159159

SEMICONDUCTOR PACKAGE SINGULATING SYSTEM AND METHOD

Field Of Invention

The present invention relates generally to a semiconductor singulating system. In particular, the invention relates to a semiconductor singulating system for singulating semiconductor packages having topologically planar surfaces that are structurally resilient to applied forces.

Background

Integrated circuit (IC) chips are fabricated with multiple IC chips being typically arranged on a single substrate. In a conventional IC chip fabrication process, silicon dies are initially bonded on the paddles of a lead frame by die bonding, wire bonding apparatus or flip chip mounting, and subsequently encapsulated in a molding compound to obtain a single substrate and eventually singulated to obtain individually separated packages of IC chips therefrom.

Generally, the packages forming the substrate are separated using a saw, a dicing saw or the like cutting devices. The substrate is often supported on a rubber pad which interfaces the substrate and a saw jig or the like support. Air is then extracted through a plurality of holes formed in the rubber pad for creating a vacuum therethrough. The vacuum secures the substrate to the saw jig both before and after the packages are separated and during the sawing thereof.

Each of United States Patent Nos. 6,638,791 B2 (Tieber 1), 6,187,791 B1 (Tieber 2), 6,165,232 (Tieber 3) and 6,321,739 B1 (Roberts) discloses such a vacuum securing method. Tieber 1, Tieber 2 and Tieber 3 describe the use of a nest arrangement for supporting a substrate. The nest arrangement has a plurality of pedestal for protruding from corresponding grids of a retainer plate. Vacuum generated through a channel formed in each pedestal secures the substrate to the nest arrangement for subsequent dicing thereof. Roberts describes a similar fixturing system without the use of the retainer plate for removing the substrate from the nest arrangement.

G00002

As the sizes of semiconductor packages reduces, the demand for smaller packages increases. However, the foregoing conventional vacuum-through-a-rubber-pad method, as described by Tieber 1, Tieber 2, Tieber 3 and Roberts, is unable to meet the securing requirements of these smaller packages. Although the packages have reduced in size, the cutting force introduced during separation thereof (i.e. the dicing process) still remains the same. Dicing is a contact cutting process that generates large forces (i.e. tangential and transverse forces).

Therefore, holding forces for securing the substrate to the saw jig and as provided by the frictional forces of between the rubber pad and the individual packages, must overcome the side cutting forces of the saw blade to prevent shifting of the packages during sawing thereof. When the sizes of the packages reduces, the effective area for effecting frictional forces reduces as well, thereby resulting in the failure of the dicing process due to the shifting or flying off of the packages.

To improve over the frictional forces of the rubber pad, United States Patent Nos. 6,344,402 B1 (Sekiya) and 6,594,890 B2 (Arai) discloses the use of an adhesive pad instead of the rubber pad.

Arai describes the use of an adhesive pad having pores formed therein. A semiconductor wafer placed onto the adhesive pad is not only held by adhesive forces of the adhesive pad but also by suction forces from the vacuum generated through the pores. However, an additional step using an additional heater is required for heating the adhesive pad at a predetermined temperature to separate the semiconductor wafer from the adhesive pad.

Sekiya describes the use of an adhesive tape and vacuum combination for attaching a semiconductor wafer to a frame. However, an additional step is also required in Sekiya to dislodge the diced semiconductor wafer from the frame using a blow of air ejected from a surface that was initially used for creating the vacuum.

Furthermore, the use of adhesive or an adhesive tape for securing semiconductor packages is inefficacious. Additional steps are required for post-processing the

singulated semiconductor packages to cleanly remove the adhesive or adhesive tape from each of the singulated semiconductor packages or vice-versa.

United States Patent No. 3,976,288(Cuomo) describes a fixture for positionally retaining a semiconductor wafer during a dicing process. The fixture has a planar wafer receiving area with a row of grooves formed therein along the plane of the receiving area. A base member is for supporting a semiconductor wafer thereon. The base member further has a plurality of channels formed therein for generating vacuum therethrough. Cuomo further describes a cover having a plurality of ribs with compressible material attached to each thereof. Each adjacent pair of the plurality of ribs is spaced apart to facilitate passage of a saw-blade therethrough.

Since semiconductor wafers are typically planar and brittle and have substantially flat surface topologies, the planar and rigid receiving area of the base member in Cuomo is for ensuring vacuum sealing and to prevent the brittle wafer from bending. However, if such a fixture is applied to semiconductor package singulation, especially quad flat no-lead packages or the like small packages with a copper lead frame, the warpage of such semiconductor package substrates will result in vacuum leakage along the interface between the semiconductor package and the rigid and flat receiving area of the base member.

Furthermore, due to the large circumferential dimensions of the semiconductor wafers, each rib of the cover has to extend a longer span across the surface of the semi-conductor wafer. This inevitably leads to the thickening of the cross-section of each rib to ensure structural rigidity across a longer span. However, the saw-blade is typically provided with and held between v-shaped hubs. The amount of saw-blade radially protruding from each adjacent pair of ribs is small due to the radially thin saw-blade. Therefore, extending the saw-blade too far through the each adjacent pair of ribs will result in the v-shaped hubs colliding with the ribs. Therefore in Cuomo, portions of the ribs outwardly opposing the compressible material are chamfered for conforming with and accommodating the v-shaped hubs to prevent damage thereto when the saw-blade is inserted between each adjacent pair of ribs. The thick cross-section of each rib with the v-shape chamfer is not applicable for use in conjunction

with the singulation of the miniaturized semiconductor packages due to the relatively larger size of the ribs when compared with the smaller semiconductor packages.

Furthermore, grooves have to be formed in the base member of Cuomo to accommodate overshoot of the saw blade past the semiconductor wafer and towards the base member during dicing of the wafer thereby. Fabricating the grooves in the member is not only time-consuming but also expensive.

Hence, this clearly affirms a need for an improved system for singulating semiconductor packages.

Summary

A combination of suction forces and clamping forces immobilises a substrate during singulation thereof in an embodiment of the invention. The substrate is supported in a compressible support pad having channels for generating vaccum therethrough and thereby introducing suction forces to the substrate. The support pad is coupled to a base plate. The clamping forces are applied to the substrate when a clamp is mounted to the saw jig for clamping the substrate therebetween.

Therefore, in accordance with a first aspect of the invention, there is disclosed a semiconductor package singulating system comprising:

a saw jig comprising a support pad for supporting a substrate thereonto, the saw jig for applying suction forces to the substrate for securing the substrate to the saw jig, the support pad being elastically resilient, at least a portion of the substrate being a semiconductor package and the substrate comprising a first portion and a second portion; and

a clamp for cooperating with the saw jig for clamping the substrate therebetween, the clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig for providing unimpeded access by a saw blade to at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate for separating the first and second portions thereof,

wherein the suction forces applied to the substrate further prevent positional mobility of at least one of the first portion and the second portion of the substrate during one of application and removal of the clamp from the substrate.

In accordance with a second aspect of the invention, there is disclosed a semiconductor package singulating method comprising the steps of:

providing a saw jig having a support pad;

positioning a substrate onto the support pad,

applying suction forces by the saw jig to the substrate for securing the substrate to the saw jig, the support pad being elastically resilient, at least a portion of the substrate being a semiconductor package and the substrate comprising a first portion and a second portion; and

cooperating a clamp with the saw jig for clamping the substrate therebetween, the clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig for providing unimpeded access by a saw blade to at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate for separating the first and second portions thereof,

wherein the suction forces applied to the substrate further prevent positional mobility of at least one of the first portion and the second portion of the substrate during one of application and removal of the clamp from the substrate.

In accordance with a third aspect of the invention, there is disclosed a semiconductor package singulating system comprising:

a saw jig comprising a support pad for supporting a substrate thereonto, the saw jig for applying suction forces to the substrate for securing the substrate to the saw jig, the support pad being elastically resilient and the substrate comprising:

a first semiconductor package;

a second semiconductor package being unseparated from the first semiconductor package; and

a first parting line formed between the first semiconductor package and the second semiconductor package, and

a first clamp for cooperating with the saw jig for clamping the substrate therebetween, the first clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig for providing unimpeded access by a saw blade to the first parting line and at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate when cutting substantially along the first parting line thereof for separating the first semiconductor package from the second semiconductor package,

wherein after separation of the first semiconductor package from the second semiconductor package, the suction forces applied to the substrate further prevent positional mobility of the first semiconductor package and the second semi-conductor package substrate during one of application and removal of the clamp from the substrate.

Brief Description Of The Drawings

Embodiments of the invention are described hereinafter with reference to the following drawings, in which:

FIG. 1a shows an exploded perspective view of a semiconductor package singulating system with a single piece support pad, a y-clamp for mounting onto a saw jig and a substrate;

FIG. 1b shows an exploded perspective view of the semiconductor package singulating system of FIG. 1a with a multiple pieces support pad;

FIG. 2 shows a partial side sectional elevation view of the semiconductor package singulating system of FIG. 1a with a x-clamp mounted to the saw jig for clamping semi-singulated QFN packages therebetween;

FIG. 3 shows a partial side sectional elevation view of the semiconductor package singulating system of FIG. 1a;

FIG. 4a shows a front elevation view of the y-clamp of FIG. 1a;

FIG. 4b shows a partial front elevation view of view 'A' of the y-clamp of FIG. 4a;

FIG. 5 shows a partial plan view of unsingulated QFN packages formed as a segment of the substrate of FIG. 1a with x-parting lines and y-parting lines;

FIG. 6 shows a partial plan view of semi-singulated QFN packages obtained from singulating along the x-parting lines of the unsingulated QFN packages of FIG. 5;

FIG. 7 shows a partial plan view of singulated QFN packages obtained from singulating along the y-parting lines of the semi-singulated QFN packages of FIG. 6;

FIG. 8 shows a partial side sectional elevation view of the semiconductor package singulating system of FIG. 2 with a x-clamp mounted to the saw jig for clamping singulated QFN packages therebetween;

FIG. 9 shows a plan view of the x-clamp of FIG. 2 with ribs extending from a flange and structurally supported by braces;

FIG. 10 shows a process flow chart of a semiconductor package singulating method implementable by the semiconductor package singulating system of FIG. 1a;

FIG. 11 shows a plan view of the x-clamp of FIG. 9 with the ribs being shaped as fingers extending from at least one of the flange and the braces; and

FIG. 12 shows a partial side sectional elevation view of the semiconductor package singulating system of FIG. 1a wherein each of the ribs is formed with a rigid beam and a compressible layer.

Detailed Description

A semiconductor package singulating system is described hereinafter for addressing the foregoing problems.

A first embodiment of the invention, a semiconductor package singulating system 20 is described with reference to FIG. 1a, which shows an exploded perspective view of the semiconductor singulating system, and FIG. 2, which shows a partial side sectional view of the semiconductor package singulating system 20.

As shown in FIG. 1a, the semiconductor package singulating system 20 comprises a saw jig 22 and a clamp 24. The saw jig 22 is for supporting a substrate 26 thereon. The saw jig 22 comprises a base plate 28 for supporting the substrate 26 therewith and a support pad 30 for interfacing the substrate 26 and the base plate 28. The support pad 30 is elastically resilient and for applying frictional grip to the substrate 26.

As shown in FIG. 1a and more specifically in FIG. 2, the support pad 30 comprises a plurality of pad channels 32 extending from a first face to a second face of the support pad 30. The support pad 30 is substantially planar with the first face and the second face being outwardly opposing. When the substrate 26 is supported by the saw jig 22 with the substrate 26 abutting the first face of the support pad 30, vacuum is generated through the plurality of channels 32 for substantially vacuum coupling the substrate 26 to the support pad 30.

The base plate 28 comprises a recess 36 formed therein and a plurality of plate channels 38. The plate channels 38 extend from the recess 36 to a plate face 40 of the base plate 28. The plate face 40 of the base plate 28 mates with the second face of the support pad 30 when the support pad 30 is coupled to the base plate 28. Each of the plurality of plate channels 38 is in alignment with a corresponding one of the plurality

of pad channels 32 for facilitating fluid communication between the recess 36 and the pad channels 32.

The substrate 26 comprises a leadframe 42 and a plurality of unsingulated semiconductor packages 44a having topologically planar surfaces and being arranged and grouped into segments 46. The semiconductor package singulating system 20 is hereinafter applied to Quad Flat No-Lead (QFN) packages. However, application of the semiconductor package singulating system is not limited to only QFN packages.

A portion of a leadframe 42 forming the unsingulated QFN packages 44a extends from the periphery of segments 46. Hereinafter, the leadframe 42 refers only to the exposed portions thereof extending from and substantially along the perimeter of the segments 46. Each of the QFN packages is a semiconductor device. Typically, the leadframe 42 is shaped and dimensioned for arranging and spacing the segments 46 apart along a row as shown in FIG. 1a. Alternatively, the unsingulated QFN packages 44a are grouped into only one segment (not shown). The segments 46 are obtained through molding, for example polymer molding, to thereby encapsulating dies that have already been bonded to the leadframe 42. The substrate 26 is planar.

The support pad 30 is made from one or a combination of rubber, elastomer, polymeric compound and the like elastically resilient material. The elastic resiliency of the support pad 30 not only provides frictional resistance along its plane but also deforms elastically to adapt to the topology and warpage of the segments 46 and leadframe 42 when the substrate 26 is depressed thereinto.

The support pad 30 is mounted to the base plate 28 using adhesive or the like coupling means. The support pad 30 defines a receiving area for disposing the segments 46 of the substrate 26 thereonto. Therefore, the support pad 30a is sized to accommodate all the segments 46 of the substrate 26. Alternatively, more than one support pad is used for supporting the substrate 26 as shown in FIG. 1b. When more than one support pad 30a is used, each support pad 30a is sized and dimensioned to accommodate only one corresponding segment 46 of the substrate 26.

Substrate locating pins 48a extend from the base plate 28 and correspond with locating apertures 48b or notches (not shown) formed in the leadframe 42 of the substrate 26. The substrate 26 is aligned with the saw jig 22 when each of the substrate locating pins 48a is inserted through the corresponding locating aperture. Aligning the substrate 26 with the saw jig 22 consequently aligns the segments 46 of the substrate 26 with the support pad 30.

The saw jig 22 is mounted onto a saw table 50 which provides structural support thereto. A vacuum pump (not shown), which is preferably structurally integral with the saw table 50, is coupled to the recess 36 of the base plate 28 via a vacuum port 52 as shown in FIG. 2. The recess 36 in the base plate 28 functions as an air junction between the plate channels 38 and the vacuum port 52 being coupled thereto. Therefore, the vacuum pump is operable for creating a vacuum within the recess 36 and consequently through the plate channels 38 and the pad channels 32. Suction forces being generated by the vacuum created through the pad channels 32 attaches the substrate 26 to the saw jig 22.

With further reference to FIGS. 3, 4a and 4b, the saw jig 22 is further for cooperating with the clamp 24 for clamping the substrate 26 therebetween. The saw jig 22 and the clamp 24 apply clamping forces to at least a portion of the substrate 26 for further immobilisation thereof. The clamp 24 comprises a flange 58 shaped and dimensioned for extending contiguous to the periphery of the leadframe 42, and a row of ribs 60 extending from the flange 58. A slot 62 is formed between each adjacent pair of ribs 60.

Within each segment 46 of the substrate 26, the unsingulated QFN packages 44a are arranged in a grid configuration which comprises rows and columns as shown in FIG. 5. The row of ribs 60 corresponds with one of the rows and the columns of the grid configuration. The rows and the columns of the grid configuration defines x-parting lines 66a and y-parting lines 66b on each segment 46 of the substrate 26. With reference to FIGS. 5, 6, 7 and 8, the segments 46 of the substrate 26 are preferably singulated initially along the x-parting lines 66a to obtain semi-singulated QFN packages 44b and subsequently along the y-parting lines to obtain singulated QFN

packages 44c therefrom. The x-parting lines 66a are substantially perpendicular to the y-parting lines 66b.

The clamp 24 is mountable onto the saw jig 22 using bolts, spring-loaded fasteners, hydraulic fasteners, pneumatic fasteners, electro-magnets, rare-earth magnet assemblies or the like coupling devices. The saw table 50 further comprises clamp locating pins (not shown) for passage through corresponding locating channels 66c formed in the clamp 24 and locating channels 66d formed in the saw jig 22. The clamp locating pins cooperates with the locating channels 66c and 66d for aligning the clamp 24 with the saw jig 22. When the clamp 24 is mounted onto the saw jig 22 with the substrate 26 being held therebetween, each rib 60 depresses one corresponding row of unsingulated QFN packages 44a onto the support pad 30.

The ribs 60 are further shaped to form a concavity 67, as shown in FIG. 3, for receiving the segments 46 of the substrate therewithin when the clamp 24 is mounted to the saw jig 22. As illustrated by FIG. 2, the slots 62 are shaped and dimensioned for passage of a saw blade 68 therethrough. Furthermore, the slots 62 are aligned for exposing one of the x-parting lines 66a and the y-parting lines 66b to the saw blade 68.

The clamp 24 is generally segregated into two types, namely, an x-clamp 70a as shown in FIG. 9, and a y-clamp 70b as shown in FIG. 1. The x-clamp 70a has slots 62 aligned for exposing the x-parting lines 66a and the y clamp 70b has slots 62 aligned for exposing the y-parting lines 66b. The segments 46 of the substrate 26 are arranged along an axis that is substantially parallel to the x-parting lines 66a. Therefore, each rib 60 of the x-clamp 70a extends a longer distance over all the segments 46 as compared to each rib 60 of the y-clamp 70b which only extends over one of the segments 46.

The relatively longer ribs 60 of the x-clamp 70a are structurally weaker due to over-suspension thereof. The x-clamp 70a further comprises one or more braces 72 that extend laterally across the ribs 60 for structurally supporting and thereby strengthening the ribs 60 as shown in FIG. 9.

With reference to FIG. 3, a clamp plane 74, a flange plane 76 and a support plane 78 are formed when the clamp 24 is mounted onto the saw jig 22 with the substrate 26 being disposed therebetween. The ribs 60 of clamp 24, of any one of the x-clamp 70a and the y-clamp 70b, abut the segments 46 of the substrate 26 along the clamp plane 74. The flange plane 76 coincides with the support pad 30 and is formed along a face of the flange 58 that outwardly opposes both the concavity 67 and the saw jig 22. The segments 46 of the substrate 26 abut the support pad 30 along the support plane 78.

The ribs 60 of the clamp 24 are further shaped and dimensioned for spatially interdisplacing the clamp plane 74 and the flange plane 76. The support plane 78 is formed between the flange plane 76 and the clamp plane 74. The spatial interdisplacement between the clamp plane 74 and the flange plane 76 facilitates cutting of the segments 46 of the substrate 26 to thereby separate the QFN packages 44a along one of the x-parting lines 66a and the y-parting lines 66b when the saw blade 68 is introduced through each of the slots 62 without coming into contact with the flange 58.

When the saw blade 68 is introduced into each slot 62 of the clamp 24 for cutting the corresponding segment 46 of the substrate 26, the saw blade 68 coincides with the support pad 30 to thereby cut a portion thereof.

With reference to FIG. 10, the semiconductor package singulating system 20 is for implementing a semiconductor package singulating method 100. In the semiconductor package singulating method 100, the substrate 26 is first positioned onto the support pad 30 of the saw jig 22 preferably using a pick-and-place device (not shown) in a step 110.

The pick-and-place device is for picking, manipulating and subsequently releasing the substrate 26. Locating means (not shown) on the pick-and-place device interact with the substrate 26 for aligning the substrate 26 with the gripper when the substrate is being picked for transfer to the saw jig 22. The pick-and-place device is pre-aligned with the saw jig 22. Therefore, when the pick-and-place device positions the

substrate 26 onto the support pad 30 in the step 110, the substrate 26 is already in alignment with the support pad 30.

In a next step 112 following the step 110, the vacuum pump is activated for gripping the substrate 26 to the saw jig 22. Next in a step 113, the substrate 26 is partially-singulated by the saw-blade 68 for separating the lead frame 42 from the segments 46 of the substrate 26. Following the step 113, the x-clamp 70a is mounted onto the saw jig 22 for clamping the substrate 26 therebetween in the step 114. Once the lead frame 42 is separated from the segments 46, a space is created between each adjacent pair of segments 46 for better accommodating the corresponding braces 72 of the x-clamp 70a when the x-clamp is mounted onto the saw jig 22 in the step 114.

Alternatively, when the substrate 26 comprises only one segment 46 (not shown) and more than one segment with reduced peripheral span, the need for the braces 72 in the x-clamp 70a is eliminated. When the braces 72 are not present in the x-clamp 70a, the step 113 of pre-singulating the substrate 26 is skipped to allow the step 114 to follow after the step 112 has been performed.

Once the substrate 26 is firmly clamped between the saw jig 22 and the x-clamp 70a, the saw blade 68 is introduced thereto through each of the slots 62 of the x-clamp 70a in a step 116. Through each slot 62, the saw blade 68 is first fed into the unsingulated QFN packages 44a initially along a z-axis 80 and subsequently along the x-parting lines 66a for obtaining semi-singulated QFN packages 44b.

After being singulated along the x-parting lines 66a, the semi-singulated QFN packages 44b are still connected along the y-parting lines 66b. This results in the unsingulated QFN 44a being substantially not dislocatable from their predisposed position by the cutting forces introduced by the saw blade 68 during singulation thereof. Therefore, the ribs 60 of the x-clamp 70a can alternatively be shaped and dimensioned as fingers 82 extending from the braces 72 of the x-clamp 70a and only for depressing only a portion of each segment 46 of the substrate 26 as shown in FIG. 11.

Additionally, when each of the unsingulated QFN packages 44a is not substantially miniaturised, the use of the x-clamp 70a for clamping the substrate 26 during singulation thereof along the x-parting lines 66a can be eliminated. However, each of the unsingulated QFN packages 44a must be dimensioned to enable the suction forces generated by the vacuum through the pad channels 32 and the structural integrity of portions of the substrate 26 transverse to the unsingulated y-parting lines 66b to substantially immobilise the substrate 26 during singulation thereof by the saw-blade 68. Although use of the x-clamp 70a can be eliminated in this situation, the use of the y-clamp 70b is still necessary for singulating along the y-parting lines 66b.

After obtaining the semi-singulated QFN packages 44b, the x-clamp 70a is dismounted from the saw jig 22 in a step 118. Subsequently in a step 120, the y-clamp 70b is mounted onto the saw jig 22 for clamping the semi-singulated QFN packages 44b therebetween. The saw balde 68 is then introduced along the z-axis 80 into the semi-singulated QFN packages 44b and subsequently along each of the y-parting lines 66b for obtaining singulated QFN packages therefrom in a step 122. The the suction forces from the pad channels 32 and clamping forces from the y-clamp 70b prevent mobility and dislocation of the semi-singulated QFN packages 44b when cutting forces are introduced thereto during singulation thereof along the y-parting lines 66b.

The z-axis 80 is substantially perpendicular to the x-parting lines 66a and the y-parting lines 66b. As the support pad 30 is elastically resilient, it dampens vibrations generated by the cutting forces of the saw blade 68 when the saw blade 68 is being introduced along the z-axis 80 towards the support pad 30 during singulation of the unsingulated QFN packages 44a in the step 116 and during singulation of the semi-singulated QFN packages 44b in the step 122.

In a step 124, the y-clamp 70b is dismounted from the saw jig 22 to reveal the singulated QFN packages 44c. The suction forces from the pad channels 32 further prevents mobility of the singulated QFN packages 44c during and after dismounting of the y-clamp 70b from the saw jig 22.

Steps 114 to 124 of the semiconductor package singulating method 100 describe singulation along the x-parting lines 66a before singulation along the y-parting lines 66b to obtain the singulated QFN packages 44c from the unsingulated QFN packages 44a. However, steps 114 to 124 are rearrangable to enable mounting of the y-clamp for singulation along the y-parting lines 66b before mounting of the x-clamp 70a for singulation along the x-parting lines 66a to thereby obtain the singulated QFN packages 44c therefrom. When the substrate is singulated along the y-parting line 66b first using the y-clamp, the step 113 of pre-singulating the substrate 26 can also be eliminated since the braces 72 are not formed on the y-clamp 70b and therefore do not require spatial accommodation by the space created between adjacent segments 46 in the step 113. Once the substrate 26 has been singulated along the y-parting lines 66b, the leadframe 42 between the segments 46 is flushed away by water introduced thereto before the substrate 26 is subsequently singulated along the x-parting lines 66a.

Following the step 124, a gripper of the pick-and place device (not shown) engages and grips the singulated QFN packages in a step 126. The vacuum pump is then deactivated in a step 128 before the gripper removes the singulated QFN packages 44c from the saw jig 22 for post-processing in a step 130.

In the step 130, the gripper disposes the singulated QFN packages 44c within a cage. The cage and the singulated QFN packages 44c therein are being subjected initially to a washing process for removing debris and dust therefrom, and subsequently to a drying process. The washed and dried singulated QFN packages 44c are then sorted and placed into holders, carriers or the like semiconductor package storing means.

A second embodiment of the invention, a semiconductor package singulation system as shown in FIG. 12, comprises three main elements: a saw jig 22, a clamp 24 formed with a plurality of ribs 60. The descriptions in relation to the structural configurations of and positional relationships between the substrate 26, the base plate 28, the pad channels 32, the plurality of ribs 60 and the z- axis 80 with reference to FIGS. 1a, 1b, 2 and 3 are incorporated herein.

In the second embodiment, each of the plurality of ribs 60 comprises a rigid beam 92 and a compressible layer 94. The rigid beam 92 comprises an inward face 96 that opposes the support pad 30 when the clamp 24 is mounted onto the saw jig 22. The compressible layer 94 is one of formed along and coupled onto the inward face 96 of the rigid beam 92. The compressible layer 94 is made from one of rubber, elastomer, polymeric compound or the like elastically resilient material. When the substrate 26 is held between the clamp 24 and the saw jig 22, the compressible layer 94 forms an interface between the rigid beam 92 and the substrate 26 with the clamp plane 74 being formed substantially along the interface between the compressible layer 94 and the substrate 26.

Although only QFN packages are discussed in this embodiment of the invention, both the semiconductor package singulating system and the semiconductor singulating method are not precluded from being applied to other forms of semiconductor packages.

In the foregoing manner, a semiconductor package singulating system for implementing a semiconductor package singulating method is described according to two embodiments of the invention for addressing the foregoing disadvantages of conventional singulation and dicing system and fixtures therefor. Although only two embodiments of the invention are disclosed, it will be apparent to one skilled in the art in view of this disclosure that numerous changes and/or modification can be made without departing from the scope and spirit of the invention.

Claims

1. A semiconductor package singulating system comprising:

a saw jig comprising a support pad for supporting a substrate thereonto, the saw jig for applying suction forces to the substrate for securing the substrate to the saw jig, the support pad being elastically resilient, at least a portion of the substrate being a semiconductor package and the substrate comprising a first portion and a second portion; and

a clamp for cooperating with the saw jig for clamping the substrate therebetween, the clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig for providing unimpeded access by a saw blade to at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate for separating the first and second portions thereof,

wherein the suction forces applied to the substrate further prevent positional mobility of at least one of the first portion and the second portion of the substrate during one of application and removal of the clamp from the substrate.

2. The semiconductor package singulating system as in claim 1, the saw jig further comprising:

a base plate for coupling the support pad thereto, the support pad for interfacing the substrate and the base plate, the support pad being resilient and for applying frictional grip to the substrate.

3. The semiconductor package singulating system as in claim 2, the support pad comprising:

a plurality of pad channels extending from a first face to a second face of the support pad, the support pad being substantially planar and the first face and the second face being outwardly opposing,

whereby when the substrate is supported by the saw jig with the substrate abutting the first face of the support pad, vacuum is generated through the plurality of channels to substantially vacuum couple the substrate to the support pad.

4. The semiconductor package singulating system as in claim 3, the base plate comprising:

a recess formed in the base plate; and

a plurality of plate channels extending from the recess to a plate face of the base plate, the plate face of the base plate mating with the second face of the support pad when the support pad is coupled to the base plate, each of the plurality of plate channels being in alignment with a corresponding one of the plurality of pad channels for facilitating fluid communication between the recess and the pad channels.

5. The semiconductor package singulating system as in claim 4, further comprising:

a saw table for mounting the saw jig thereonto; and

a vacuum pump being couplable to the recess of the base plate and being operable for generating a vacuum within the recess.

6. The semiconductor package singulating system as in claim 2, the support pad being made from one of rubber, elastomer and polymeric compound.

7. The semiconductor package singulating system as in claim 2, the clamp comprising:

a plurality of ribs, each of the first portion and the second portion of the substrate being depressed by a corresponding one of the plurality of ribs, each of the plurality of ribs being spaced apart from an adjacent rib; and

a plurality of slots formed between each adjacent pair of the plurality of ribs, each of the plurality of slots being shaped and dimensioned for the passage of a saw blade therethrough.

8. The semiconductor package singulating system as in claim 7, the plurality of ribs being shaped and dimensioned for forming a concavity for receiving at least a portion of the substrate therewithin when the clamp is mounted onto the saw jig.

9. The semiconductor package singulating system as in claim 7, the clamp being couplable to the saw jig for clamping the substrate between at least one of the plurality of ribs and at least a portion of the support pad, the support pad being deformable for adapting to the shape and size of the substrate.

10. The semiconductor package singulating system as in claim 9, the clamp further comprising:

a flange, the plurality of ribs extending from the flange, the flange extending along at least a portion of the periphery of the base plate for exposing the substrate supported by the support pad to the plurality of ribs when the clamp is coupled to the saw jig.

11. The semiconductor package singulating system as in claim 10, the plurality of ribs abuts the substrate substantially along a clamping plane.

12. The semiconductor package singulating system as in claim 11, the flange being planar,

wherein when at least one of the clamp is coupled to the saw jig and the substrate is clamped between at least a portion of the support pad and at least one of the plurality of ribs, a flange plane is formed on a face of the flange outwardly opposing the saw jig, the support pad being coincident with the flange plane and the substrate abutting the support pad along a support plane.

13. The semiconductor package singulating system as in claim 12, the plurality of ribs and the support pad being shaped and dimensioned for spatially interdisplacing the clamp plane and the flange plane, the support plane being formed between the flange plane and the clamp plane,

wherein the spatial interdisplacement between the clamp plane and the flange plane facilitates cutting of the substrate to thereby separate the first and second portions thereof when the saw blade is introduced between one pair of the plurality of ribs without contact with the flange.

14. The semiconductor package singulating system as in claim 13, wherein the saw blade coincides with the support pad to thereby cut a portion thereof during cutting of the substrate.

15. The semiconductor package singulating system as in claim 13, each of the plurality of ribs comprising:

a rigid beam having an inward face opposing the support pad when the clamp is mounted onto the saw jig; and

a compressible layer being one of formed along and coupled onto the inward face of the rigid beam, the compressible layer being made from one of rubber, elastomer and polymeric compound,

wherein when the substrate is held between the clamp and the saw jig, the compressible layer forms an interface between the rigid beam and the substrate and the clamp plane is formed substantially along the interface between the compressible layer and the substrate.

16. The semiconductor package singulating system as in claim 2, the base plate comprising:

a plurality of substrate locating pins corresponding with a plurality of locating features formed in the substrate, each of the plurality of locating features being one of an aperture and a notch, each of the plurality of locating features for cooperating with a corresponding one of the plurality substrate locating pins for aligning the substrate with the saw jig.

17. A semiconductor package singulating method comprising the steps of:

providing a saw jig having a support pad;

positioning a substrate onto the support pad,

applying suction forces by the saw jig to the substrate for securing the substrate to the saw jig, the support pad being elastically resilient, at least a portion of the substrate being a semiconductor package and the substrate comprising a first portion and a second portion; and

cooperating a clamp with the saw jig for clamping the substrate therebetween, the clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig for providing unimpeded access by a saw blade to at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate for separating the first and second portions thereof,

wherein the suction forces applied to the substrate further prevent positional mobility of at least one of the first portion and the second portion of the substrate during one of application and removal of the clamp from the substrate.

18. The semiconductor package singulating method as in claim 17, the step of providing a saw jig comprising the step of:

providing the saw jig with a base plate for coupling the support pad thereto, the support pad for interfacing the substrate and the base plate, the support pad being resilient and for applying frictional grip to the substrate.

19. The semiconductor package singulating method as in claim 18, the step of positioning a substrate onto the support pad comprising the step of:

positioning the substrate onto the support pad and over a plurality of pad channels extending from a first face to a second face of the support pad, the support pad being substantially planar and the first face and the second face being outwardly opposing,

whereby when the substrate is supported by the saw jig with the substrate abutting the first face of the support pad, vacuum is generated

through the plurality of channels to substantially vacuum couple the substrate to the support pad.

20. The semiconductor package singulating method as in claim 19, the step of providing a saw jig having a base plate further comprising the steps of:

forming a recess in the base plate; and

forming a plurality of plate channels extending from the recess to a plate face of the base plate, the plate face of the base plate mating with the second face of the support pad when the support pad is coupled to the base plate, each of the plurality of plate channels being in alignment with a corresponding one of the plurality of pad channels for facilitating fluid communication between the recess and the pad channels.

21. The semiconductor package singulating method as in claim 20, the step of providing a saw jig further comprising the steps of:

mounting the saw jig onto a saw table; and

coupling a vacuum pump to the recess of the base plate and being operable for generating a vacuum within the recess.

22. The semiconductor package singulating method as in claim 18, the step of providing a saw jig having a support pad further comprising the step of:

fabricating the support pad from one of rubber, elastomer and polymeric compound.

23. The semiconductor package singulating method as in claim 18, the step of cooperating the clamp with a saw jig comprising the steps of:

forming a plurality of ribs; and

depressing each of the first portion and the second portion of the substrate with a corresponding one of the plurality of ribs, each of the plurality of ribs being spaced apart from an adjacent rib,

wherein a plurality of slots formed between each adjacent pair of the plurality of ribs, each of the plurality of slots being shaped and dimensioned for the passage of a saw blade therethrough.

24. The semiconductor package singulating method as in claim 23, the step of forming a plurality of ribs comprising the step of:

shaping and dimensioning the plurality of ribs for forming a concavity for receiving at least a portion of the substrate therewithin when the clamp is mounted onto the saw jig.

25. The semiconductor package singulating method as in claim 23, the step of cooperating the clamp with the saw jig comprising the step of:

coupling the clamp to the saw jig for clamping the substrate between at least one of the plurality of ribs and at least a portion of the support pad, the support pad being deformable for adapting to the shape and size of the substrate.

26. The semiconductor package singulating method as in claim 25, the step of forming the plurality of ribs comprising the step of:

extending the plurality of ribs from a flange, the flange extending along at least a portion of the periphery of the base plate for exposing the substrate supported by the support pad to the plurality of ribs when the clamp is coupled to the saw jig.

27. The semiconductor package singulating method as in claim 26, the step of cooperating the clamp with the saw jig further comprising the step of abutting the plurality of ribs with the substrate substantially along a clamping plane.

28. The semiconductor package singulating method as in claim 27, the step of extending a plurality of ribs from a flange comprising the step of:

providing a planar flange for extending the plurality of ribs therefrom,

wherein when at least one of the clamp is coupled to the saw jig and the substrate is clamped between at least a portion of the support pad and at least one of the plurality of ribs, a flange plane is formed on a face of the flange outwardly opposing the saw jig, the support pad being coincident with the flange plane and the substrate abutting the support pad along a support plane.

29. The semiconductor package singulating method as in claim 28, the step of cooperating the clamp with the saw jig further comprising the step of:

shaping and dimensioning the plurality of ribs and the support pad for spatially interdisplacing the clamp plane and the flange plane, the support plane being formed between the flange plane and the clamp plane,

wherein the spatial interdisplacement between the clamp plane and the flange plane facilitates cutting of the substrate to thereby separate the first and second portions thereof when the saw blade is introduced between one pair of the plurality of ribs without contact with the flange.

30. The semiconductor package singulating method as in claim 29, the step of shaping and dimensioning the plurality of ribs and support pad comprising the step of:

shaping and dimensioning the support pad for a saw blade to coincide therewith to thereby cut a portion thereof during cutting of the substrate.

31. The semiconductor package singulating method as in claim 29, the step of forming the plurality of ribs further comprising the steps of:

forming the plurality of ribs wherein each of the plurality of ribs comprising:

a rigid beam having an inward face opposing the support pad when the clamp is mounted onto the saw jig; and

a compressible layer being one of formed along and coupled onto the inward face of the rigid beam, the compressible layer being made from one of rubber, elastomer and polymeric compound,

wherein when the substrate is held between the clamp and the saw jig, the compressible layer forms an interface between the rigid beam and the substrate and the clamp plane is formed substantially along the interface between the compressible layer and the substrate.

32. The semiconductor package singulating method as in claim 18, the step of cooperating a clamp with the saw jig for clamping the substrate therebetween comprising the steps of:

providing the base plate with a plurality of substrate locating pins formed thereon;

providing the substrate with a plurality of locating features formed therein, each of the plurality of locating features being one of an aperture and a notch, the plurality of locating features corresponding with the plurality of substrate locating pins; and

interacting each of the plurality of locating features of the substrate with a corresponding one of the plurality substrate locating pins to thereby align the substrate with the saw jig.

33. A semiconductor package singulating system comprising:

a saw jig comprising a support pad for supporting a substrate thereonto, the saw jig for applying suction forces to the substrate for securing the substrate to the saw jig, the support pad being elastically resilient and the substrate comprising:

a first semiconductor package;

a second semiconductor package being unseparated from the first semiconductor package; and

a first parting line formed between the first semiconductor package and the second semiconductor package, and

a first clamp for cooperating with the saw jig for clamping the substrate therebetween, the first clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig for providing unimpeded access by a saw blade to the first parting line and at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate when cutting substantially along the first parting line thereof for separating the first semiconductor package from the second semiconductor package,

wherein after separation of the first semiconductor package from the second semiconductor package, the suction forces applied to the substrate further prevent positional mobility of the first semiconductor package and the

second semi-conductor package substrate during one of application and removal of the clamp from the substrate.

34. The semiconductor package singulating system as in claim 33, further comprising:

a second clamp for cooperating with the saw jig for clamping the substrate therebetween, the substrate further comprising:

a third semiconductor package being unseparated from the second semiconductor package; and

a second parting line formed between the second semiconductor package and the third semiconductor package, the second parting line being substantially perpendicular to the first parting line,

the second clamp for applying clamping forces to the substrate to further secure the substrate to the saw jig without impeding access by the saw blade to the second parting line and at least a portion of the substrate when the substrate is clamped between the saw jig and the clamp,

whereby the suction forces and the clamping forces applied to the substrate substantially prevent positional mobility thereof when cutting forces are introduced by the saw blade to the substrate when cutting along the second parting line thereof for separating the second semiconductor package from the third semiconductor package,

wherein after separation of the second semiconductor package from the third semiconductor package, the suction forces applied to the substrate further prevent positional mobility of the first semiconductor package, the second semi-conductor package substrate and the third semiconductor package during one of application and removal of the clamp from the substrate.

35. The semiconductor package singulating system as in claim 33, the saw jig further comprising:

a base plate for coupling the support pad thereto, the support pad for interfacing the substrate and the base plate, the support pad being resilient and

for applying frictional grip to the substrate, the support pad being made from one of rubber, elastomer and polymeric compound and comprising:

a plurality of pad channels extending from a first face to a second face of the support pad, the support pad being substantially planar and the first face and the second face being outwardly opposing, and the base plate comprising:

a recess formed in the base plate; and

a plurality of plate channels extending from the recess to a plate face of the base plate, the plate face of the base plate mating with the second face of the support pad when the support pad is coupled to the base plate, each of the plurality of plate channels being in alignment with a corresponding one of the plurality of pad channels for facilitating fluid communication between the recess and the pad channels,

whereby when the substrate is supported by the saw jig with the substrate abutting the first face of the support pad, vacuum is generated through the plurality of channels to substantially vacuum couple the substrate to the support pad,

36. The semiconductor package singulating system as in claim 33, further comprising:

a saw table for mounting the saw jig thereonto; and

a vacuum pump being couplable to the recess of the base plate and being operable for generating a vacuum within the recess.

37. The semiconductor package singulating system as in claim 33, the clamp comprising:

a plurality of ribs, each of the first semiconductor package, the second semiconductor package and the third semiconductor package of the substrate being depressed by a corresponding one of the plurality of ribs onto at least a portion of the support pad, the support pad being deformable for adapting to the shape and size of the substrate, the plurality of ribs being spaced apart from an adjacent rib and being shaped and dimensioned for forming a

concavity for receiving at least a portion of the substrate therewithin when the clamp is mounted onto the saw jig;

a plurality of slots formed between each adjacent pair of the plurality of ribs, each of the plurality of slots being shaped and dimensioned for the passage of a saw blade therethrough; and

a flange, the plurality of ribs extending from the flange, the flange extending along at least a portion of the periphery of the base plate for exposing the substrate supported by the support pad to the plurality of ribs when the clamp is coupled to the saw jig.

38. The semiconductor package singulating system as in claim 37, further comprising:

a clamping plane formed substantially along the interface between the plurality of ribs and the substrate;

a flange plane is formed on a face of the flange outwardly opposing the saw jig when at least one of the clamp is coupled to the saw jig and the substrate is clamped between at least a portion of the support pad and at least one of the plurality of ribs, the support pad is coincident with the flange plane;

a support plane formed along the interface between the substrate and the support pad, the plurality of ribs and the support pad being shaped and dimensioned for spatially interdisplacing the clamp plane and the flange plane, the support plane being formed between and being parallel to the flange plane and the clamp plane,

wherein the spatial interdisplacement between the clamp plane and the flange plane facilitates cutting of the substrate to thereby separate the first and second portions thereof when the saw blade is introduced between one pair of the plurality of ribs without contact with the flange.

39. The semiconductor package singulating system as in claim 38, each of the plurality of ribs comprising:

a rigid beam having an inward face opposing the support pad when the clamp is mounted onto the saw jig; and

a compressible layer being one of formed along and coupled onto the inward face of the rigid beam, the compressible layer being made from one of rubber, elastomer and polymeric compound,

wherein when the substrate is held between the clamp and the saw jig, the compressible layer forms an interface between the rigid beam and the substrate and the clamp plane is formed substantially along the interface between the compressible layer and the substrate.

40. The semiconductor package singulating system as in claim 38, wherein the saw blade coincides with the support pad to thereby cut a portion thereof during cutting of the substrate.

41. The semiconductor package singulating system as in claim 40, the base plate comprising:

a plurality of substrate locating pins corresponding with a plurality of locating features formed in the substrate, each of the plurality of locating features being one of an aperture and a notch, each of the plurality of locating features for cooperating with a corresponding one of the plurality substrate locating pins for aligning the substrate with the saw jig.