IMPROVED SINGULATION ASSEMBLY AND METHOD

Field of the Invention

The invention relates to the singulation of IC units from a substrate and in particular a system and method established for delivering said IC units to a singulation system.

Background

A key success factor in the manufacture of integrated circuits (IC) is the rate at which substrates containing multiple IC's can be diced. Measured in units per hour (UPH), increasing this rate is therefore important for the economic well being of the supplier of IC units, and therefore to the device used for the dicing. Investment in the capital infrastructure used for the singulation of the IC units is one limiting factor in the total UPH for the manufacturing establishment. A further limitation is available factory space in which said singulation devices can be located so as to maximize both the number of machines available and also the available factory floor space used to house said machine.

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A fully integrated system may occupy a space not including clearance space around said machine of 4.5 metres by 1.5 metres. A successful processor of said IC units would therefore seek to have as many of said machines within a fixed factory space so as to maximize UPH. However, the factory space is also a drain on infrastructure investment as said spaces must adopt clean room environments so as to avoid damage to the substrates and subsequent singulated IC units. Therefore, it is a serious economic decision to shift premises from an existing factory space to a new one in order to increase UPH. This is because the new factory space will require further infrastructure investment at a loss opportunity cost of the infrastructure already invested in the smaller factory space.

Therefore, in the holistic economic environment of processing of IC units, the footprint of the singulation system can be a serious limitation to the economic output of said organization.

An example of a prior art singulation system is that shown in PCT application no. PCT/SG2005/000288, the contents of which are incorporated herein by reference. Here the singulation system as shown in Figure 1 of the prior art specification represents a very large linear processing system occupying a footprint of 4.5 metres by 1.5 metres.

Summary of Invention

It is therefore an object of the present invention to increase efficiency by reducing the footprint of a singulation system.

In a first aspect the invention provides a system for processing a substrate comprising a loading device for loading the substrate to a first end of a linearly disposed storage area, said storage area adapted to receive the substrate at the first end and transport said substrate to a second end opposed to the first; a demounting device for demounting the substrate from the second end of the storage area in a direction orthogonal to a longitudinal axis of the linearly disposed storage area; a rail assembly adapted to receive the demounted substrate, and transport the substrate to a selection station in a direction parallel and opposed to the direction of travel of the storage area, said selection station adapted to inspect the substrate.

In a second aspect the invention provides a method of processing a substrate comprising the steps of loading the substrate to a first end of a linearly disposed storage area; transporting said substrate along the storage area to a second end opposed to the first end; demounting the substrate from the second end of the storage area in a direction orthogonal to a longitudinal axis of the linearly disposed storage area; transporting the substrate along a rail assembly in a direction parallel and opposed to the direction of travel of the storage area.

Thus by manipulating the process path of the integrated circuit from loading up to delivery to the singulation station, the overall footprint of the singulation system can be reduced.

Brief Description of Drawings

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 superseding the generality of the preceding description of the invention.

Figure 1 is a plan view of the singulation system according to one embodiment of the present invention;

Figure 2 is a plan view of the delivery system according to the embodiment shown in Figure 1;

Figures 3A and 3B show an onloader assembly according to one embodiment of the present invention;

Figures 4A and 4B show an inlet rail assembly according to a further embodiment of the present invention;

Figures 5A and 5B show a strip picker assembly and rotary laser chuck assembly according to a further embodiment of the present invention;

Figures 6A and 6B show a laser compartment according to a further embodiment of the present invention and;

Figures 7A and 7B show a strip picker assembly according to a still further embodiment of the present invention.

Description of Preferred Embodiment

The singulation system 5 of Figure 1 comprises a delivery system 10, a dicing station 15 and an unloading section 20. In this embodiment, the singulation system 5 incorporates the loading of substrates 25 to the delivery system 10 which subsequently pass through the singulation system following a quality assessment with the singulated IC units, that pass inspection, then delivered 30 to the unloading station 20.

As shown in more detail in Figure 2, the invention generally relates to the upstream portion of the system, being the delivery system 10 comprising 4 sections, namely the on loader assembly 40, the pusher 60, the inlet rail assembly 80 and the strip picker 100.

Referring now to Figures 3A and 3B, on loading the substrate to the on loader assembly 40, the substrate is passed by magazine 49 in a predetermined orientation, that is, with the longitudinal axis 51 of the substrate perpendicular to the direction of loading of the magazine 41. In this embodiment, the on loader assembly 40 acts as a storage means, as well as

a loading/delivery device, as multiple substrates can be stored on multiple magazines in the on loader 40 from the upper stage 46 to the lower stage 42 as they pass through the on loader 40. This is particularly so in the upper stage 46 whilst "racked" 49 prior to engagement by the magazine clamp 48. The substrates are transported from the upper stage 46 to the lower stage 42 through the on loader via linear slides 44, 54 operated by servomotors. A rubber belt 52 driven by rollers in communication with an electric or hydraulic motor towards the magazine clamp 48 is used for manipulation of the magazines 41 within the upper stage 46.

The magazine clamp 48 picks up the magazine 41 containing the substrate and indexes the first substrate to the substrate slot 50. In this embodiment, the magazine clamp 48 indexes the substrates vertically, so as to limit the plan area required. The individual substrates are subsequently pushed by the pusher 60 one substrate at a time on to the inlet rail 65 via the substrate slot 50. The pusher 60 pushes the substrates using a probe 62 which bears directly on the substrate in the magazine 41. In so doing, the probe 62 applies an axial load to the substrate, moving the substrate in a direction co-linear with the longitudinal axis of the magazine 41. Once all the substrates have been pushed to the inlet rail 65 the magazine clamp 48 will place the empty magazine 47 on the lower stage 42 where the empty magazines are subsequently removed by the operator.

With reference to Figures 4A and 4B, the inlet rail 80 comprises a pair of guide rails 82, a gripper chuck 88 and a framed lifter plate 84. The width of the guide rails 82 is adjustable by servomotor 92 which adjusts the guide rails to correspond to the width of the substrate. The frame lifter plate 84 has a top surface with apertures 83 for applying a vacuum force to hold the substrate. The gripper chuck 88 gripping action is via an air gripper cylinder 86 and the horizontal motion is driven by servomotor 90. The gripper chuck 88 will grip the substrate at the front and pull it along the guide rail 82 until it reaches the frame lifter plate. The gripper chuck 88 then pulls the substrate until the centre of the substrate coincides with the center 85 of the frame lifter plate 84. The gripper chuck 88 will then keep clear of the frame lifter plate 84 and the frame lifter plate 84 will be raised with the substrate mounted thereon to clear the guide rails 82. The strip picker 100 moves to the frame lifter plate 84 to pick up the substrate, using a separate vacuum nozzle (not shown).

With reference to Figures 5A and 5B, the strip picker assembly 101 comprises a linear slide 122, 123 and strip picker 100, said strip picker 100 including three location pins, to match the substrate locating holes for precise picking and placing of the substrate. The strip picker 100 also has two interlocking pins 127A,B, to match the locating holes in the frame lifter plate and the rotary laser chuck 120 for precise positioning. The strip picker 100 moves vertically using a servomotor and is mounted on the linear slide 122 for horizontal motion which is also driven by a servomotor. The strip picker 100 uses a vacuum to hold the substrate, and will pick up the substrate from the

frame lifter plate 84 and place it on the rotary laser chuck 120. The "alignment & orientation" (AO) vision camera 130 checks the substrate for alignment and orientation, as well as checking the substrate type. The AO vision camera 130 is also mounted on a linear slide 124 driven by a servomotor. The system compensates for the offset for minor misalignment for laser cutting by adjusting the rotary laser chuck 120 and the laser. The substrate will be rejected, and removed to a reject bin 125, if the alignment is outside of specification or if the substrate is of the wrong orientation or type.

The rotary laser chuck 120 comprises a rotary table 126 and a linear slide 135. The rotary motion is driven by a servomotor, with the linear slide 135 also driven by a servomotor using a linear encoder for greater precision in positioning. The rotary laser chuck 120 has a top surface 128 with apertures for a vacuum to hold the substrate. The rotary laser chuck 120 moves under a laser head 140 for the cutting process to begin. The rotary laser chuck 120 translates in horizontally from the strip picker 100 at a substrate loading position 131 to the laser head 132 and finally to the second strip picker substrate unloading position 133.

With reference to Figures 6A and 6B, the laser compartment 145 comprises two laser heads 140, an ion blower 150, a first suction hood 170, a safety door 155 and a second suction hood 180. The ion blower 150 blows off the fine particles inherent from the laser cutting with the first suction hood 170

"vacuuming" away these particles. Further, there is a safety door 155 for periodic preventative maintenance.

The laser heads 140 act to cut the IC substrate to the desired shape. In particular, the laser heads may be adapted to perform profile cutting of the IC's to match complex shapes including curvilinear shapes which may be required of irregular shaped SD cards and similar devices. Such laser cutting may be further advantageous given the inflexibility for a dicing saw to perform such curvilinear cuts. Further laser cutting may be further advantageous over the use of a dicing saw in that waste material which may adhere to saw and affect the quality of the cut, does not present such a problem for a laser cut, and may be more easily removed. In cases where these advantages are maximized with the dicing speed of a saw, the laser heads 140 may be adapted to perform partial cutting of the IC's, such as for the curvilinear portions, with linear portions performed by a dicing saw.

As discussed, in preferred embodiment, the laser heads 140 may be arranged to provide any one, or a combination, of full peripheral cuts, partial peripheral cuts, and cuts of the IC of varying depth. The last option of cutting to variable depth is particularly advantageous when the IC is too thick for a single pass, and so multiple passes may be necessary. Such thick IC's may relate to sandwich construction or arrangement that creates an IC of non-standard thickness. Alternatively, the IC may be a sandwich construction of dissimilar materials having, for instance, different thermal characteristics, and so different

levels of thermally formed internal stresses. Thus cutting of said IC's may lead to differential warping of the IC. In this case either partial peripheral or partial depth cutting of the IC may be advantageous.

The second suction hood 180 is used to suck out the debris on the substrate after it is cut with the rotary laser chuck 120 then rotated at 90°. It is also used to suck the debris on the rotary laser chuck 120 after the cut substrate is unloaded, before the new substrate is loaded. In this embodiment, the first suction hood 170 and second suction hood 180 do not necessarily operate together as there is only one rotary laser chuck 120, and so they can share the same vacuum source with a toggle valve. After laser cutting, the rotary laser chuck 120 will move out of the laser compartment 145 for inspection and unloading of the substrate.

With reference to Figures 7A and 7B, the strip picker assembly 160 comprises a camera 190 and a second strip picker 165. The "cutting function" (CF) vision camera 190 inspects the laser cut substrate and output if the substrate is cut or not. If the laser is not functioning, the whole machine will stop to prompt the user that there is a laser error and consequently the substrate can be removed from the rotary laser chuck 120 without further disruption. The (CF) vision camera 190 can also check for any offset in cutting of substrate.

The rotary laser chuck 120 will rotate 90° so as to align the substrate to the dicing chuck table for the next process. The second strip picker 165 will pick up

the substrate from the rotary laser chuck 120 and place it on the interface block 200. The rotary chuck table 120 will then move to the second suction hood 180 to remove the debris from the laser cutting before returning to the loading position 131 for the next substrate.

The interface block 200 on the dicing machine comprises a stationary top surface 205 with apertures for a vacuum force to hold the laser cut substrate. The substrate will wait at the interface block 200 for the frame lifter (not shown) from the dicing machine to pick it up for sawing.

Claims :

1. A system for processing a substrate comprising

a loading device for loading the substrate to a first end of a linearly disposed storage area, said storage area adapted to receive the substrate at the first end and transport said substrate to a second end opposed to the first;

a demounting device for demounting the substrate from the second end of the storage area in a direction orthogonal to a longitudinal axis of the linearly disposed storage area;

a rail assembly adapted to receive the demounted substrate, and transport the substrate to a selection station in a direction parallel and opposed to the direction of travel of the storage area, said selection station adapted to inspect the substrate.

2. The system according to claim 1, wherein storage area comprises a receiving portion at the first end for receiving the loaded substrate, a conveyor to move the substrate from the receiving portion to the second end and a demounting portion at the second end for the substrate at which point the substrate is stationery until acted upon by the demounting device.

3. The system according to claim 2, wherein the demounting device comprises a locating means for detecting that the substrate has reached the second end and an actuator for biasing the substrate from the demounting portion to the rail assembly.

4. The system according to claim 3, wherein the rail comprises a guiding apparatus of adjustable width, said width adjustable to accommodate the width of the substrate.

5. The system according to claim 4, wherein the guiding apparatus comprises a pair of parallel guide rails in communication with a motor for adjusting the distance between said rails.

6. The system according to any one of the preceding claims, wherein the demounting device comprises a projection mounted to a linear slide, such that the projection contacts the substrate and pushes the substrate in the orthogonal direction through movement of the linear slide.

7. The system according to any one of the preceding claims, wherein the rail assembly further comprises a lifter plate onto which the substrate is demounted said lifter plate having apertures in

communication with a vacuum source to hold the substrate to the lifter plate.

8. The system according to claim 7, wherein the rail assembly further comprising a gripper chuck for engaging the substrate and positioning it onto the lifter plate.

9. The system according to any one of the preceding claims, wherein the rail assembly further comprises a first picker assembly having a vacuum nozzle arrangement to engage the substrate at the lifter plate, said picker assembly including a motor and rail upon which the vacuum nozzle arrangement is movable from the lifter plate to the selection station.

10. The system according to claim 9, wherein the selection station comprises a laser chuck assembly, said laser chuck assembly comprising a laser chuck mounted to a rail, said laser chuck adapted to receive the substrate from the picker assembly and pass the substrate along said rail so as to permit inspection of said substrate by an inspection device.

11. The system according to claim 10, wherein said inspection device includes an orientation and alignment vision camera for determining pre-determined parameters of the substrate within the laser chuck.

12. The system according to claim 11, wherein the pre-determined parameters include any one or a combination of: substrate type, alignment and orientation.

13. The system according to any one of claims 9 to 12, wherein said laser chuck assembly adapted to move the laser chuck with said substrate along the rail, from the inspection device to a cutting zone within a laser cutting apparatus.

14. The system according to any one of claims 9 to 13, wherein said laser chuck assembly adapted to move the laser chuck with said substrate along the rail, from the laser cutting apparatus to a substrate unloading position.

15. The system according to any one of claims 13 or 14, wherein said laser cutting apparatus comprises at least one laser cutting head, an ion blower for blowing residue particles from the cutting zone to a suction hood.

16. A method of processing a substrate comprising the steps of:

loading the substrate to a first end of a linearly disposed storage area,

transporting said substrate along the storage area to a second end opposed to the first end;

demounting the substrate from the second end of the storage area in a direction orthogonal to a longitudinal axis of the linearly disposed storage area;

transporting the substrate along a rail assembly in a direction parallel and opposed to the direction of travel of the storage area.

17. The method according to claim 16, wherein the demounting step comprises the steps of :

detecting that the substrate has reached the second end, and;

biasing the substrate from the demounting portion to the rail assembly.

18. The method according to claim 17, wherein the biasing step comprises the steps of:

contacting the substrate with a projection mounted to a linear slide, and;

pushing the substrate in the orthogonal direction through movement of the linear slide to a lifter plate.

19. The method according to any one of claims 16 to 18, further comprising the steps, after the pushing step, of:
engaging the substrate with a vacuum nozzle arrangement, and;
moving said substrate from the lifter plate to the selection station.

20. The method according to claim 19, further comprising the step, after the moving step, of:
inspecting said substrate using an inspection device at the selection station.

21. The method according to claim 20, wherein the inspecting step comprises inspecting the substrate using an orientation and alignment vision camera, and determining pre-determined parameters of the substrate within the laser chuck.

22. The method according to claim 21, wherein the pre-determined parameters include any one or a combination of: substrate type, alignment and orientation.

23. The method according to claim 21 or 22, further comprising the step, after the inspecting step, of moving the laser chuck with said substrate along the rail, from the inspection device to a cutting zone within a laser cutting apparatus.

24. The method according to claim 23, further comprising the step, after the moving step, of cutting the substrate using the laser cutting apparatus, then moving said laser chuck with said substrate along the rail, from the laser cutting apparatus to a substrate unloading position.