

METHOD AND APPARATUS FOR INTEGRATED CIRCUIT INSPECTION

Field of Invention

- 5 The invention relates to the processing of integrated circuit units and in particular, processing of substrates containing said units prior to the singulation of the units from the substrates.

Background of the Invention

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In processing integrated circuit units, a key economic factor is the rate at which units are processed, measured in UPH (Units Per Hour).

- The units are formed in arrays and placed on substrates which are subsequently
15 singulated in order for the units to be individually applied. In the formation of the substrates, solder balls are fixed to the substrates to act as electrodes for later use. It is outside the scope of the present specification to describe the process of fixing the solder balls. However, the last step in the process is the final engagement of the balls to the units through the substrates passing a reflow oven. From here, the substrates are
20 transported to a device for singulating the substrate into individual units.

The specific means of singulating the substrates are also outside the scope of the present specification. However, between the reflow oven and the singulation machine, there are

opportunities for facilitating the process of the substrates so as to maintain or increase the UPH through the singulation device.

The present invention therefore, seeks to enhance the facilitation of the substrates through the singulation device so as to further enhance the UPH rate of this downstream process.

Summary of Invention

10 In a first aspect the invention process a system for inspection and collating substrates comprising a receiving rack in communication with a reflow oven; said receiving rack arranged to receive a plurality of substrates from said reflow oven; an inspection device for inspecting said substrates and recording a status of each inspected substrate; a collector for receiving said substrates from said receiving rack, the collector including a
15 racking device for collating the substrates according to the recorded status.

In a second aspect the invention process A method for inspection and collating substrates, the method comprising the steps of: receiving substrates from a reflow oven by a receiving rack; inspecting said substrates using an inspection device; conveying
20 said substrates to a collector from said receiving rack, and; collating said substrates by status, determined from the inspection device, using a racking device.

Accordingly the inspection system according to the present invention achieves two major goals. By placing an inspection station after the reflow oven, a further step in the

singulation process is removed and brought upstream. Typically, a singulation process represents a bottle neck and, therefore, removal of any step within this process may enhance the UPH rate for the device and, therefore, facilitate the singulation process. The implantation of a system in accordance with the present invention, therefore, has
5 the opportunity to remove the inspection step. The removal of this step may also be enhanced by adopting a device that increases the rate of inspection not possible within a singulation device. Accordingly, not only can the removal of the inspection step increase the UPH rate for the overall process, it may also facilitate a faster inspection not possible with the singulation device and so further increase UPH.

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In a still further embodiment, the means of increasing the inspection rate may include a continuous inspection process in that unlike inspection stages in devices of the prior art, the substrate passes continuously under the inspection device and so emulates a continuous process rather than a batch process. This may, therefore, lead to a faster rate
15 of inspection and, therefore, further enhance the UPH for the overall process.

In a still further advantage of the present invention, by detecting substrates containing a defect, said substrates can be removed from the overall process prior to processing by the singulation device. Accordingly, the singulation device, which represents a bottle
20 neck in the overall process, can avoid having to process defect substrates, or a high proportion of defect substrates, by only delivering substrates which a high level of integrity which can be determined from the earlier inspection stage. The singulation device will not process any substrates which subsequently would have been rejected by an inspection stage within the singulation process. Thus, the quality of substrates

entering the singulation stage may be dramatically increased and, therefore, still further increasing UPH.

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
10 preceding description of the invention.

Figure 1 is a flow diagram for a portion of the substrate process indicating the location of the device according to the present invention.

15 Figure 2A is an isometric view an inspection device according to one embodiment of the present invention;

Figure 2B is a detailed view of the device of Figure 2A;

20 Figure 3 is a plan view of the device shown in Figure 2A;

Figure 4 is an elevation view of the device according to Figure 2A;

Figure 5 is an isometric view of a magazine handler according to a further embodiment of the present invention.

Description of Preferred Embodiment

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Figure 1 shows the context into which one embodiment of the present invention fits. A process system 5 arranged to attach solder balls to the units within a substrate prior to delivery to a singulation device (not shown) which dices the substrate into individual units.

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Substrates prior to solder ball placement are loaded to the magazine loader 10, which load the substrates to the solder ball placement device, such as the device described in PCT/SG2007/000402, the contents of which are incorporated by reference.

15 Following placement of the solder balls, the substrates pass through the re-flow oven and washer device 20 to secure the solder balls and finalise the manufacture of the substrate.

According to the present invention, the reflow inspection device 25 is employed for
20 vision inspection of the solder balls after the reflow oven 20. This vision inspection 25 is arranged to check for missing solder balls, offset solder balls, extra solder balls and diameter error to the solder balls. The solder balls were attached to area-array package substrates via Solder Ball Placement Machines prior to Reflow Oven where they form the final interconnection to the substrate.

According to the present invention, and as shown in Figure 2A, the inspection device 25 comprises a receiving rack, which in this case is shown as a nestling conveyor 30, an inspection device 40 and a collector, which in this case is shown as a magazine handler

5 45. In the embodiment shown in Figure 2B, additional components are also shown including a multi-lane consolidator 35, a consolidator buffer 50, 95, and offload conveyor 60.

These specific components are described and shown in Figures 2 to 5. The receiving
10 rack, or nestling conveyor, 30 comprises a set of rollers within a bank of from 3 to 5 slots or lanes 90, 91, 92, 93 depending on the substrate width. The substrates roll into the lanes of rollers from the washer machine 20, where they are stopped by the stopper in each lane until the multi-lane consolidator 35 is indexed to the specific lane 90 and the stopper is lowered to allow the substrate to be transferred over.

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The multi-lane consolidator 35 forms a forward portion of a conveyor having multiple parts throughout the process. In this embodiment, the consolidator 35 comprises of a pair of guide rails 36A, B with driving belts, which are mounted on a linear slide driven
20 by stepper motor with feedback. The width of the guide rails 36A, B is adjustable by a stepper motor and corresponds to the width of the substrate that is keyed into the product recipe during initial setup. The Multi Lane Consolidator 35 receives the substrates from each of the respective lanes of the nestling conveyor 30 by indexing to the individual lanes. After receiving the substrate, the consolidator will index to the
25 after reflow inspection conveyor 55 with the stopper lowering to allow the substrate to transfer over to the conveyor 55.

- Consolidator buffer 96 comprises a buffer track 95 and a buffer bin 50 for the collection of substrates when there is no empty magazine or an error has occurred at the magazine handler 45. The buffer track 95 can hold up to 4 substrates and will roll the excess substrates into the buffer bin 50. The purpose of the consolidator buffer 96 is to prevent jam up at the nestling conveyor 30 as the conveyor of the reflow oven and the washer machine 20 will continuously feed substrates to the nestling conveyor 30. In a further embodiment the buffer track and bin may be replaced by a bin (not shown) for disposal or re-entering of substrates which are in excess of capacity at any given moment. The Multi Lane Consolidator will index to the bin position and roll the substrates into the bin.
- 15 After Reflow Inspection 40 comprises a camera 85 with low angle ring light 86 mounted on linear slide driven by servo motor. The camera 85 may be a line scan camera which will capture an image of an object while “on the fly” and the object position is feed back to the vision system by a linear encoder.
- 20 This “on the fly” inspection allows for the inspection process to become continuous, rather than a batch process, markedly increasing the rate of processing. By way of illustrative example, a substrate may take 6 to 7 seconds to pass the inspection device giving an indication of the rate of processing.

The line scan camera 85 has an advantage where it can capture large image at one time which is much faster than a normal area scan camera which need to take a few shots of the large object. The camera will capture the image of the substrate when it scans the substrate position by the linear encoder while the camera is being moved above the substrate with the low angle ring light switched on. The vision inspection will determine the status of each substrate by checking for missing balls, extra balls, ball diameter, ball pitch and ball to pad distance. If any of these defects are detected, the substrate will have a “defect” status, otherwise it will have a “good” status. This information is then communicated to the collector, which in the present example is a magazine handler. Communication may be through sending the information to a central database, or to a controller specifically connected with the magazine handler.

After Reflow Inspection Conveyor 55 comprises a pair of guide rails 56A,B with driving belts, substrate lifter and process top plate 57. On the conveyor 55, the substrate will be lift up by the substrate lifter to locate on top plate 57. There is also a vacuum lifter option to flatten wrapped substrates for better image quality.

The offload conveyor 60 comprises a pair of guide rails with driving belts and substrate offload pusher 61 driven by stepper motor. The width of the guide rails is adjustable by the stepper motor and it corresponds to the width of the substrate that is keyed into the product recipe during initial setup. The offload conveyor 60 receives the substrate from the after reflow inspection conveyor 55 and then send it to the magazine by the offload pusher 61.

The collector, in this case a magazine handler 45 comprises an empty magazine conveyor 75, good magazine conveyor 80, reject magazine platform 70 and dual magazine grippers 65. The empty magazine conveyor 75 is where empty magazines or cassettes are inserted. A rubber belt driven by the rollers and motor moves the empty magazine towards the magazine grippers 65. The dual magazine grippers 65 comprise 2 grippers where the upper gripper 67 is for holding reject magazines and the lower gripper 66 is for holding good magazines. The good or reject substrates which are determined by the inspection device 40 are pushed into the respective magazines. The good magazine gripper 66 will then pick up the empty magazine and index first substrate slot to the offload conveyor 60. The offload pusher 61, from the offload conveyor 60, pushes the substrate into first substrate slot in the magazine. The magazine gripper 65 will then index to the next substrate slot. This process repeat until the magazine is full. Once the magazine is full, the good magazine grippers 66 will place the full magazine on the good magazine conveyor 80 where the full magazines can be removed by the operator. The reject magazine gripper 67 also picks up the empty magazine from the empty magazine conveyor 75.

Once there is any reject substrate, the reject magazine gripper 67 will index to the offload conveyor 60. The reject magazine gripper 67 will place full reject magazine onto the reject magazine platform 70 which can hold 2 magazines. The reject magazine platform 70 is mounted on a slide driven by cylinder which will only shuttle in when the reject magazine gripper is offloading the full reject magazine. The dual magazine grippers 65 are an effective cost saving design which performs dual functions with only

a set of robot. There is an option of low cost design where the reject magazine gripper is replaced by a bin and the offload pusher will push reject substrate into this bin. For this low cost design, the reject magazine platform 70 can also be removed and the operator can remove the reject substrates from the bin.

Claims

1. A system for inspection and collating substrates prior to a singulation process for singulating the substrates into individual units, the system comprising
 - 5 a receiving rack in communication with a reflow oven; said receiving rack arranged to receive a plurality of substrates from said reflow oven;
 - an inspection device for inspecting said substrates and recording a status of each inspected substrate;
 - a collector for receiving said substrates from said receiving rack, the
 - 10 collector including a racking device for collating the substrates according to the recorded status.
2. The system according to claim 1 wherein said receiving rack includes a bank of slots, each slot arranged to receive a substrate.
- 15 3. The system according to claim 2 wherein said conveyor system includes a consolidator adjacent to the receiving rack for receiving the substrates from said receiving rack, the consolidator arranged on a linear slide so as to move to a respective slot containing the respective substrate.
- 20 4. The system according to claim 3 wherein the consolidator includes a buffer whereby substrates may be stored prior to conveying to the collector.

5. The system according to claim 4 wherein the buffer includes a buffer conveyor for conveying substrates in the buffer to a bin.
6. The system according to claim 3 wherein the conveyor is arranged to continuously convey the substrates via the inspection device.
7. The system according to any one of the preceding claims wherein the inspection device is arranged to communicate the status of each substrate inspected to the collector.
8. The system according to claim 7 wherein the collector includes at least one gripper for engaging substrates on the conveyor and moving said substrates to respective locations based upon the status received from the inspection device.
9. The system according to claim 7 or 8 where the collector includes two grippers, the first for engaging substrates having a status of "defect" and placing these in a reject zone and a second gripper for engaging substrates having a status of "good" and moving these to a good zone.
10. A method for inspection and collating substrates prior to a singulation process for singulating the substrates into individual units, the method comprising the steps of:
 - receiving substrates from a reflow oven by a receiving rack;
 - inspecting said substrates using an inspection device;

conveying said substrates to a collector from said receiving rack; and
collating said substrates by status, determined from the inspection device,
using a racking device.

- 5 11. The method according to claim 10 wherein said conveying step includes the steps
of: indexing a consolidator to a slot of the receiving rack and then receiving the
substrate from said slot of the receiving rack.
- 10 12. The method according to claim 11 wherein the conveying step further includes the
step of storing substrates in a buffer of the consolidator prior to conveying to the
collector.
13. The method according to claim 12 further including the step of removing said
substrates from said buffer to a bin.
- 15 14. The method according to any one of claims 11 to 13 wherein the conveying step is
performed continuously via the inspection device.
- 20 15. The method according to any one of claims 10 to 14 wherein the inspecting step
includes communicating the status of each substrate inspected to the collector.
16. The method according to any one of claims 10 to 15 wherein the collating step
includes the steps of engaging the substrates, using a gripper, on the conveyor

and; moving said substrates to respective locations based upon the status received from the inspection device.

17. The system according to claim 1, wherein the inspection device is located between
5 a reflow oven and a singulation machine.
18. The system according to claim 1, wherein the inspection device is a line scan camera.
- 10 19. The system according to claim 1 further including a conveyor for conveying the substrates from the receiving rack to the collector via the inspection device.
20. The method according to claim 10 wherein the conveying step includes conveying the substrates from the receiving rack to the collector via the inspection device.