A METHOD AND SYSTEM FOR SINGULATION OF INTEGRATED CIRCUITS

Field of the Invention

The invention relates to the singulation of IC units from a substrate and in particular system and methods established for said singulation. Further, the invention relates to the singulation of IC units, said IC units having a combination of linear and profile peripheral elements.

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.

A growing market for ICs is the application for memory cards such as micro SD cards used in a range of applications including cameras, PDAs, MP3 players etc. A characteristic of the micro SD card is the changing shape from a routinely square or 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 curvi-linear shape or more generally profile shape. The profile portions of the SD card include chamfers whereby a corner of the rectangle is removed, recesses to accommodate fittings within the device and curved portions for or fitting to the end product. Consequently, different types of dicing/cutting may be required for a batch of IC's. The growth in demand for

"profiled" IC's demonstrates the importance of efficient dicing processes and apparatus.

The flexibility to perform multiple types of cutting, whilst maintaining, or perhaps increasing UPH will influence the economic value of a dicing machine, and not just for profile cutting, but for any dicing process whereby different cutting is required, whether differing by geometry or by direction.

Statement of Invention

It is therefore an object of the invention to offer an alternative process and/or system for providing different types of cutting actions, applied to a single type of IC, whilst maintaining an acceptable UPH.

In a first 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.

In a second 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.

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.

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.

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.

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.

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.

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.

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.

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, 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 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, 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 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^{o} to 360^{o}. Said selective rotation may be to accommodate such a variation in the cut. Alternatively the rotation of the 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 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 1 to 9 are isometric views showing the sequential steps of a process according to one embodiment of the present invention.

Description of Preferred Embodiment

Figures 1 to 9 show sequential views of the method and system according to one embodiment of the present invention. The invention forms one part of the overall system for singulating substrates 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 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 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 1 shows the first step in one embodiment of the process according to the present invention. In this case, a singulation table 5 is shown having two components 10,15 for receiving substrates. The first component 10 includes a recess 19 for receiving a first substrate and similarly the second component 15 includes a recess 20 for receiving a second substrate. Both components 10, 15

include regions 25 within the recesses 19, 20 for receiving substrates. Each of these regions 25 has a central orifice 30 through 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 30 is located to correspond to a particular IC unit that will be subsequently be singulated from the substrate. The components 10, 15 further include bolt holes 35 through which the components 10, 15 maybe secured to an overall infrastructure incorporating a mechanism for rotating the overall table 5 during subsequent steps.

Figure 2 shows the table 5 having substrates 40, 45 lowered 50 into the recesses 19, 20. Each substrate incorporate IC units 55 within an overall frame 60. It is the intention of the present invention to singulate the IC units 55 from the overall frame 60 whereby the IC units are then further processed and the frames discarded.

Figure 3 shows the substrates 40, 45 secured within the recesses 19, 20. The vacuum applied through the vacuum orifice 30 hold the substrates 40, 45 securely, ready for application of the cutting process.

Following engagement of the substrates 40, 45, the cutting process may begin. A characteristic of the invention is that each component 10, 15 of the singulation table 5 performs a distinct predetermined cut. In this embodiment, the first

component 10 performs a cut parallel to the Y axis defined by the coordinate axis 65 whereby the Y axis is parallel to a longitudinal axis of the substrate.

The second component 15 defines the second predetermined cut 85, 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, such debris may be removed during subsequent washing processes of both the singulation table 5 and the singulated IC units on completion of the process.

It should be further noted that this embodiment defines the processing of only 2 substrates. In alternative embodiments the singulation table may accept a single substrate located on a single enlarged component. Alternatively, either of the components 10, 15 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 3 or more components for receiving 3 or more substrates whereby each component defines distinct predetermined cutting steps or alternatively may share similar predetermined cutting steps or any combination of such cutting steps applied to substrates within the multiple components.

Figure 4 shows the subsequent step whereby the substrates 40, 45 having being subjected to predetermined cuts are then lifted 100 from the singulation table 5. The lifting may occur using a variety of known apparatus such as vacuum lifters whereby engagement portions may contact the substrates, apply a vacuum and then lift the substrates once the vacuum through the vacuum orifice 30 has been released.

Figure 5 shows the next step whereby the substrates 40, 45 are held in the same orientation but the singulation table 5 undergoes a 180° rotation 105 so as to align the recesses 19, 20 with the different substrates. The substrates are then lowered into contact with the opposed recesses 20, 19 of the rotated components 15, 10. Thus, as shown in Figure 6 the substrates are now vacuum held 115, 120 within the recesses 15, 10 of the opposed component of the singulation table.

A further characteristic of the invention, as mentioned previously, is that the 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 7, on securing the substrates, at component 15 a cut in the X direction 125 is performed on the first substrate 40 and at component 10 a cut in the Y direction is performed, but now the second substrate 45.

Figure 8 shows the result of the completion of the predetermined cuts whereby IC units 135, 140 have been singulated from the previous substrates 40, 45 and removed from the singulation table 5. Said IC units 135, 140 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 5 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 145 a further 180° so as to return the components to their original position as shown in Figure 9.

The claims defining the invention are as follow:

1. 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.

2. The method according to claim 1, 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;

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, 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.

3. The method according to claim 1, wherein the first and second pre-determined cuts are linear cuts along orthogonal axes within a plane defined by the substrate.

4. The method according to claim 1, wherein the first pre-determined cut is a linear cut and the second pre-determined cut is a profile cut.

5. The method according to claim 3 or 4, wherein each linear cut is made by a dicing saw.

6. The method according to claim 4, wherein the profile cut is made by any one or a combination of a water jet cutter, a laser cutter and an air jet cutter.

7. The method according to any one of the preceding claims, wherein on singulating the plurality of IC units, said IC units are unloaded from the singulating table

8. The method according to claim 7, further including the step of then rotating the table back to the first position.

9. 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.

10. The system according to claim 9, wherein

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

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 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 from the first to the second position.

11. The system according to claim 9 or 10, further including unloading means for unloading the singulated IC units from the singulating table.

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