

IMPROVED SINGULATION SYSTEM AND METHOD

Field of the Invention

5 The invention relates to integrated circuits (IC) and the manufacture thereof. In particular, the invention relates to the singulation of IC's from a substrate containing a plurality of the IC's. More specifically, the IC's are those having complex plan shapes comprising a combination of linear and profile portions.

10 Background

 A growing market for IC's is their application for memory cards such as micro SD cards used in a range of applications including cameras, PDA's, MP3 players etc. A characteristic of the micro SD card is the change in shape from a routinely square or
15 rectangular IC to, instead, requiring a more complex shape including not only linear portions around the peripheral edge of the IC, but also portions having curve linear shape or more generally profiles. The profile portions of the SD cards include chamfers whereby a corner of the rectangle is removed, recesses to accommodate fittings within the device and curved portions again fittings of the device or even as aesthetic appeal.

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 Traditionally square and rectangular IC's are diced or singulated using a dicing saw which can efficiently cut long, linear edges of a substrate, singulating IC's quickly and efficiently. With the introduction of a profiled plan shape dicing saws are less efficient as, for instance, a chamfered corner must be angled at potentially non-standard angles. For more
25 delicate actions, such as indenting a recess into the edge of an IC, dicing saws are poorly suited indeed. For curvi-linear shapes, it is in fact not feasible to use a dicing saw.

 To overcome the shortcomings of a dicing saw, the IC's maybe punched whereby a suitably shaped die pushes into the substrate to shear the IC unit from the substrate. While
30 achieving the desired shape can be quickly and efficiently removed from the substrate, such punching processes have the drawback of causing damage to the substrate as well as localised damage along the edges of the IC's and so leading to excessive wastage.

Alternatively, a router maybe used, by guiding the cutting portion around the desired edge. Again this achieves the result, however, the tolerance required for a router is typically high and so reducing the effective numbers of IC's that can be incorporated onto a substrate.

5 Further operating a router around a complex shape is extremely time consuming, as the process is relatively slow compared to that of a saw. The consequence of using a router is the reduction in the "units per hour" (UPH), which is the measure of efficiency of a dicing machine. Thus, whilst a router achieves the desired result, the UPH resulting from the router is typically below an economic threshold for the manufacturing process.

10 A further alternative is to use a water jet or a fluid jet cutting device. Here the jet nozzles which maybe in the range of 0.4 mm to 0.2 mm in diameter provide high velocity fluid such as water within a concentrated region at high pressure. The water may have an abrasive material to aid the cutting process, which also has a highly detrimental effect on the
15 nozzle of the water jet requiring continual replacement proportional to use. A further drawback of a water jet system is the speed at which a water jet nozzle may be operated being consistently slower than a dicing saw, which must be balanced against the effectiveness of the water jet system to accommodate complex cutting. Further, repeated down time caused by clogging of the nozzles or damage through corrosion further limits the economic benefit of
20 the water jet. Further still, special brackets and jigs are required to support an IC being cut by a water jet, as compared to simple vacuum arrangement of dicing saws.

Statement of Invention

25 It is therefore an object of the present invention to provide a system that can singulate an IC having a combination of linear and profile shaped edges, at a UPH in excess of the prior art systems.

In a first aspect the invention provides a system for singulating an IC unit from a
30 substrate, said IC unit having a combination of linear and profile peripheral edges, said system comprising a profile cutting device for cutting the profile portions of the IC unit; a

longitudinal cutting device for cutting the linear portions of the IC unit, said cutting means located within a singulation zone.

5 In a second aspect, the invention provides a method for singulating an IC unit from a substrate, said IC unit having a combination of linear and profile peripheral edges, said method comprising the steps of profile cutting the profile portions of the IC unit using a profile cutting device, and longitudinal cutting the linear portions of the IC unit using a longitudinal cutting device, said cutting steps occurring within a singulation zone.

10 Thus in addressing the IC's having a combination of linear and profile edges, the present invention addresses this by using a combination of cutting processes.

This has the advantage of optimising the speed of the longitudinal cutting device, and the flexibility of the profile-cutting device, so as to maximise UPH.

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In a preferred embodiment, the present invention may further include a sorting means for sorting the singulated IC units into categories, said categories may comprise one or a combination of pass, reject and rework.

20 In a preferred embodiment, the present invention may further comprise a loading means for loading the substrate to the singulation zone.

In a preferred embodiment, the present invention may further include an off-loader for removing the singulated IC units from the singulation zone.

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In a preferred embodiment, the profile-cutting device may include any one or a combination of water jet cutter, an air jet cutter and a laser cutter. The fluid-type profile cutters, such as water and air, suffer from considerable abrasion and wear. Particularly if an abrasive grit is used in the fluid to enhance the cutting action. As a result, such a nozzle of the
30 cutter may have a very limited life, in conventional circumstances. By using the profile cutter in combination with the longitudinal cutting device, the usage of the profile-cutting device per unit will be reduced, as a proportion of the IC will be cut by the longitudinal cutting device.

Consequently, whilst the life of the profile-cutting device is short, the life measured “per IC unit” is considerably lengthened.

5 In a preferred embodiment, the longitudinal cutting device may include a dicing saw having a single or dual blade.

10 In a third 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
15 adapted to inspect the substrate.

20 In a fourth 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.

25 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.

30 In a fifth aspect, the invention provides a method of singulating a plurality of IC units from a first substrate, comprising the steps of: loading the first substrate to a first location on a singulating table, whilst said table is in a first position; performing a first pre-determined cut of a first portion of the first substrate; lifting the first substrate from the singulating table;

rotating the singulating table from the first position to a second position; replacing the first substrate to a second location on the singulating table; performing a second pre-determined cut of a second portion of the first substrate so as to singulate the plurality of IC units from the first substrate.

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In a sixth aspect, the invention provides a system for singulating a plurality of IC units from a first substrate, comprising a loading means adapted to load the first substrate to a first location on a singulating table; a first cutting means for performing a first pre-determined cut of a first portion of the first substrate; a lifting means for lifting and replacing the first substrate from the singulating table; said table including rotation means for rotating from a first position to a second position; a second cutting means for performing a second pre-determined cut of a second portion of the first substrate so as to singulate the plurality of IC units from the first substrate, wherein the lifting means is adapted to replace the first substrate to a second location on the singulation table following rotation of the table from the first to the second position.

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Accordingly, by lifting the substrate from the table, rotating the table and replacing the substrate, the orientation of the substrate is changed. This permits dedicated cutting apparatus to act on specific areas of the singulation table, and by changing the orientation of the substrate relative to the cutting apparatus in the middle of the process, will increase the throughput rate, measured in "units per hour" (UPH), whilst still providing the flexibility to use different types or different oriented cutting apparatus.

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The system is adaptable to a range of singulation devices, such as that disclosed in PCT/SG2005/000288, the contents of which are incorporated herein by reference. By making suitable modification to the chuck table and dicing machine, designated as "4" and "Z" respectively in Figures 1(a) and 1(b) of PCT/SG2005/000288, the system according to the present invention can be incorporated accordingly.

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It will be clear to the skilled addressee that the system according to the present invention could be incorporated into other types of dicing machine, and so reference to the device of PCT/SG2005/000288 shall not be construed as limiting but merely illustrative.

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In a preferred embodiment, the first pre-determined cut may be along the x-axis of the substrate, being parallel to a longitudinal axis of the substrate. Further, the second pre-determined cut may be along the y-axis, or laterally across the substrate.

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Alternatively, the first predetermined cut may be a linear cut and the second pre-determined cut may be a profile cut. Thus, for complex shaped IC units, the different peripheral shapes of the IC may be cut in two different locations on the singulation table.

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In a preferred embodiment, the method may include loading a second substrate to the second location on the singulating table, adjacent to the first substrate, whilst said table is in the first position. Thus, the second substrate may be cut concurrently with the first, in the adjacent location on the singulation table to the first. That is, whilst the first substrate is experiencing the first pre-determined cut, the second substrate may be experiencing the second pre-determined cut. On completion of this stage, the substrates may then be lifted, the table rotated, and the substrates replaced. Thus, the substrates have effectively swapped position, and accordingly swapped process, such that the first substrate may undergo the first pre-determined cut, and the second substrate subjected to the first pre-determined cut.

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In a preferred embodiment, for linear cuts performed on the substrate(s), said cuts may be performed by a dicing saw. Further, where the cuts may be profile cuts, these may be performed by proprietary apparatus adapted to the cutting of substrates, such as would be well known to the skilled addressee. For instance, a water jet cutter (for example, cutters providing a water jet, with or without abrasives at 10 ksi/700 bar, and performing a cut in the range 0.2 mm to 0.5 mm), a laser cutter (for example, a pulse-excited solid-state laser), an air jet cutter, a router or drilling device. Alternatively, the profile cut may be achieved using dicing blades of a specific shape, and so adapted to meet specific criteria, including profile shape to be cut, material of substrate, and quality or speed of cutting action.

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In a preferred embodiment, the invention may include means for unloading the singulated IC units. In a more preferred embodiment, this may include a vacuum picker, such

as that disclosed in Figure 11 of PCT/SG2005/000288, or other suitable device for the appropriate engagement and lifting of a single IC unit.

In a preferred embodiment, the means for rotating the singulation table may include,
5 but limited to, a hydraulic or electrical motor mounted to a rotatable shaft upon which the table is mounted. Alternatively, the table may be mounted to bearing such that said motors rotate the table within a frame, possibly within a recess to control the path of rotation. Said table may be rotated under automatic control, for instance through communication with a control system operating this part of the process. Further, said table may be adapted to rotate
10 180° and then return to its original position. Alternatively, the table may rotate a full 360°. In a still further embodiment the table may selectively rotate from 0° to 360°.

In a more preferred embodiment, the system according to the present invention may further include a control system for control the process, either through direct operator input,
15 pre-determined sequence or a closed loop control such that the sequence, speed or other actions may influence or control the process. Other actions may include failure of the system or associated upstream and downstream process, or quality system for accepting rejecting or re-working the substrate prior to cutting or the singulated IC units.

In a preferred embodiment the steps of performing either the first and/or second pre-determined cuts may include a selective incremental rotation of the singulating table to meet specific criteria for the first and/or second pre-determined cuts. In a more preferred embodiment said criteria may include accommodating small variations in the cut for instance, a substantially linear cut may include a small recess. It may not be economic to designate the
25 cut as a profile cut and so a small rotation of the table may permit a linear cut, angled to the major linear cut and so have the overall action performed by a linear cutting device such as a dicing saw rather than a possibly less efficient profile cutting device for only a small variation. To this end, the table may be selectively rotatable from 0° to 360°. Said selective rotation may be to accommodate such a variation in the cut. Alternatively the rotation of the
30 table may be to accommodate misalignment of the substrate or other reasons that may benefit the cutting process.

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
5 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.

Figures 1A and 1B are plan views of IC's having a combination of linear and profile
10 edges;

Figure 2 is a schematic view according to a first embodiment of the present invention;

Figure 3 is a schematic view according to a second embodiment of the present invention.

Figure 4 is a plan view of the singulation system according to one embodiment of
15 the present invention;

Figure 5 is a plan view of the delivery system according to the embodiment shown in Figure 1;

Figures 6A and 6B show an onloader assembly according to one embodiment of the present invention;

20 Figures 7A and 7B show an inlet rail assembly according to a further embodiment of the present invention;

Figures 8A and 8B show a picker assembly according to a further embodiment of the present invention;

Figures 9A to F show a laser compartment and twin table assembly according to a
25 further embodiment of the present invention;

Figures 10A to D show a strip picker assembly according to a still further embodiment of the present invention;

Figures 11A to D show an interface rotary block according to a further embodiment of the present invention;

Figures 12A to I show sequential steps of a process according to one embodiment of the present invention.

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Description of Preferred Embodiment

Figures 1A and 1B show two examples of IC's having a combination of profile and linear edges. Whilst shapes will differ considerably between end use applications, memory capacity and aesthetic requirements, the IC's shown provide typical elements that are common among similar devices.

Figure 1A shows an IC 5 having a substantially rectangular shape. The IC 5 has linear edges 15a to d. detracting from the regular rectangular shape are a variety of profile portions. Whilst the linear portions may be conventionally diced by a dicing saw, the profile portions may be less easily accommodated. At two corners of the IC 5, are filleted corners 25a, b, having a set radius. Further one linear edge 15d is interrupted by an inclined portion 20a, similar to an inclined step in the edge 15d. A smaller discontinuity 30 is placed at a point along the opposed linear edge 15b.

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Figure 1B shows an alternative IC 10. Again, the IC 10 is substantially rectangular in shape, having linear portions 18a to d. However, one edge of the IC 10 instead incorporates a circular portion 35 almost along one edge of the IC 10, with only very short linear portions 45a, b on either side finishing the edge. Further, a rectangular recess 40, having steps 50a,b indenting the recess 40 into the IC 10, and so dividing one edge into two linear portions 18a,b. Lastly, one corner has been chamfered 20b.

Figures 2 and 3 show alternative embodiments 55, 80 of the invention. In Figure 2, the system 55 includes an onloader 60 for loading the substrate to a singulation zone (not shown) ready to be processed. The substrate is cut using a profile cutting device, in this case a water jet cutter 65, which cuts the profile portions of the IC for the entire substrate. The remaining

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portions of the IC's, being the longitudinal linear edges are cut using an appropriate cutting device, in this case a dicing saw 70, which completes the singulation process.

5 The singulated IC's are then sorted in terms of quality, such as "pass", "reject" and "rework" then offloaded to the appropriate station or a reject bin.

The system is adaptable to a range of singulation devices, such as that disclosed in PCT/SG2005/000288, the contents of which are incorporated herein reference. By making suitable modification to the chuck table and dicing machine, designated as "4" and "Z" 10 respectively in Figures 1(a) and 1(b), the system according to the present invention can be incorporated to accommodate IC's having a profile edge, whilst maintaining an acceptable UPH.

15 It will be clear to the skilled addressee that the system according to the present invention could include incorporated within other types of dicing machine, and so reference to the device of PCT/SG2005/000288 shall not be construed as limiting but merely illustrative.

Profile cutters of this type include laser cutters, such as pulse-excited solid-state lasers, water jet cutters, including those with and without abrasives in the water jet, and air jet 20 cutters.

Figure 3 shows an alternative arrangement where the longitudinal cutter 90 is implemented first, and then the profile cutter 95 next. Similar to the previous embodiment, the first cutter in this case a dicing saw 90, partially cuts the peripheral edges of the IC's. The 25 profile cutter, such as a water jet 95, finishes the job by cutting the remaining profile edges.

There are a number of parameters that need to be met for such a system. One such issue includes the proportion of the peripheral edge to be cut by the longitudinal cutter as compared to the profile cutter. To determine this the shape of the required IC must be known. 30 This may be "hard-wired" into the controller of the device, and so there may be visual recognition due to a camera arrangement identifying "fiducial" marks on the substrate. In this case, the proportion of longitudinal cuts to profile cuts may be well established.

As profile-cutting devices are considerably slower than longitudinal cutting devices, for instance a comparison between a water jet and a dicing saw, it will be preferable to minimise the use of the water jet so as to increase UPH. Further, the greater the use of the water jet, the higher the abrasion on the after jet nozzle and so shorten the life of the water jet compared with the overall life of the system. However, the effectiveness of a dicing saw to cut, for instance, the longitudinal portions 45a, b of Figure 1B, may make tooling and tolerance difficult, outweighing the benefit of the speed of cut. The longitudinal portions 18a, b of Figure 1B, being longer may, in the determination of performance, be better suited to longitudinal cutting.

Alternatively, the detection system may identify the shape of each IC, or batch of IC's, and determine the proportion based on speed of process, maintenance costs and complexity of shape. Thus, a processor within the controller may be capable of determining an optimum proportion, based on pre-determined parameters, such as total production run, proportion of profile edges to linear edges, required speed of production, type of profile cutting device used etc.

Figure 4 shows one embodiment of the present invention whereby the schematic shown in Figure 2 has a laser cutting device replacing the water jet 65. Specifically, the singulation system 105 of Figure 4 comprises a delivery system 110, a dicing station 115 and an unloading section 120 and 130. In this embodiment, the singulation system 105 incorporates the loading of substrates 125 to the delivery system 110 which subsequently pass through the singulation system following a quality assessment with the singulated IC units that pass inspection, and then delivered through 120 to the unloading station 130.

As shown in more detail in Figure 5, the invention generally relates to the upstream portion of the system, being the delivery system 110 comprising 8 sections, namely the on loader assembly 140, the pusher 160, the inlet rail assembly 180, the strip picker 200, the twin laser table assembly 220, the laser head assembly 240, the second strip picker 260 and the interfacing rotary block 300.

Referring now to Figures 6A and 6B, on loading the substrate to the on loader assembly 140, the substrate is passed by magazine 149 in a predetermined orientation, that is, with the longitudinal axis 151 of the substrate perpendicular to the direction of loading of the magazine 141. In this embodiment, the on loader assembly 140 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 140 from the upper stage 146 to the lower stage 142 as they pass through the on loader 140. This is particularly so in the upper stage 146 whilst "racked" 149 prior to engagement by the magazine clamp 148. The substrates are transported from the upper stage 146 to the lower stage 142 through the on loader via linear slides 144, 154 operated by servomotors. A rubber belt 152 driven by rollers in communication with an electric or hydraulic motor towards the magazine clamp 148 is used for manipulation of the magazines 141 within the upper stage 146.

The magazine clamp 148 picks up the magazine 141 containing the substrate and indexes the first substrate to the substrate slot 150. In this embodiment, the magazine clamp 148 indexes the substrates vertically, so as to limit the plan area required. The individual substrates are subsequently pushed by the pusher 160 one substrate at a time on to the inlet rail 165 via the substrate slot 150. The pusher 160 pushes the substrates using a probe 162 which bears directly on the substrate in the magazine 141. In so doing, the probe 162 applies an axial load to the substrate, moving the substrate in a direction co-linear with the longitudinal axis of the magazine 141. Once all the substrates have been pushed to the inlet rail 165 the magazine clamp 148 will place the empty magazine 147 on the lower stage 142 where the empty magazines are subsequently removed by the operator.

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With reference to Figures 7A and 7B, the inlet rail 180 comprises a pair of guide rails 182, a gripper chuck 188 and a framed lifter plate 184. The width of the guide rails 182 is adjustable by servomotor 192 which adjusts the guide rails to correspond to the width of the substrate. The frame lifter plate 184 has a top surface with apertures 183 for applying a vacuum force to hold the substrate. The gripper chuck 188 gripping action is via an air gripper cylinder 186 and the horizontal motion is driven by servomotor 190. The gripper chuck 188 will grip the substrate at the front and pull it along the guide rail 182

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until it reaches the frame lifter plate. The gripper chuck 188 then pulls the substrate until the centre of the substrate coincides with the center 185 of the frame lifter plate 184. The gripper chuck 188 will then keep clear of the frame lifter plate 184 and the frame lifter plate 184 will be raised with the substrate mounted thereon to clear the guide rails 182. The
 5 strip picker 200 moves to the frame lifter plate 184 to pick up the substrate, using a separate vacuum nozzle (not shown).

With reference to Figures 8A and 8B, the strip picker assembly 201 comprises a linear slide 222, 223 and strip picker 200, said strip picker 200 including three location
 10 pins, to match the substrate locating holes for precise picking and placing of the substrate. The strip picker 200 also has two interlocking pins 227A, B, to match the locating holes in the frame lifter plate and the twin laser table unit for precise positioning. The strip picker 200 moves vertically using a servomotor and is mounted on the linear slide 222 for horizontal motion which is also driven by a servomotor. The strip picker 200 uses a vacuum
 15 to hold the substrate, and will pick up the substrate from the frame lifter plate 184 and place it on the twin laser table unit. The "alignment & orientation" (AO) vision camera 230 checks the substrate for alignment and orientation, as well as checking the substrate type. The AO vision camera 230 is also mounted on a linear slide 224 driven by a servomotor. The system compensates for the offset for minor misalignment for laser cutting by adjusting
 20 the twin laser table unit and the laser. The substrate will be rejected, and removed to a reject bin 225, if the alignment is outside of specification or if the substrate is of the wrong orientation or type.

With reference to Figures 9A to 9F, there is shown a twin laser table unit 220
 25 comprising linear slides 228A, B and a laser head 240 positioned above said slides. The substrate is moved by the strip picker to the twin laser table unit 220, and in particular to blocks 229A, B capable of moving along the linear slides 228A, B from a receiving position 231, to a laser cutting position 232 and finally to an unloading position 233 from which the laser cut substrates are removed by a further picker assembly. Said movement
 30 may be through use of linear motors and linear encoders in order to locate the substrates within the desired degree of accuracy.

The laser head 240 comprises a single laser source which provides two cutting heads 239A, B from said single source. Said heads 239A, B receive the laser from an assembly of mirrors and lens in order to achieve the desired result. It will be clear to the skilled person how to achieve the desired twin beam effect, the specifics of which shall not limit the scope of the invention to any one arrangement. The heads are offset in the Y-direction to allow the positioning of the blocks 229A, B as the substrates are cut simultaneously by the two heads 239A, B.

Also shown is a laser compartment 245, an ion blower 250, a first suction hood 270, a safety door 255 and a second suction hood 280. The ion blower 250 blows off the fine particles inherent from the laser cutting with the first suction hood 270 "vacuuming" away these particles. Further, there is a safety door 255 for periodic preventative maintenance.

The laser heads 240 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 240 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 a preferred embodiment, the laser heads 240 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.

5 The second suction hood 280 is used to suck out the debris on the substrate after it is cut with the twin laser table unit 220. It is also used to suck the debris on the twin laser table unit 220 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 twin laser table unit 220, and so they can share the
10 same vacuum source with a toggle valve. After laser cutting, the twin laser table unit 220 will move out of the laser compartment 245 for inspection and unloading of the substrate.

 With reference to Figures 10A to 10D, the strip picker assembly 260 comprises a camera 290 and a second strip picker 265. The "cutting function" (CF) vision camera 290
15 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 twin laser table unit 220 without further disruption. The (CF) vision camera 290 can also check for any offset in cutting of substrate.

20 The strip picker 265 is positioned on two orthogonal linear slides so as to pick up the laser cut substrate and permit longitudinal movement in the X-direction from the twin laser table unit to the interface rotary block. To accommodate the parallel linear slides 228A, B of the twin laser table unit 220, the strip picker 265 further permits linear movement in the Y-direction to alternate between the blocks 229A, B. In an alternative
25 arrangement, the strip picker assembly may include a twin strip picker so as to have a separate strip picker for each of the two blocks of the twin laser table unit. This may have the advantage of increasing the flow of laser cut substrates from the twin laser table unit to the interface rotary block.

30 With reference to Figures 11A to 11C, the interface rotary block 291 comprises a surface 292 onto which the laser cut substrate is placed. The surface is rotatable about a

the rotary table 294. The surface is in communication with a vacuum source to hold the laser cut substrate. The interface rotary block 291 on receiving the laser cut substrate, then rotates 90° so as to correctly align the laser cut substrate ready for transport into the sawing area by the frame lifter. In an alternative arrangement, the twin laser table unit
 5 may be replaced by a rotary chuck table, which performs the 90° rotation, with the strip picker 265 then moving the laser cut substrate to a interface block.

Figures 12A to 12I show a further preferred embodiment of the present invention, which may be part of the combined profile cut/sawing phases 65, 70 of Figure 2. Specifically,
 10 Figures 12A to 12I show sequential views of the method and system according to a further embodiment of the present invention. The invention forms one part of the overall system for singulating substrates, previously described, having IC units and eventually delivering the IC units for future use. Consequently, the process and system according to the present invention are appropriate to be incorporated into a larger device or system for the processing of
 15 substrates to produce singulated IC units. One such system is that disclosed in PCT/SG2005/000288. In addition to providing a complete solution for the singulation of substrates to produce IC units, in particular the system includes a singulation stage, similar in concept to the present invention, but less efficient. The present invention may replace this within the larger device or similar larger device in order to enhance the UPH of the overall
 20 system. It will be clear to the skill addressee that the method and system of the present invention may be so incorporated into other such devices using accepted and well-known workshop practices.

Figure 12A shows the first step in one embodiment of the process according to the
 25 present invention. In this case, a singulation table 305 is shown having two components 310, 315 for receiving substrates. The first component 310 includes a recess 319 for receiving a first substrate and similarly the second component 315 includes a recess 320 for receiving a second substrate. Both components 310, 315 include regions 325 within the recesses 319, 320 for receiving substrates. Each of these regions 325 has a central orifice 330 through
 30 which a vacuum may be applied such that cumulatively the orifice holds the substrate in place. The regions define the location of individual IC units within the overall substrate and thus the vacuum orifice 330 is located to correspond to a particular IC unit that will be

subsequently be singulated from the substrate. The components 310, 315 further include bolt holes 335 through which the components 310, 315 may be secured to an overall infrastructure incorporating a mechanism for rotating the overall table 305 during subsequent steps.

5 Figure 12B shows the table 305 having substrates 340, 345 lowered 350 into the recesses 319, 320. Each substrate incorporates IC units 355 within an overall frame 360. It is the intention of the present invention to singulate the IC units 355 from the overall frame 360 whereby the IC units are then further processed and the frames discarded.

10 Figure 12C shows the substrates 340, 345 secured within the recesses 319, 320. The vacuum applied through the vacuum orifice 330 hold the substrates 340, 345 securely, ready for application of the cutting process.

15 Following engagement of the substrates 340, 345, the cutting process may begin. A characteristic of the invention is that each component 310, 315 of the singulation table 5 performs a distinct predetermined cut. In this embodiment, the first component 310 performs a cut parallel to the Y axis defined by the coordinate axis 365 whereby the Y axis is parallel to a longitudinal axis of the substrate.

20 The second component 315 defines the second predetermined cut 385, which in this embodiment is along the X axis, that is, laterally across the substrate. It should be noted that there are known systems for the removal of debris and waste material from the cutting process. The debris may be removed by a number of different methods including vacuum during and just following the cutting process. Alternatively in cases of low cutting debris,
25 such debris may be removed during subsequent washing processes of both the singulation table 305 and the singulated IC units on completion of the process.

30 It should be further noted that this embodiment defines the processing of only two substrates. In alternative embodiments, the singulation table may accept a single substrate located on a single enlarged component. Alternatively, either of the components 310, 315 may be used to process a single substrate. Thus, the invention is not limited to two substrates, but may be used for a single substrate only.

In a further alternate embodiment, the singulation table may incorporate three or more components for receiving three or more substrates whereby each component defines distinct predetermined cutting steps or alternatively may share similar predetermined cutting steps or
5 any combination of such cutting steps applied to substrates within the multiple components.

Figure 12D shows the subsequent step whereby the substrates 340, 345 having being subjected to predetermined cuts are then lifted 100 from the singulation table 305. The lifting may occur using a variety of known apparatus such as vacuum lifters whereby engagement
10 portions may contact the substrates, apply a vacuum and then lift the substrates once the vacuum through the vacuum orifice 330 has been released.

Figure 12E shows the next step whereby the substrates 340, 345 are held in the same orientation but the singulation table 305 undergoes a 180° rotation 405 so as to align the
15 recesses 319, 320 with the different substrates. The substrates are then lowered into contact with the opposed recesses 320, 319 of the rotated components 315, 310. Thus, as shown in Figure 12F the substrates are now vacuum held 415, 420 within the recesses 315, 310 of the opposed component of the singulation table.

A further characteristic of the invention, as mentioned previously, is that the
20 components define the predetermined cut steps. Thus, maintaining the substrates in the same orientation through lifting them clear from the singulation table, and then subsequently rotating the table, transfers the predetermined cutting step to the next substrate. As shown in Figure 12G, on securing the substrates, at component 315 a cut in the X direction 425 is
25 performed on the first substrate 340 and at component 310 a cut in the Y direction is performed, but now the second substrate 345.

Figure 12H shows the result of the completion of the predetermined cuts whereby IC
units 435, 440 have been singulated from the previous substrates 340, 345 and removed from
30 the singulation table 305. Said IC units 435, 440 may be lifted using known devices such as vacuum pickers which individually engage the IC units with a vacuum seal and subsequently lift them away from the singulation table 305 to subsequent stages in the process, such as

washing, quality control inspection or other required processes. The remaining substrate frame may then be discarded and the singulation table cleaned of cutting debris.

Finally the table may be rotated 445 a further 180° so as to return the components to
5 their original position as shown in Figure 12I.

Claims :

- 5 1. A system for singulating an IC unit from a substrate, said IC unit having a combination of linear and non-linear peripheral edges, said system comprising a profile cutting device for cutting the non-linear portions of the IC unit; a longitudinal cutting device for cutting the linear portions of the IC unit, said cutting means located within a singulation zone.
- 10 2. The system according to claim 1, further including a sorting means for sorting the singulated IC units into categories, said categories comprising one or a combination of pass, reject and rework.
- 15 3. The system according to claim 1 or 2, further comprising a loading means for loading the substrate to the singulation zone.
4. The system according to any one of the preceding claims, further including an off-loader for removing the singulated IC units from the singulation zone.
- 20 5. The system according to any one of the preceding claims, wherein the profile cutting device includes any one or a combination of water jet cutter, an air jet cutter and a laser cutter.
- 25 6. The system according to any one of the preceding claims, wherein the longitudinal cutting device includes a dicing saw having a single or dual blade.
- 30 7. A method for singulating an IC unit from a substrate, said IC unit having a combination of linear and non-linear peripheral edges, said method comprising the steps of:
profile cutting the non-linear portions of the IC unit using a profile cutting device,
and

longitudinal cutting the linear portions of the IC unit using a longitudinal cutting device, said cutting steps occurring within a singulation zone.

5 8. The method according to claim 7, further comprising the step of sorting the singulated IC units into categories, said categories comprising one or a combination of pass, reject and rework.

9. The method according to claim 7 or 8, further comprising the step of loading the substrate to the singulation zone,

10 10. The method according to any one of claims 7 to 9, further comprising the step of removing the singulated IC units from the singulation zone.

15 11. A method of singulating a plurality of IC units from a first substrate, comprising the steps of:

loading the first substrate to a first location on a singulating table, whilst said table is in a first position;

performing a first pre-determined cut of a first portion of the first substrate;

20 lifting the first substrate from the singulating table;

rotating the singulating table from the first position to a second position;

replacing the first substrate to a second location on the singulating table;

performing a second pre-determined cut of a second portion of the first substrate so as to singulate the plurality of IC units from the first substrate.

25 12. The method according to claim 11, further including the steps of :

loading a second substrate to the second location on the singulating table, adjacent to the first substrate, whilst said table is in the first position;

30 performing the second pre-determined cut on a second portion of the second substrate;

lifting the second substrate from the singulating table following the first pre-determined cut of the first substrate and the second pre-determined cut of the second substrate;

replacing the second substrate to the first position on the singulating table,
5 following the step of rotating the singulating table from the first position to the second position;

performing the first pre-determined cut of a first portion of the second substrate so as to singulate a plurality of IC units from the second substrate.

- 10 13. The method according to claim 11, wherein the first and second pre-determined cuts are linear cuts along orthogonal axes within a plane defined by the substrate.
14. The method according to claim 11, wherein the first pre-determined cut is a linear cut and the second pre-determined cut is a profile cut.
- 15 15. The method according to claim 13 or 14, wherein each linear cut is made by a dicing saw.
16. The method according to claim 14, wherein the profile cut is made by any one or a
20 combination of a water jet cutter, a laser cutter and an air jet cutter.
17. The method according to any one of claims 11 to 16, wherein on singulating the plurality of IC units, said IC units are unloaded from the singulating table
- 25 18. The method according to claim 17, further including the step of then rotating the table back to the first position.
19. A system for singulating a plurality of IC units from a first substrate, comprising
30 a loading means adapted to load the first substrate to a first location on a singulating table;
- a first cutting means for performing a first pre-determined cut of a first portion of the first substrate;

a lifting means for lifting and replacing the first substrate from the singulating table;

said table including rotation means for rotating from a first position to a second position;

5 a second cutting means for performing a second pre-determined cut of a second portion of the first substrate so as to singulate the plurality of IC units from the first substrate, wherein the lifting means is adapted to replace the first substrate to a second location on the singulation table following rotation of the table from the first to the second position.

10 20. The system according to claim 19, wherein

the loading means adapted to load a second substrate to the second location on the singulating table, adjacent to the first substrate;

15 the second cutting means adapted to perform the second pre-determined cut on a second portion of the second substrate;

the lifting means adapted to lift and replace the second substrate from the singulating table, at the same time as the first substrate;

performing a first pre-determined cut of a second portion of the second substrate
20 so as to singulate the plurality of IC units from the second substrate;

the first cutting means for performing the first pre-determined cut of a first portion of the first substrate so as to singulate the plurality of IC units from the first substrate, such that, the lifting means is further adapted to replace the second substrate to the first location on the singulation table following rotation of the table
25 from the first to the second position.

21. The system according to claim 19 or 20, further including unloading means for unloading the singulated IC units from the singulating table.

30 22. 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;

5 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;

10 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.

15 23. The system according to claim 22, 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.

20 24. The system according to claim 23, 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.

25 25. The system according to claim 24, wherein the rail comprises a guiding apparatus of adjustable width, said width adjustable to accommodate the width of the substrate.

30 26. The system according to claim 25, wherein the guiding apparatus comprises a pair of parallel guide rails in communication with a motor for adjusting the distance between said rails.

27. The system according to any one of claims 22 to 26, 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.

- 5 28. The system according to any one of claims 22 to 27, 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.
- 10 29. The system according to claim 28, wherein the rail assembly further comprising a gripper chuck for engaging the substrate and positioning it onto the lifter plate.
- 15 30. The system according to any one of claims 22 to 29, 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.
- 20 31. The system according to claim 30, wherein the selection station comprises a laser table assembly, said laser table assembly comprising at least two laser tables each mounted to corresponding rails, said laser table 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.
- 25 32. The system according to claim 31, wherein said inspection device includes an orientation and alignment vision camera for determining pre-determined parameters of the substrate within the laser table.
- 30 33. The system according to claim 32, wherein the pre-determined parameters include any one or a combination of: substrate type, alignment and orientation.

34. The system according to any one of claims 30 to 33, wherein said laser table assembly adapted to move the laser tables with said substrates along the rail, from the inspection device to a cutting zone within a laser cutting apparatus.
- 5 35. The system according to any one of claims 30 to 33, wherein said laser table assembly adapted to move the laser tables with said substrates along the rail, from the laser cutting apparatus to a substrate unloading position.
- 10 36. The system according to any one of claims 34 or 35, 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.
- 15 37. 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;
- 20 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.
- 25 38. The method according to claim 37, 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.
- 30 39. The method according to claim 38, 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.

- 5 40. The method according to any one of claims 37 to 39, 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.
- 10 41. The method according to claim 40, further comprising the step, after the moving
 step, of:
 inspecting said substrate using an inspection device at the selection station.
- 15 42. The method according to claim 41, 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 table.
- 20 43. The method according to claim 42, wherein the pre-determined parameters include
 any one or a combination of: substrate type, alignment and orientation.
- 25 44. The method according to claim 42 or 43, further comprising the step, after the
 inspecting step, of moving the laser tables with said substrates along the rail, from
 the inspection device to a cutting zone within a laser cutting apparatus.
- 30 45. The method according to claim 44, further comprising the step, after the moving
 step, of cutting the substrate using the laser cutting apparatus, then moving said
 laser tables with said substrates along the rail, from the laser cutting apparatus to a
 substrate unloading position.