC units in the various categories in the sorting station, said stations may be laterally moveable so as to position said stations at the appropriate position subject to the requirements of the picker assemblies. For instance, the first inspection station may include a turntable that is laterally moveable along a rail or similar mechanism that permits sliding in order to receive the wafer frame from the wafer frame cassette.

On receiving the wafer frame, the first inspection station may then slide back into place so as to align with the rails. Thus in order for various IC units to be positioned beneath the picker assembly, the first inspection station may be moveable along said rail so as to position the appropriate IC unit beneath the picker assembly.

Alternatively, the first inspection station may incorporate a turntable whereby the wafer frame is received by the turntable which forms part of the first inspection station. Accordingly, movement of the wafer frame so as to align with the first picker assembly may be achieved through rotation of the wafer frame together with movement of the first picker assembly along the rail so as to achieve the desired relative position of the first picker assembly and the wafer frame.

Similarly, the vision devices associated with each of the first, second and third inspection stations may also be moveable in a direction lateral to the linear path. This may also be achieved through mounting to a rail whereby the vision devices are positioned along the lateral rail with the picker assembly positioned along the longitudinal rail in order to achieve the desired relative position in order to conduct the inspection.

In a similar manner, each of the receptacles upon which the IC units are placed may also be moveable in a lateral direction and again, the position relative to the second picker assembly in order to place the respective IC units in the appropriate receptacles.

Thus by ensuring the picker assemblies can only move in a longitudinal direction, positioning the various stations relative to the respective picker assemblies may be achieved through a combination of lateral or rotational movement of the various stations relative to the respective picker assemblies.

Alternatively, the first picker assembly may include a rail or other means of movement along an axis perpendicular to the linear path. Thus, in order to reach a peripheral edge of the wafer frame, the first picker assembly may be able to move along this perpendicular axis, as required, to engage units outside the normal reach of said picker assembly.

Similarly, the second picker assembly may also be movable along a perpendicular axis. In this case, this perpendicular movement may be required to match that of the first

picker, so as to align for the flipping step. Alternatively, or as well as, the perpendicular movement may be useful in placing the units in the respective sorting receptacles, subject to the category into which the units fit.

- 5 In a preferred embodiment, the system may include a central processing unit, and or control system, for monitoring the process. Further such a control system may monitor and record results from the various inspection stations so as to determine and record any detected defect.
- 10 As mentioned, the sorting station may include several receptacles, based on the results of the various inspection stations. The control system may control the second picker so as to ensure defective units are deposited in a receptacle for such defects. Similarly, “good” units may be delivered to a suitable receptacle. Such a receptacle may be a tape onto which the “good” units are placed for delivery to an end user. The “defect”
- 15 receptacle may be a tray or bin for disposal.

In a preferred embodiment, a third category may be “re-work” whereby the defect is minor, such as misalignment, that may be corrected easily, such as in this case the application of compressed air to “knock” the unit back into place. Such a “re-work”

20 receptacle may be a canister shaped to re-align units on delivery thereto.

In a preferred embodiment, a fourth inspection station may be placed to confirm, or otherwise, the presence of individual units or balls within the “good” unit receptacle.

In a third aspect, the invention provides a method of flipping an IC unit comprising the steps of: engaging said IC unit with a picker assembly, said picker assembly in a vertical orientation; rotating said picker assembly to a horizontal orientation; disengaging said IC unit and substantially simultaneously engage said unit with a second picker assembly
5 a horizontal orientation; rotating said second picker assembly to a vertical orientation.

In a fourth aspect, the invention provides a system for flipping an IC unit comprising a first and second picker assembly each having a vacuum source operating at an engagement end of said respective picker assemblies for engagement of said IC unit;
10 said first and second picker assemblies capable of rotation from a vertical orientation to a horizontal orientation and located such that in the horizontal orientation said respective engagement ends are proximate to each other; wherein in the horizontal orientation, disengagement of the vacuum source of the first picker assembly and engagement of the vacuum source of the second picker assembly results in the IC unit
15 being transferred from the first to the second picker assembly, whereupon the IC unit is flipped on rotation of the second picker assembly to the vertical orientation and disengagement of the vacuum source.

In a fifth aspect, the invention provides an engagement device for engaging a plurality
20 of IC units comprising a plurality of pickers spaced in a cylindrical array; a hub located at the centre of said cylindrical array such that said plurality of pickers are rotatable about said hub; said engagement device mountable to a rail for moving along said rail; wherein when to a rail, said engagement device is rotatable from a vertical to a

horizontal orientation such that IC units engaged by said pickers and rotated 90° about a horizontal axis.

Brief Description of Drawings

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It will be convenient to further describe the present invention with respect to the accompanying drawings that 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 superceding the generality of the preceding description of the invention.

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Figure 1 is a plan view of a complete IC processing line according to one embodiment of the present invention;

15 Figure 2 is a schematic view of the sorting system according to a further embodiment of the present invention;

Figure 3 is a plan view of the arrangement of components within a machine operating the method according to Figure 2;

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Figures 4A to 4C are elevation and plan views of a turret picker according to a further embodiment of the present invention and;

Figure 5 shows an elevation view of a pair of turret pickers each according to Figures 4A to 4C.

Description of Preferred Embodiment

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A significant departure of the present invention from the prior art is the use of linear movement along a principle axis of the IC units during processing, rather than relying on rotation, or a hub type approach where the units are delivered then returned to a central point. This arrangement avoids lost time in the acceleration and deceleration of the apparatus, minimizing wear, saving processing time, and simplifying the mechanism underlying this movement.

It follows, therefore, that a feature of the system and method according to present invention is the movement of the IC units along linear paths from loading of the wafer frame of IC units to the first inspection station, to delivery of the units to the various downstream processes.

To place the following embodiment of the present invention into context, the integrated circuit units may range from 0.5 x 0.5 mm up to 8 x 8 mm. Whilst not restricted to units of this size, this nevertheless provides an example of the application of a machine according to an embodiment of the present invention.

With reference to the figures, Figure 1 shows an overall arrangement of a production line for processing integrated units. Firstly, the packages 25 are loaded to a dicing unit

15 in the form of either individual packages 25 or in cassettes of said packages which are then delivered sequentially to dicing source 30 so as to singulate the units whilst within the wafer frames. From here, the wafer frames 35 are delivered to a washing station 20 which in this embodiment permits two sets of wafer frames at a time to be
5 washed simultaneously. From here, the wafer frames are delivered within a cassette to the sorting unit 5 which is the subject of the present invention. It is within the sorting unit 5 that the integrated units are inspected, categorized and if appropriate, packaged ready for delivery to end users.

10 Figure 2 shows a schematic view of the sorting system 60 according to one embodiment of the present invention. The process begins with a cassette of wafer frames 65 being loaded to the sorting unit 60 via a loading station. Wafer frames 65 are removed 75 from the cassette through engagement with a gripper 70 which pulls the individual wafer frames 65 along a linear path 75 and delivered to a turntable 85, said turntable
15 movable from a position to receive the wafer frame and back to the first inspection station. This places the wafer frame 65 in the first inspection station 90 to undergo alignment, type and orientation inspection by alignment cameras 95 prior to further processing.

20 Following inspection, the individual singulated IC units 87 are removed from the wafer frame 65 using engagement devices, in this case pickers and in a more preferred embodiment, using turret pickers 100. The turret pickers 100 as shown in Figures 4A, 4B, 4C and 5 have engagement ends 205 in communication with a selectively engageable vacuum source such that when a particular picker is adjacent to an

individual IC unit 210, the vacuum is engaged and so the picker engages the unit 210. When the array of pickers within the turret picker assembly 100 have all engaged IC units, the picker travels along a linear rail 102 which defines the linear path according to the present invention. The picker travels along the rail to the second inspection station 5 115 whereby the fiduciary marks of the individual IC units are identified just prior to the flipping of the IC units at the flipping station 120. In this embodiment, there is a second turret picker assembly 110 having its own alignment camera 105 mounted to a second parallel rail 103. Both rails 102, 103 function in the same way, that is to provide a linear path for the respective turret picker assemblies 100, 110 with the turret picker 10 assemblies 100, 110 acting independently so as to increase the capacity of processing of the individual units taken from the wafer frame 65. Thus, the use of the two rails together increases the capacity of the system according to the present invention by almost a faction of 2.

15 The turret pickers 100, 110 deliver the IC units to the flipping station 120 whereupon the units are flipped, that is, inverted such that the opposite side of the chip can undergo inspection.

The flipping action, as shown in Figures 4A, 4B, 4C and 5, is achieved in this 20 embodiment by the combination of the first turret pickers 100 and the second turret pickers 140. A characteristic of the turret pickers is their ability to rotate from a vertical orientation which the IC units are engaged to a horizontal orientation and thus rotating about a horizontal axis. The turret pickers rotate 215 90 degrees to a horizontal orientation whereby the first picker 100 having the IC unit 220 engaged brings the

engagement portion 205 of the picker in proximity to the engagement portion 225 of the second picker 140 which is also in a horizontal orientation. By disengaging the vacuum source of the first picker 100 and engaging the vacuum source of the second picker 140, the IC unit 220 is transferred from the first picker 100 to the second picker 140. In so
5 doing, the side of the IC unit 220 that was engaged with the first picker 100 is now exposed and the formerly exposed side of the IC unit is now engaged with the second picker. By rotating the second picker 140 from the horizontal orientation to a vertical orientation, the exposed side of the IC unit is now directed downwards and may now be exposed to vision devices used for inspection.

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In fact, on rotating back to the vertical orientation, the second picker 140, 130 delivers the IC unit to the third inspection station 125 which is directed to checking the pad of the IC unit that was formerly hidden from the camera whilst in engaged with the first picker 100, 110. Having been flipped, the IC unit undergoes inspection through use of
15 camera 125 so as to ensure the pad is present and not damaged before further processing.

The second turret pickers 130, 140 now deliver the IC units to the sorting station. The sorting station in this embodiment comprises three possible outcomes for the IC units
20 based upon the results obtained from the first, second and third inspection stations. If a serious defect is found from any one of the inspection stations, then the IC unit will be placed in the defect tray 135. In order to accommodate the placement of the defective units, the tray 135 is capable of lateral movement 137 so as to place voids in the tray in proximity to the respective turret pickers 130, 140. Alternatively, if a defect from any

one of the stations is detected but the defect is only minor such as the IC unit being misaligned or the presence of an extra ball for instance, then according to several embodiments of the invention, the IC unit may be placed either in the defect tray 135 or into the rework canister 145. For instance, in the case of an extra ball not mounted to the chip or a simple misalignment, placement of the unit within the tray 135 or the canister 145 may realign the chip through guides placed therein or alternatively, the application of compressed air may so realign the chip or remove the extra ball. If, however, all the inspections are sufficiently passed, the chip may be placed in a tape and reel arrangement whereby the IC unit is placed within a recess within a tape which when full may be delivered to the end user. Thus, the reel 150 may progress laterally 160 filling each of the recesses with good IC chips until the reel is complete. To ensure placement of the chips, a further camera is provided as a fourth inspection station 155 which checks the presence or absence of chips within the recesses within the tape.

Figure 3 shows an embodiment of the present invention and in particular, a plan view of a device that puts the schematic flow of Figure 2 into effect. A cassette 161 of wafer frames is delivered to the loading station 162. A gripper (not shown) withdraws a wafer frame 163 from the cassette 161 and places this on the turntable 165. The turntable then moves laterally so as to align with the linear path represented by the rails 187, 188. The first turret pickers 170 are combined with inspection cameras so as to travel together and inspect the IC units at the same time or just prior to engaging with the pickers of the third picker 170. In this embodiment, the turret pickers are fixed to the rails and so only accommodate linear motion in one direction with access to the IC units within the wafer frame accommodated by the turntable which rotates. The rotation of the turntable and

linear motion of the turret picker permits the turret picker to access any of the IC units within the wafer frame for delivery to the next station.

Accordingly, once each turret picker assembly is at capacity, it delivers the IC units to
5 the second inspection station 175 comprising a vision camera mounted to a rail capable of lateral motion relative to the linear path defined by the rails 187, 188.

The flipping station 177 resides between the second and third inspection stations at which point as previously described, the chip is flipped through interaction of the first
10 and second pickers. On completion of the flipping, the second pickers then deliver the IC units to the third inspection station 180 so that vision cameras mounted to a rail so as to travel laterally can inspect the underside of the IC units now exposed through the action of flipping.

15 Having completed the third inspection, the second picker assemblies now deliver the IC units to the sorting area whereby the chips are either placed in a tray 185 if defective. The tray 185 is mounted to a rail so as to laterally travel across the line of the linear path rails 187, 188. On filling of the tray 185, it is then delivered to an extreme end of the rail placing the tray adjacent to the loading station. Thus, when full and requiring
20 replacement, the tray 185 is adjacent to the point at which the wafer frame cassette 161 is delivered to the loading station and so, next to where an operator is already residing. This convenience minimizes the time for which an operator's involvement is required rather than placing the end point of the reject tray 185 at a less convenient point. Alternatively, the IC units may be categorized as being "good" whereupon they are

deposited within the reel assembly which comprises a reel having a length of tape there attached. The tape includes recesses into which individual units are placed. On filling of the tape, this can then be delivered to an end user. To ensure each of their recesses are filled, a further camera 190 is placed beneath the tray and viewing up through the
5 recesses, is able to determine whether any voids exists not already filled by the good IC chips.

In a third alternative, chips requiring simple rework may be placed within a canister 200 which is subsequently delivered to a rework area remote from the device according to
10 the present invention.

Claims:

1. A method for processing a plurality of IC units comprising the steps of:
 - 5 inspecting said units at a first inspection station;
moving said IC units along a linearly defined path to a second inspection station;
inspecting the units at said second inspection station;
flipping said units;
10 inspecting the units at said third inspection station, and;
sorting said units into pre-defined categories.
2. The method according to claim 1, further comprising the step, after flipping,
 - 15 of moving said IC units along the linearly defined path to a third inspection station.
3. The method according to claim 1 or 2, wherein the moving steps include engaging said units using a vacuum source of a respective first or second
 - 20 picker assemblies and moving said first or second picker assemblies along a rail, a longitudinal axis of said rail defining the linearly defined path.
4. The method according to claim 3, wherein the flipping step includes the steps of:

rotating the first picker assembly from a vertical to horizontal orientation;
disengaging the units from the first picker assembly;
engaging the units with the second picker assembly also in horizontal
5 orientation, and; rotating second picker assembly to the vertical orientation.

5. The method according to any one of the preceding claims, further including
the step of loading a wafer frame to the first inspection station, said wafer
frame containing the plurality of IC units.

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6. The method according to claim 5, wherein the loading step includes the steps
of:

loading a cassette of wafer frames to a loading station;
15 engaging the wafer frame within said cassette with a gripper;
withdrawing said frame from the cassette to an intermediate station;
biasing said wafer frame so as to place it within said first inspection station.

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7. A system for processing a plurality of IC units comprising

a first inspection station for inspecting said units;
a first engagement device for engaging said units, said engagement device
arranged to move said IC units along a linearly defined path to a second

inspection station, said second inspection station for further inspecting said units;

a flipping assembly for inverting said units;

a third inspection station for further inspecting said units, and;

5 a sorting station for receiving said units according to the pre-defined categories based on results from the first, second and third inspection stations.

8. The system according to claim 7, wherein the first inspection station is
10 arranged to inspect the units for any one or a combination of: alignment, unit type and orientation.

9. The system according to claim 7 or 8, wherein the first inspection station
includes a turntable, said turntable arranged to receive, and selectively rotate,
15 a wafer frame containing said units.

10. The system according to any one of claims 7 to 9, wherein the first
engagement device includes a picker assembly, said picker assembly
comprising at least one picker having an engagement end in communication
20 with a vacuum source, said engagement end arranged to engage individual units.

11. The system according to claim 10, wherein said first picker assembly mounted to a rail upon which the picker assembly is arranged to move along the linearly defined path.
- 5 12. The system according to claim 10 or 11, wherein said first picker assembly is arranged to move along an axis perpendicular to the linearly defined path so as to engage units at periphery of wafer frame.
- 10 13. The system according to any one of claims 7 to 12, wherein the second inspection station is arranged to inspect the units for the location and alignment of fiduciary marks.
- 15 14. The system according to any one of claims 7 to 13, wherein the third inspection station is arranged to inspect the units for defects in balls or pads of said units.
- 15 15. The system according to any one of claims 10 to 14, wherein the second engagement device includes a second picker assembly.
- 20 16. The system according to claim 15, wherein said second picker assembly mounted to the rail and arranged to move along the linearly defined path.

17. The system according to claim 15 or 16, wherein said second picker assembly is arranged to move along an axis perpendicular to the linearly defined path so as to place units at the periphery of the sorting station.
- 5 18. The system according to any one of claims 7 or 17, wherein the pre-defined categories include “good” and “defect” categories, defined by output from any one or a combination of the first, second or third inspections stations.
- 10 19. The system according to claim 18, wherein the sorting station includes receptacles for receiving respective “good” and “defect” units, said second picker arranged to move the units to said respective receptacles.
- 15 20. The system according to claims 18 or 19, wherein the pre-defined categories further include a “re-work” category, said sorting station further including a receptacle to receive said “re-work” units.
21. The system according to any one of claims 7 or 17, wherein the sorting station includes a fourth inspection station arranged to confirm or otherwise the presence of individual units or balls within the “good” unit receptacle.