Singulating And De-Tapping Arrays of Semiconductor Packages

Field of Invention

The invention relates generally to semiconductor package singulation systems. In particular, the invention relates to systems for singulating and de-tapping arrays of semiconductor packages formed on a supporting substrate.

Background

Integrated circuits (ICs) fabricated from semiconductor wafers are commonly packaged by a packaging process so that the ICs can be easily handled and are electrically connectable with an external circuitry, such as a printed circuit board (PCB). An example of a packaging process is substrate based packaging, wherein an array of individual ICs is typically arranged and encapsulated in multiple rows and columns on a supporting substrate or leadframe. Another example of a packaging process is chip scale packaging (CSP), wherein the packaging process is performed at wafer level.

The packaging process is subsequently followed by a singulation or cutting process for obtaining individual semiconductor packages, such as ball grid array (BGA) packages and quad flat no-lead (QFN) packages. A cutting blade is typically used for singulating or cutting the semiconductor packages.

The semiconductor packages are usually secured to a cutting table by a number of different ways for stabilizing the semiconductor packages and achieving accurate cuts thereon during the singulation process. One conventional method of securing in position the semiconductor packages formed on a supporting substrate is to use a saw jig having a rubber vacuum pad on which the supporting substrate is mounted. Vacuum is applied through vacuum holes of the rubber vacuum pad for holding the supporting substrate or

individual semiconductor packages during and after the singulation process, respectively. However, this conventional method faces difficulties in securing semiconductor packages with miniaturised dimensions. This is because with a smaller semiconductor package, the shearing force between the cutting blade and each semiconductor package is now sufficiently large to cause the semiconductor packages to be displaced and shift out of position. This potentially affects the quality and yield of the singulation process. The displacement of the semiconductor packages from the vacuum holes may even develop a leak in the vacuum such that the suction on the semiconductor packages is considerably reduced. This may cause the entire supporting substrate to be displaced from the rubber vacuum pad, thereby resulting in the failure of the singulation process. Therefore, the forgoing conventional method for singulating semiconductor packages has limitations for securing semiconductor packages with miniaturised dimensions during the singulation process.

Another conventional method for securing semiconductor packages formed on a supporting substrate or at wafer level utilises an ultraviolet (UV) adhesive tape that adheres to the packages prior to singulation. A metal frame or wafer ring then engages the UV adhesive tape for mounting the supporting substrate or wafer during the singulation process to the cutting table. However, removal of the singulated semiconductor packages is difficult because the packages are still held by the UV adhesive tape even after the tape has been cured by exposure to UV light to reduce the adhesiveness thereof. The semiconductor packages are susceptible to damages during the removal process as ejection pins are used for dislodging the packages from the UV adhesive tape. This potentially causes a lowering of product yield, although a reduction in the speed of ejecting the packages from the tape may alleviate the damages to the package. Additionally, although the UV adhesive tape is conventionally adhered automatically to the metal frame or wafer ring, the tape is removed from the metal frame or wafer ring manually after the semiconductor packages have been singulated. However, all this is done at the expense of production throughput.

There is therefore a need for a singulation apparatus and process for achieving high production throughput while being capable of singulating and de-tapping semiconductor packages with miniaturised dimensions.

Summary

Embodiments of the invention disclosed herein provide improved performance relating to high production throughput. Additionally, the embodiments are suitable for singulating and de-tapping semiconductor packages with miniaturised dimensions.

Therefore, in accordance with one aspect of the invention, an apparatus for singulating a semiconductor package formed on a substrate and separating the same and a tape removably adhered to the same is disclosed. The apparatus comprises a transferring unit and a station. The transferring unit for securing and displacing the semiconductor package. The station comprises a heating plate and a vacuum plate with the heating plate interfacing the tape and the vacuum plate when the semiconductor package and the tape are removably disposed on the heating plate. The vacuum plate is for creating vacuum through the heating plate for securing the tape to the heating plate and the heating plate for providing thermal energy to the tape for facilitating separation of the semiconductor package from the tape removably adhered thereto. The semiconductor package and the tape removably adhered thereto are separated by initially the station securing the tape and providing thermal energy to the tape for reducing adhesion between the semiconductor package and the tape and subsequently the transferring unit securing and displacing the semiconductor package from the tape.

In accordance with a second aspect of the invention, a method for singulating a semiconductor package formed on a substrate and separating the same and a tape removably adhered to the same is disclosed. The method comprises the step of disposing the semiconductor package and the tape removably adhered thereto on a station comprising a heating plate and a vacuum plate. The heating plate interfaces the tape and the vacuum plate when the semiconductor package and the tape are removably disposed

on the heating plate. The method further comprises the step of securing the tape to the heating plate by vacuum created by the vacuum plate through the heating plate for securing the tape to the heating plate, with the heating plate for providing thermal energy to the tape for facilitating separation of the semiconductor package from the tape removably adhered thereto. The method further comprises the step of providing thermal energy generatable by the heating plate to the tape for reducing adhesion therebetween and for facilitating separation of the semiconductor package from the tape removably adhered thereto, and the step of displacing the semiconductor package away from the tape by a transferring unit removably engaged to the semiconductor package.

Brief Description Of The Drawings

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

Fig. 1 is a top view of a molded side of arrays of semiconductor packages formed on a supporting substrate;

Fig. 2 is a top view of an active side of arrays of semiconductor packages formed on a supporting substrate;

Fig. 3 is a perspective view of the semiconductor packages and the supporting substrate, a tape and a saw jig;

Fig. 4 is a cross-sectional view of the semiconductor packages and the supporting substrate of Fig. 1 prior to singulating the semiconductor packages;

Fig. 5 is a cross-sectional view of the semiconductor packages and the supporting substrate of Fig. 1 after singulating the semiconductor packages;

Fig. 6 is a cross-sectional view of the semiconductor packages and the supporting substrate of Fig.1 during drying of the semiconductor packages;

Fig. 7 is a cross-sectional view of the semiconductor packages and the supporting substrate of Fig.1 during provision of thermal energy to the tape; and

Fig. 8 is a cross-sectional view of the semiconductor packages and the supporting substrate after the semiconductor packages and tape are separated.

Detailed Description

With reference to the drawings, an apparatus and a method according to embodiments of the invention for singulating semiconductor packages formed on a substrate are disclosed for improving performance relating to production throughput.

Various conventional methods for improving the production throughput of singulating an array of semiconductor packages are disclosed herein. These conventional methods have limitations in production quality and yield of singulating semiconductor packages with miniaturised dimensions. Other conventional methods have difficulties with production throughput as adhesive tapes used for securing the semiconductor packages during singulation are manually removed from a metal frame or wafer ring.

For purposes of brevity and clarity, the description of the invention is limited hereinafter to applications related to singulating and de-tapping semiconductor packages formed on a supporting substrate. This however does not preclude embodiments of the invention from other applications, such as wafer level packaging, that require similar operating performance as the applications for singulating and de-tapping the substrate formed semiconductor packages. The functional and operational principles on which the embodiments of the invention are based remain the same throughout the various embodiments.

Embodiments of the invention are described in greater detail hereinafter for an apparatus and method for singulating an array of semiconductor packages and separating the same and a tape. In the detailed description and illustrations provided in Figs. 1 to 8 of the drawings, like elements are identified with like reference numerals.

With reference to Fig. 1, an exemplary type of a semiconductor packaging panel 100 is shown. Arrays of semiconductor packages 102 are typically formed on a supporting substrate 104, such as a metal leadframe or ceramic substrate. Each array of semiconductor packages 102 comprises multiple rows and columns of individual ICs that

are encapsulated in a mold 106 on a molded side 108 of the semiconductor packaging panel 100. The supporting substrate 104 typically supports more than three arrays of semiconductor packages 102. The other side of the semiconductor packaging panel 100 is an active side 202 having scribe lines or streets 204 that define the boundary of each individual semiconductor package 102, as shown in Fig. 2. Examples of the individual packages are ball grid array (BGA) packages, micro leadframe packages (MLP) and quad flat no-lead (QFN) packages.

Fig. 3 shows a perspective view of the semiconductor packaging panel 100 having an array of semiconductor packages 102 formed on the supporting substrate 104, a tape 302 and a saw jig 304. The saw jig 304 comprises a substantially rectangular metal frame 306 having a panel of vacuum pads 308 centrally located on the metal frame 306. Each vacuum pad 308 is substantially planar and has a plurality of openings therein that are closely spaced apart. The vacuum pads 308 are preferably made of rubber.

The tape 302, preferably a thermal adhesive tape or the like thermal de-activatable tape, is adhered to the molded side 108 of the semiconductor packaging panel 100 and in particular the molds 106 that encapsulate the individual ICs. The tape 302 is structurally made of thermo-expandable microcapsules that allow the tape 302 to be firmly adhered to the molds 106 during singulation of the array of semiconductor packages 102. The level of adhesion between the tape 302 and the molded side 108 of the supporting substrate 104 is reducible by applying a predetermined amount of thermal energy to the tape 302.

The application of the predetermined amount of thermal energy increases the temperature of the tape 302 and causes the thermo-expandable microcapsules to foam, resulting in the formation of minute undulations on the surface of the tape 302. This drastically reduces the area of contact between the tape 302 and the molds 106. Consequently, the adhesion between the tape 302 and the molded side 108 of the supporting substrate 104 is effectively removed when the temperature of the tape 302 reaches a desired level, for example between 90°C and 170°C.

The tape 302 advantageously avoids the need for any tensioning during adhesion thereof to the semiconductor packaging panel 100. This is because the tape 302 does not expand during the singulation of the array of semiconductor packages 102, thus ensuring that the semiconductor packages 102 are not displaced during the singulation process.

Fig. 4 shows a cross-sectional view of the semiconductor packaging panel 100 prior to singulation of the semiconductor packages 102 on a cutting station 400. The tape 302 and the semiconductor packaging panel 100 are disposed on the saw jig 304 such that the tape 302 is in contact with the panel of vacuum pads 308. The vacuum pads 308 are disposed on an upper side 402 of the metal frame 306 of the saw jig 304. The saw jig 304 has a plurality of through-holes 404 located adjacent to the openings 405 of each of the vacuum pad 308 for creating a passageway 406. The passageway 406 is connected to a saw jig recess 408 on a lower side 410 of the saw jig 304. The saw jig 304 is mounted on a vacuum plate 412 having a vacuum plate recess 414 thereon that matches and reciprocates the saw jig recess 408 on the lower side 410 of the saw jig 304 such that a sealed cavity 416 is formed by the reciprocating recesses 408 and 414.

An inlet portion 418 of the vacuum plate recess 414 is connected to a vacuum system (not shown) for applying suction on the tape 302 such that the vacuum system is in fluid communication with the passageway 406. The suction provided by the vacuum system secures the tape 302 and the supporting substrate 104 to the saw jig 304 during the singulation of the array of semiconductor packages 102.

With reference to Fig. 5, a cross-sectional view of the semiconductor packaging panel 100 after a process singulating the array of semiconductor packages 102 is shown. The vacuum system provides the necessary suction on the tape 302 for preventing unnecessary movements of the array of semiconductor packages 102 during the singulation thereof. A blade 502 is used for cutting the array of semiconductor packages 102 along the streets 204 on the active side 202 of the semiconductor packaging panel 100. The cutting is repeated on all the streets 204 on the active side 202 of the supporting

substrate 104 until the arrays of semiconductor packages 102 are singulated into individual semiconductor packages 504. During singulation, the adhesion between the tape 302 and the molded side 108 of the semiconductor packaging panel 100 in conjunction with the suction provided by the vacuum system overcomes the shearing force attributed by the cutting of the array of semiconductor packages 102 by the blade 502.

After the singulation of the arrays of semiconductor packages 102, the singulated semiconductor packages 504 and the tape 302 are displaced by a transferring unit (not shown) and disposed on a drying station 600, as shown in Fig 6. The drying station 600 has a vacuum plate 602 and vacuum system substantially similar to the cutting station 400 for securing the tape 302 and the singulated semiconductor packages 504 thereon. Once the tape 302 and the singulated semiconductor packages 504 are secured to the vacuum plate 602 of the drying station 600, a drying unit 604 having a plurality of air nozzles 606 is then used for providing drying air 608 for drying the singulated semiconductor packages 504. The drying air 608 is blown through the air nozzles 606 directed at each of the singulated semiconductor package 504.

Once the singulated semiconductor packages 504 are dried, the transferring unit 702 as shown in Fig. 7 engages the singulated semiconductor packages 504 and transfers the packages 504 and the tape 302 onto a de-taping station 700 for de-tapping the packages 504. The transferring unit 702 has a vacuum head 704 that preferably uses vacuum for engaging the singulated semiconductor packages 504. The de-taping station 700 has a vacuum plate 706 and vacuum system substantially similar to the cutting and drying stations 400 and 600 for securing the tape 302 thereon during the de-tapping of the singulated semiconductor packages 504.

A heating plate 708 is disposed on the vacuum plate 706 of the de-taping station 700 and is in fluid communication (not shown) with the vacuum system. The heating plate 708 is also connected to a control unit 710 for providing thermal energy to the tape 302. The

transferring unit 702 then places the singulated semiconductor packages 504 and tape 302 onto the heating plate 708 and remains in that position throughout the provision of thermal energy to the tape 302 for securing the singulated semiconductor packages 504 as the tape 302 expands. The control unit 710 is subsequently activated for providing the required predetermined thermal energy necessary for the complete removal of the adhesion between the tape 302 and the singulated semiconductor packages 504.

The transferring unit 702 then lifts the singulated semiconductor packages 504 from the tape 302 and transfers the packages 504 away from the de-taping station 700 for subsequent processing, as shown in Fig. 8. The transferring unit 702 then removes the tape 302 from the de-taping station 700. Vacuum is applied to the tape 302 by the vacuum system for securing the tape 302 to the heating plate 708 prior to lifting the singulated semiconductor packages 504 from the tape 302 and transferring the packages 504 away from the de-taping station 700.

In the foregoing manner, an apparatus for separating a semiconductor package formed on a substrate and a tape removably adhered to the semiconductor package with an improvement for throughput and wider applications are disclosed. Although only a number of embodiments of the invention are disclosed, it becomes 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. For example, although thermal adhesive tapes are used for mounting the semiconductor packages to the various processing stations in the forgoing embodiments, the mounting may be efficiently performed if the tapes are substituted by heat sensitive adhesion tapes or the like for providing the mounting of semiconductor packages to the various processing stations.

Claims:

1. An apparatus for separating a semiconductor package formed on a substrate and a tape removably adhered thereto, the apparatus comprising:

a transferring unit for securing and displacing the semiconductor package, and

a station comprising a heating plate and a vacuum plate, the heating plate interfaces the tape and the vacuum plate when the semiconductor package and the tape are removably disposed on the heating plate, the vacuum plate for creating vacuum through the heating plate for securing the tape to the heating plate and the heating plate for providing thermal energy to the tape for facilitating separation of the semiconductor package from the tape removably adhered thereto,

wherein the semiconductor package and the tape removably adhered thereto are separated by initially the station securing the tape and providing thermal energy to the tape for reducing adhesion between the semiconductor package and the tape and subsequently the transferring unit securing and displacing the semiconductor package from the tape.

2. The apparatus of claim 1, the vacuum created by the vacuum plate through the heating plate being generated by a vacuum system, the vacuum system being in fluid communication with the vacuum plate.

3. The apparatus of claim 1, wherein the station secures the tape by means of vacuum.

4. The apparatus of claim 1, wherein the tape is removably adhered to a molded side of the semiconductor package.

5. The apparatus of claim 1, wherein the apparatus further comprising a cutting station for singulating the semiconductor package prior to separating the semiconductor package and the tape.

6. The apparatus of claim 5, wherein the apparatus further comprising a drying station for drying the semiconductor package after the semiconductor package is singulated by the cutting station.

7. The apparatus of claim 1, wherein the transferring unit secures the semiconductor package preferably by means of vacuum.

8. The apparatus of claim 1, wherein when the station provides thermal energy for reducing adhesion whereby the tape is removably adhered to the semiconductor package is dependable on the amount of thermal energy provided by the station.

9. The apparatus of claim 8, wherein the amount of thermal energy is controllable by a control unit.

10. The apparatus of claim 1, wherein the tape is displaceable by the transferring unit from the station after separating the semiconductor package and the tape.

11. The apparatus of claim 1, wherein the station has a substantially planar surface for interacting with the tape.

12. A method for separating a semiconductor package formed on a substrate and a tape removably adhered to the semiconductor package, the method comprising the steps of:

disposing the semiconductor package and the tape removably adhered thereto on a station comprising a heating plate and a vacuum plate, the heating plate interfaces the tape and the vacuum plate when the semiconductor package and the tape are removably disposed on the heating plate,

securing the tape to the heating plate by vacuum created by the vacuum plate through the heating plate for securing the tape to the heating plate, the heating plate for

providing thermal energy to the tape for facilitating separation of the semiconductor package from the tape removably adhered thereto,

providing thermal energy generatable by the heating plate to the tape for reducing adhesion therebetween and for facilitating separation of the semiconductor package from the tape removably adhered thereto; and

displacing the semiconductor package away from the tape by a transferring unit removably engaged to the semiconductor package.

13. The method of claim 12, wherein the method further comprising the step of singulating the semiconductor package by a cutting station prior to securing the semiconductor package.

14. The method of claim 13, wherein the step of singulating the semiconductor package by the cutting station further comprising the step of drying the semiconductor package by a drying station.

15. The method of claim 12, the step of displacing the semiconductor package away from the tape comprising the step of engaging the semiconductor package by the transferring unit by means of vacuum.

16. The method of claim 15, the step of displacing the semiconductor package away from the tape further comprising the step of displacing the transferring unit engaged to the semiconductor package away from the station to thereby displace the semiconductor chip away from the tape.

17. The method of claim 12, the heating plate being in fluid communication with a vacuum system.

18. The method of claim 12, wherein the step of providing energy for reducing adhesion whereby the tape is removably adhered to the semiconductor package is dependable on the amount of thermal energy provided to the tape by the heating plate.

19. The method of claim 18, wherein the amount of thermal energy provided to the tape by the heating plate is controllable by a control unit.