159159

SYSTEM AND METHOD FOR ENGAGING SINGULATED SUBSTRATES

Field of the Invention

The invention relates to the singulation of substrates to create individual integrated circuit units. In particular, the invention relates to the processing of said units and specifically to the systems and methods used for moving these units through said process.

Background

Unit picker assemblies are used to engage individual singulated integrated circuit (IC units) following the dicing of respective substrates. Within the assembly are individual unit pickers, each arranged to engage an IC unit by vacuum. Key determinants for the successful operation of a unit picker assembly include:

i) Speed of engagement and subsequent travel following the engagement;

ii) The accuracy of placement of the unit;

iii) The capital cost of the processing equipment.

With decreasing profit margins for integrated circuits, and in particular, memory the pressure to reduce processing costs is significant and hence the need to speed production whilst maintaining quality. It follows that the cost of infrastructure to

G00002

achieve these processes will equally suffer from pressure to reduce cost whilst maintaining speed and quality.

Given the volume of integrated circuit chips contained within a substrate, a potential bottleneck is the ability for the various systems to move the IC units from station to station once singulated. Different systems have been developed to achieve this, for instance that disclosed in PCT/SG2005/000288, the contents of which are incorporated herein by reference. In this system for processing integrated circuit units, Figure 11 shows a unit picker assembly 11A comprising several unit pickers 11B. In order for the unit pickers to engage individual IC units, the unit picker assembly involves a complex arrangement designed to engage the various units in a specified manner. Whilst both efficient and effective, the cost of such equipment is particularly high.

It would therefore be advantageous to adopt a unit picker assembly that incorporates aspects that may lead to a lower capital cost.

Summary of Invention

In a first aspect the invention provides a unit picker assembly for engaging singulated IC units, the assembly comprising; a plurality of unit pickers, each unit picker having an engagement end for engagement of an IC unit; each of said unit pickers movably mounted to permit movement from a retracted position to a unit engagement position; an actuator assembly arranged to move to a plurality of actuating positions, each of said

positions corresponding to one of said unit pickers from the retracted position to the unit engagement position; wherein whilst in any of said actuating positions the actuator assembly is arranged to move the corresponding unit picker from the retracted position to the engagement position.

In the second aspect the invention provides a unit picker assembly for engaging singulated IC units, the assembly comprising a plurality of unit picker pairs, each unit picker within said pair having an engagement end for engagement of an IC unit; each of said unit pickers movably mounted to permit movement from a retracted position to a unit engagement position; a plurality of drive members, each drive member corresponding to each of said unit picker pairs; said drive member having opposed ends such that each unit picker within said corresponding pair contacts the drive member adjacent to opposed ends of said drive member; wherein each of said drive members being rotatable about a horizontal axis intermediate said opposed ends such that rotation of the drive member in a first direction forces one of said unit pickers downward and a rotation in a second direction drives the other unit picker downwards.

In the third aspect the invention provides a unit picker for engaging an IC unit comprising a unit picker shaft having an engagement end for engaging said integrated circuit unit; said engagement end in selective communication with a vacuum source for selectively engaging and disengaging said integrated circuit unit; an ejector pin reciprocally movable within said shaft; wherein said ejector pin is selectively retractable

within the shaft to permit engagement of said IC unit and selectively projectable from said engagement end for disengaging said IC unit.

In the fourth aspect the invention provides a method for engaging singulated IC units, the method comprising the steps of: providing a plurality of unit pickers, each unit picker having an engagement end for engagement of an IC unit; moving an actuator assembly to a first actuating position corresponding to a first of said unit pickers; actuating said first unit picker and so moving the unit picker from a retracted position to a unit engagement position and engaging a first IC unit.

In the fifth aspect the invention provides a method for engaging singulated IC units, the method comprising the steps of: providing a pair of unit pickers, each unit picker within said pair having an engagement end for engagement of an IC unit; providing a drive member corresponding to said unit picker pair, said drive member having opposed ends such that each unit picker contacts the drive member adjacent to opposed ends of said drive member; rotating said drive member in a first direction; said rotation forcing a first of said unit pickers downward; engaging a first IC unit with said first unit picker; rotating said drive member in a second direction; said rotation forcing a second of said unit pickers downward, and; engaging a second IC unit with said second unit picker.

The ratio of motors to unit pickers has traditionally been one to one. The present invention may reduce the ratio to be at least two pickers per motor and potentially may

have a much greater ratio. On this basis the potential capital costs saving may be significant through implementation of an assembly according to the present invention.

In an alternative arrangement, the plurality of unit pickers may be arranged as a circular array, with the actuator assembly and unit pickers moving relative to each other about a common vertical axis. In one embodiment, the actuator assembly may rotate about the axis to engage each unit picker. In an alternative embodiment, the actuator assembly may remain rotationally static, with the unit pickers rotating so as to bring each of said pickers into corresponding position with the actuator. In either case, the driving mechanism may either rotate the unit pickers or rotate the actuator assembly.

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.

Figures 1A, 1B and 1C are isometric views of a unit picker assembly according to one embodiment of the present invention;

Figures 2A and 2B are elevation cross sectional views of the unit picker assembly according to Figure 1A;

Figures 3A, 3B and 3C are sequential elevation views of the unit picker assembly according to Figure 1A;

Figures 4A, 4B and 4C are various views of a unit picker assembly according to a second embodiment of the present invention;

Figures 5A, 5B and 5C are sequential elevation views of the unit picker assembly of Figure 4A performing a simultaneous engagement;

Figures 6A, 6B and 6C are sequential elevation views of the unit picker assembly of Figure 4A performing an individual engagement and;

Figures 7A, 7B and 7C are sequential views of the unit picker assembly of Figure 4A.

Detailed Description

The present invention seeks to reduce the capital cost of unit picker assemblies as compared to the prior art, by increasing the ratio of unit pickers to the number of motors required to operate the said unit pickers.

Figures 1A, 1B and 1C show an embodiment of the present invention whereby the unit picker assembly 5 operates eight unit pickers 11 using only two motors 20, 32 specifically, the unit picker assembly 5 comprises an array of unit pickers 10 mounted to a frame 15. Each unit picker is movably mounted to move in a reciprocal movement from a retracted position to an engagement position whereby the unit picker can engage an IC unit.

A driving mechanism 25 comprises a motor 32 arranged to drive a ball screw arrangement 45, 50 through a belt drive 34. The belt drive 34 is mounted between drive bearings 40, 58 which rotate the ball screw shaft 45 so as to drive a slide 50. The slide 50 has mounted to an underside an actuator assembly 21. The driving mechanism is therefore arranged to move the actuator assembly 21 along a linear path defined by the ball screw mechanism. Adopting a ball screw mechanism provides for accurate placement of the actuator assembly 21, and so providing control of the process.

The picker array 10 comprises a block 9 integrating the eight unit pickers 11 and providing apertures through which the unit pickers 11 can slide in a vertical reciprocal action. The unit pickers themselves comprise an engagement shaft 22 coupled to an actuator shaft 65 through coupling block 17. The engagement shaft and actuator shaft are vertically aligned in parallel and arranged within the block 9 so as to slide in a vertical reciprocal action as a single unit. The actuator shaft 65 further includes a spring 64 arranged to bias the unit picker 11 upwards.

The actuator shaft 65 further includes an engagement block 60 arranged to receive a downward force from the actuator assembly 21 and so provide the downward action for the unit picker 11 to engage a singulated IC unit (not shown).

The engagement shaft 22 is in fact a hollow shaft having an ejector pin placed within the bore of the shaft (not shown). The ejector pin is positioned to be acted upon by a lever 33 which is positioned at the top of the engagement shaft 22. The lever 33 is arranged to receive a horizontal force, causing rotation about a horizontal axis which consequently pushes the ejector pin downwards.

The actuator assembly 21 is more clearly shown in the functional diagrams of Figures 2A and 2B. In particular Figure 2A shows a cross sectional elevation view of the actuator assembly 21 located under the driving mechanism 25. The actuator assembly 21 is mounted to the slide 50 traveling along the bold screw shaft 45. The actuator assembly includes a motor 20 which rotates a contact arm 80. The contact arm 80 is arranged to contact the actuator block 60 through pressing down on the block 60 which, as discussed, moves the actuator rod 65 against the upward force of the spring 64.

Therefore, the function of the unit picker assembly 5 according to the present invention is to have the drive mechanism move the actuator assembly such that the contact arm 80 contacts the actuator block of any one of the unit pickers 11. In this way the unit picker assembly operates only one picker at a time. In applications where the engagement of individual singulated IC units is not a "bottleneck" within the process, there may be

little benefit in engaging several IC units at one time and therefore there may be little benefit in having multiple motors driving the unit pickers 11. Given this criteria, a unit picker assembly according to the present invention need only engage one unit at a time and, therefore, is able to operate an array of eight unit pickers (in this case) by using only two motors being the drive mechanism motor 40 and the actuator assembly motor 20.

Figures 3A to 3C show a sequential view of the operation of the unit picker assembly according to the present invention. In Figure 3A, the contact arm 80 is rotated by the motor 20, depressing the actuator block 60 of a unit picker 11. The actuator shaft 12, coupled to the engagement shaft 22, directs the engagement end 30 towards a singulated IC unit two on a vacuum bed 1. At this point the ejector pin 85 remains retracted within the engagement shaft 22.

Figure 3B shows the next step as the contact arm 80 lowers the unit picker into contact with the singulated unit 2. The vacuum tube 13 then imparts a vacuum 90 at the engagement end 30 and so engaging the unit 2. The contact arm 80 then releases the unit picker with the spring 64 retracting the unit picker away from the vacuum bed 1.

Not shown is the next stage whereby the driving mechanism moves the actuator assembly to the next unit picker and repeats the process of moving the picker downwards by contacting the contact arm 80 against the respective actuator block. It will be appreciated that the clearance between adjacent pickers may be in excess of the

clearance between adjacent singulated IC units following singulation. Therefore the unit picker assembly will also be shifted so as to place the next unit picker directly above the respective singulated unit still residing on the vacuum plate 1. Once the second unit picker is in position, the actuator assembly which has been moved to coincide with the second picker will actuate the unit picker so as to direct it downwards for engagement with the unit picker. Once all the unit pickers have engaged the respective singulated units, these units can then be moved to the next station by moving the entire unit picker assembly along for instance a linear rail within the overall system.

Figure 3C shows the next phase on reaching the next processing station. Once again the contact arm moves the unit picker downwards such that the engagement end 30 is in proximity to a recess within a receiving block 3. Once proximate to the recess but not actually fitting the unit within the recess, the vacuum tube 13 releases the vacuum. To ensure the unit 2 is disengaged from the unit picker, a linear actuator 69 mounted to the actuator assembly projects a horizontal ram 70. The ram 70 contacts the lever 33 causing rotation 36 about a horizontal axis. The lever mounted at the top of the engagement shaft 22 contacts the ejector pin 85 which in turn projects a portion 95 of the ejector pin from the engagement end 30. This small projection 95 dislodges the unit 2 and so permitting the unit to fall within the recess of the receiving plate 3. It will be noted that some units may dislodge as a result of releasing the vacuum with the ejector pin acting to ensure complete disengagement of the units in case some units stick through electrostatic attraction or other cause.

As before, the next phase involves the contact arm rotating back so as to permit the unit picker to retract. The unit picker assembly then shifts so as to place the next unit picker directly above a recess within the receiving plate 3. The actuator assembly is then moved to the second picker so as to repeat the process and so place the unit within the second recess.

Thus by adopting the aforementioned process, a unit picker assembly can be constructed so as to shift singulated IC units between processing stations with the unit picker assembly having a construction requiring less motors and consequently less capital cost compared to the prior art, being unit picker assemblies having a motor for each unit picker.

Figures 4A, 4B and 4C show a unit picker assembly according to a second embodiment of the present invention. The unit picker assembly 100 has a similar unit picker array 105 to that of the first embodiment having parallel actuator and engagement shafts 120, 130 coupled by a coupling block 135. The unit pickers 121 are positioned within a block 106 which permits vertical motion which, together, is mounted to a frame 115. Where the unit picker array 105 varies from that of the first embodiment is the contacting portion located at the top of the actuator shaft 130. Whereas in the first embodiment a contact block was used, in this case, located at the top of the actuator shaft 130 is a follower 140 arranged to contact a drive member, such as a rotating arm 150. In this embodiment, the rotating arm is intended to act in a "cam-type" arrangement with the follower remaining in contact with the rotating arm.

In keeping with the principle of the present invention of reducing the ratio of motors to unit pickers in the embodiment of figures 4A to 4C, the ratio is four motors to eight pickers. In the second embodiment, the driving mechanism and actuator assembly is removed and replaced by an actuator array 151. In this case for eight pickers, there are four motors within the array 151 having one motor for every two pickers. Each motor is associated with a rotating arm 150 with each end of the rotating arm 150 corresponding to a unit picker 121.

The unit picker assembly 100 according to this embodiment is arranged to pick up four singulated units at a time and thus each motor involves directing a unit picker to engage a unit simultaneously. Figures 5A, 5B and 5C show the method of operation of this embodiment. In Figure 5B each motor activates to rotate 165 the rotating arm 150 in a clockwise fashion. The rotating arms being in contact with the followers 140 for each picker follow the rotating arm which is biased upwards by a spring 130. Thus by rotating 165 in a clockwise fashion, the left hand unit pickers are pushed downward 170 with the right hand pickers permitted to move upwards 175 under action of the spring 130. In the downward action the pickers are brought in to correspondence with singulated units and therefore are able to engage the units simultaneously. It will be appreciated that for this embodiment, the singulated units will have a spacing similar to that of the clearance between the individual unit pickers to permit this simultaneous engagement.

Figure 5C show the next phase whereby the rotating arm 150 is rotated 180 in a clockwise direction so as to force the right hand pickers downwards and allow the left hand pickers to be urged upwards by the spring. Thus the next four units can be engaged ready for transfer.

The exact nature of the arrangement of the units may vary, for instance, in some instances the units may be placed in a checker board arrangement and so in order for the second four units to be engaged, the unit assembly 100 may need to be shifted so as to bring the second four pickers into correspondence with the second four units. The arrangement of the units to be engaged does not form part of the invention and so the unit picker assembly 100 may be adaptable to a wide range of unit distribution.

In this embodiment where clearance 155 between the unit pickers is of importance, adjacent rotating arms may be profiled to permit an overlap 160A, B between adjacent arms so that the rotation of said arms does not interfere with each other. Thus as shown in Figure 4A and 4C, adjacent arms can be placed relatively close to each other without the arms actually contacting each other.

The unit picker assembly shown in Figures 5A, B and C show one embodiment whereby four integrated circuit units are simultaneously engaged. In this operation the rotating arms of all the adjacent motors operate at the same time to raise and lower the unit pickers as a group. Figures 6A, 6B, 6C and 6D show the same device operating according to a further embodiment of a present invention. Here the motors operate

individually so as to operate the individual pairs of unit pickers separately. In this mode, individual integrated circuit units are engaged rather than a group simultaneously.

Figure 6B shows the first step whereby the first motor rotates 61 to lower 162 the first unit picker 172 to engage a single integrated circuit unit. Correspondingly the second unit picker 173 rises 163 due to a biasing effect from a spring positioned within the assembly. It will be appreciated that the structure of the unit picker may resemble that of Figure 1C where a spring 64 is placed in series with the unit picker to bias the unit picker upwards when not subjected to a downward force from the rotating arm.

Figure 6C shows the second step whereby the rotating arm 150 rotates clockwise 164 to correspondingly raise 166 the first unit picker 172 so as to lower 167 the second unit picker 173 in order to engage an integrated circuit unit.

Having engaged an IC unit with both the first and second pickers 172, 173, the first motor returns to an equilibrium position whereby the unit pickers are level and the second motor begins operation. Figure 6D shows a rotation 168 in order to lower the third unit picker 174 in a similar fashion to that shown in Figure 6B for the first unit picker. Accordingly the array 151 of unit pickers is individually engaged in order to pick up individual integrated circuit units. Accordingly the embodiments of Figures 6A to 6D show individual operation of the unit pickers as compared to the simultaneous arrangement shown in Figures 5A to 5C. It will be appreciated that any combination

from individual operation to simultaneous operation may be possible with the arrangement according to this embodiment.

The precise nature of the engagement and disengagement of the units may vary. One example is shown in Figures 7A, 7B and 7C. It will be appreciated that the use of the ejector pin as shown in Figures 3A, 3B and 3C may be applicable with the unit picker assembly according to the second embodiment. Equally the ejector pin arrangement shown in Figures 3A, 3B and 3C may also be used with other unit picker assemblies according to the prior art. It follows also that the engagement system as shown in Figures 7A, 7B and 7C may be used with the unit picker assembly according to the first embodiment as well as other unit picker assemblies according to the prior art.

As the rotating arm 150 drives the unit picker downward 205 towards the IC unit 200, the spring will be compressed and so permitting a downward engagement as shown in Figure 7B. A vacuum 215 is applied to the unit via the engagement end 125. It will be noted that an ejector pin 210 is also located within the unit picker. During the engagement process, the ejector pin 210 is retracted within the engagement end 125 so as to avoid interfering with the IC unit 200. On engagement the unit picker is retracted with the second array of unit pickers then brought in to operation to engage the next group of IC units. The units are then transported to the next station for disengagement. Figure 7C shows the method of engagement whereby first the vacuum is released with some or perhaps most units becoming disengaged and falling within corresponding recesses within a receiving block 225. To ensure a complete disengagement of units

from the unit picker, in this embodiment a surge of air pressure 220 is applied which forces the ejector pin 210 downwards and so projecting a portion 230 out of the engagement end 125. This minor projection 230 disengages any units not already disengaged and allows them to fall within the corresponding recesses. Thus whereas in the embodiment of Figures 3A, 3B and 3C, the ejector operates by an actuator driving the ejector pin down, in this embodiment the ejector pin operates by air pressure forcing the pin into place.

Claims

1 A unit picker assembly for engaging singulated IC units, the assembly comprising;

a plurality of unit pickers, each unit picker having an engagement end for engagement of an IC unit;

each of said unit pickers movably mounted to permit movement from a retracted position to a unit engagement position;

an actuator assembly arranged to move to a plurality of actuating positions, each of said positions corresponding to one of said unit pickers from the retracted position to the unit engagement position;

wherein whilst in any of said actuating positions the actuator assembly is arranged to move the corresponding unit picker from the retracted position to the engagement position.

2. The unit picker assembly according to claim 1 further including a driving mechanism for driving the actuator assembly to each actuating position.

3. The unit picker assembly according to claim 2 wherein said driving mechanism includes a slide to which the actuator assembly is mounted and a motor for driving said slide.

4. The unit picker assembly according to claim 3 wherein said slide is mounted to a ball screw arrangement, said ball screw arrangement driven by said motor.

5. The unit picker assembly according to any one of the preceding claims wherein said actuator assembly includes a contact arm driven by a motor; said contact arm contacting the unit picker in order to achieve movement between the retracted position and engagement position.

6. The unit picker assembly according to claim 5 wherein said contact arm moves rotationally in order to contact said unit picker.

7. The unit picker assembly according to claims 5 or 6 wherein said unit picker includes a contact block for receiving contact from the contact arm.

8. The unit picker assembly according to any one of the preceding claims wherein said unit pickers include a spring arranged to apply a force to said unit picker in a direction opposite to that of the force applied by the contact arm.

9. The unit picker assembly according to any one of the preceding claims wherein said unit picker includes an ejector pin, said ejector pin arranged to be operated for dislodging IC units from an engagement end of said unit picker.

10. The unit picker assembly according to claim 9 wherein said unit picker includes a lever said lever arranged to contact the ejector pin in order to operate said ejector pin.

11. The unit picker according to claim 10 wherein said actuator assembly includes a second actuator for activating the lever in order to operate the ejector pin.

12. The unit picker assembly according to any one of the preceding claims wherein said unit picker includes an assembly of an actuator shaft coupled to an engagement shaft wherein said actuator shaft receives contact from said actuator assembly and said engagement shaft includes an engagement end for engaging the integrated circuit unit.

13. A unit picker assembly for engaging singulated IC units, the assembly comprising

a plurality of unit picker pairs, each unit picker within said pair having an engagement end for engagement of an IC unit;

each of said unit pickers movably mounted to permit movement from a retracted position to a unit engagement position;

a plurality of drive members, each drive member corresponding to each of said unit picker pairs

said drive member having opposed ends such that each unit picker within said corresponding pair contacts the drive member adjacent to opposed ends of said drive member;

wherein each of said drive members being rotatable about a horizontal axis intermediate said opposed ends such that rotation of the drive member in a first direction forces one of said unit pickers downward and a rotation in a second direction drives the other unit picker downwards.

14. The unit picker assembly according to claim 12 wherein said unit pickers are resiliently biased upwards such that said unit pickers maintain resilient contact with the drive member.

15. The unit picker assembly according to claim 12 or 13 wherein said drive members are elongate with said horizontal axis is positioned equi-distant between said opposed ends of said drive member.

16. The unit picker assembly according to claim 14 wherein the distance from the horizontal axis to the opposed ends is greater than half the distance between adjacent horizontal axes of adjacent drive members.

17. The unit picker assembly according to claim 15 wherein at least a portion of each drive member is profiled so as to permit overlap of adjacent drive members without causing contact.

18. The unit picker assembly according to any one of claims 12 to 16 wherein on rotation of said drive members, one of each pair of unit pickers is moved to an engagement position so as to engage a plurality of IC units simultaneously.

19. A unit picker for engaging an IC unit comprising

a unit picker shaft having an engagement end for engaging said integrated circuit unit;

said engagement end in selective communication with a vacuum source for selectively engaging and disengaging said integrated circuit unit;

an ejector pin reciprocally movable within said shaft;

wherein said ejector pin is selectively retractable within the shaft to permit engagement of said IC unit and selectively projectable from said engagement end for disengaging said IC unit.

20. The unit picker according to claim 18 wherein the selective projection is as a result of the application of a downward biasing force.

21. The unit picker according to claim 19 wherein the downw3ard biasing force is applied by a lever contactable at a contact end of said

ejector pin, said contact end opposed to the ejection end, said ejection end adjacent to the engagement end of said unit picker.

22. The unit picker according to claim 19 wherein said ejector pin includes a flange around the periphery of said ejector pin such, with the downward biasing force applied by a positive air pressure to directed towards said flange, causing said ejector pin to project from the engagement end.

23. A method for engaging singulated IC units, the method comprising the steps of:

providing a plurality of unit pickers, each unit picker having an engagement end for engagement of an IC unit;

moving an actuator assembly to a first actuating position corresponding to a first of said unit pickers;

actuating said first unit picker and so moving the unit picker from a retracted position to a unit engagement position and

engaging a first IC unit.

24. The method of claim 22 further including the steps of:

moving the actuator assembly to a second actuating position corresponding to a second of said unit pickers;

actuating said unit picker and so moving the unit picker from a retracted position to a unit engagement position, and

engaging a second IC unit.

25. The method of claim 23 or 24 further including the steps of:

repeating the moving and actuating steps until all unit pickers have engaged IC units.

26. A method for engaging singulated IC units, the method comprising the steps of:

providing a pair of unit pickers, each unit picker within said pair having an engagement end for engagement of an IC unit;

providing a drive member corresponding to said unit picker pair, said drive member having opposed ends such that each unit picker contacts the drive member adjacent to opposed ends of said drive member;

rotating said drive member in a first direction;

said rotation forcing a first of said unit pickers downward;

engaging a first IC unit with said first unit picker;

rotating said drive member in a second direction;

said rotation forcing a second of said unit pickers downward, and;

engaging a second IC unit with said second unit picker.