DIE EJECTOR WITH ILLUMINATING UNIT

Field of the Invention

[0001] The present invention generally relates to an apparatus for semiconductor chip processing, and in particular to a die ejector having an illuminating unit.

Background of the Invention

[0002] The semiconductor manufacturing process comprises four major steps: materials preparation, crystal growth and wafer preparation, wafer fabrication, and packaging. In the packaging step, a wafer is first mounted onto a transparent adhesive film stretched out on a wafer ring, and separated into individual dies by scribing or sawing. After singulation, the wafer, with the individual dies held in place on the adhesive film, is disposed on a wafer table of a die bonder apparatus, where the dies are subsequently picked up from the adhesive film by a Pick-and-Place mechanism for further processing.

[0003] To facilitate effective removal of the dies from the adhesive film, the die bonder apparatus has a die ejector beneath the wafer table for ejecting the individual dies from the adhesive film before the dies are picked up by the Pick-and-Place mechanism. FIG. 1A and 1B show a perspective view and a cross-sectional view of a conventional die ejector respectively. The conventional die ejector **100** comprises an ejector housing **120** mounted on a support base **101**, a needle holder **140** housed in the ejector housing **120**, and a single or a plurality of ejector needles **160** disposed on the needle holder **140**. Details of the ejector housing **120** are provided in FIG. 2. FIG. 2A shows a side view of the ejector housing; FIG. 2B a cross-sectional view; and FIG. 2C a top plan view. The ejector housing **120**, normally a single piece made of metal, has a cylindrical shaft **122** that defines a hollow inner chamber **123**, and a circular top surface **132** that has a plurality of grooves **133** and associated holes **134** extending through the thickness of the top surface **132**. Now referring back to FIG. 1B, each ejector needle **160** on the needle holder **140** is configured to be in alignment with each hole **134** on the top surface **132** of

the ejector housing **120**. The needle holder **140** together with the ejector needles **160** is operable to be raised or lowered with respect to the ejector housing **120**.

[0004] Before the conventional die ejector ejects a die, the die bonder apparatus further has an alignment system for inspecting and adjusting the position and orientation of the die. FIG. 3A and 3B show diagrams of a conventional alignment system **200** and its cooperation with the conventional die ejector **100** in semiconductor chip processing. The conventional alignment system **200** comprises a plurality of light sources **272**, only two shown as **272a** and **272b** in FIG. 3, for illuminating the dies **102 a, 102b, 102c** on the transparent adhesive film **103** supported by the wafer table **104** (not shown in FIG. 3), a vision inspection unit **280** for capturing the image of the exposed dies **102 a, 102b, 102c** and optionally processing the captured image, and a control unit **290** (not shown in FIG. 3) for receiving and processing the information from the vision inspection unit **280** and sending instructions to move the wafer table **104** in a horizontal plane so that the center die **102b** indexed to be ejected is well aligned with the center of the die ejector **100**. The light sources **272a, 272b** and the vision inspection unit **280** are both located above the wafer table **104**, opposite to the die ejector **100.** When the alignment is achieved, the needle holder **140** and the ejector needles **160** are raised with respect to the ejector housing **120**. In the raised position, each ejector needle **160** projects through the corresponding hole **134** by a pre-determined amount and ejects the die **102b** off the adhesive film **103**.

[0005] FIG. 4A shows a typical grey scale image of dies **102** captured by the vision inspection unit **280** and processed by the control unit **290**, when the conventional die ejector **100** and alignment system **200** as shown in FIG. 3 are in operation. In the image, the exposed die surface is shown as white square; solder balls **105** deposited on the exposed die surface in grey scale; and saw streets **106** as sharp dark lines between every two adjacent dies **102**. The information of the saw streets **106** extracted from the processed image can be used by the control unit **290** to indicate the position and orientation of the die **102**, and to calculate and determine the movement of the wafer table **104** (not shown in FIG. 4) for alignment.

[0006] However, with the wide use of protective coating on the die surface to protect the die against unexpected damage due to more complicated semiconductor chip manufacturing process, a problem arises in relation to the die alignment based on the

information of saw streets. Because most of the protective coating chemicals, such as Hysol, have a dark color, the contrast between the saw streets and the dies in the captured image is dramatically reduced. FIG. 4B shows a typical grey scale image of dies **102** coated with protective coating Hysol, captured and processed by the same vision inspection unit **280** and control unit **290** used for FIG. 4A. The contrast between the dies **102** and the saw streets **106** is reduced to the extent that it is impossible for the control unit **290** to precisely recognize the saw streets **106** for die alignment before ejection.

[0007] In view of the above-mentioned problem, a new generation of die ejector and/or alignment system is required.

Summary of the Invention

[0008] In order to address the problem associated with the prior art, the present invention provides a die ejector with an integrated illuminating unit.

[0009] According to one aspect of the invention, there is provided a die ejector for semiconductor chip processing, the die ejector comprising an ejector housing having a shaft and a translucent cap mounted on the shaft, wherein the cap has a sidewall and a planar top surface with a plurality of holes that extend through the thickness of the top surface; a needle holder housed in the ejector housing; a plurality of ejector needles disposed on the needle holder, each aligned with one hole of the cap; and an illuminating unit having a plurality of light sources attached to the cap, and a light reflective coating applied to the inner surface of the cap; wherein the needle holder together with the plurality of ejector needles is operable to be raised or lowered with respect to the ejector housing, so that in the raised position, each ejector needle projects through the hole of the cap by a pre-determined amount, and wherein the light reflective coating is operable to reflect the light emitted by the plurality of light sources towards the top surface of the cap.

[0010] According to another aspect of the invention, there is provided an ejector housing for semiconductor die processing, the ejector housing comprising a shaft having a hollow inner chamber for housing a needle holder and a plurality of ejector needles, wherein the needle holder together with the ejector needles is operable to be raised or lowered with respect to the shaft; and a translucent cap mounted on top of the shaft, the

cap comprising a sidewall having interconnection means for connecting with a plurality of light sources; a top surface having a plurality of holes extending through the thickness of the top surface, wherein each hole is aligned with each of the ejector needles, so that when the needle holder is raised with respect to the shaft, the ejector needles project through the holes over the top surface of the cap; and a light reflective coating on the inner surface of the cap.

[0011] According to yet another aspect of the invention, there is provided a method for die alignment and ejection in semiconductor chip processing, the method comprising the steps of: disposing a singulated wafer held on an transparent adhesive film onto a wafer table; moving the wafer table for indexing a die to a pre-determined location where a die ejector with an integrated illuminating unit is located beneath the wafer table in alignment with a vision inspection unit located above the wafer table; illuminating the wafer from beneath by the illuminating unit of the die ejector; capturing the image of the singulated wafer by the vision inspection unit and transferring the captured image to a connected control unit; processing the received image by the control unit, determining the position and orientation of the dies based on the information of the exposed saw streets and calculating the movement of the wafer table in order to align the die to be ejected with the die ejector; sending instructions by the control unit to move the wafer table according to the calculation; and raising the needle holder and ejector needles of the die ejector, thereby ejecting the die from the adhesive film.

[0012] The objectives and advantages of the present invention will become apparent from the following detailed description of embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0013] Preferred embodiments according to the present invention will now be described with reference to the Figures accompanied herein, in which like reference numerals denote like elements.

[0014] FIG. 1A and 1B show a perspective view and a cross-sectional view of a conventional die ejector respectively.

[0015] FIG. 2A shows a side view of an ejector housing of the conventional die ejector shown in FIG. 1; FIG. 2B a cross-sectional view; and FIG. 2C a top plan view.

[0016] FIG. 3A and 3B show diagrams of a conventional alignment system in cooperation with the conventional die ejector shown in FIG. 1 in semiconductor chip processing.

[0017] FIG. 4A shows a grey scale image of an uncoated die captured by a vision inspection unit and processed by a control unit of the conventional alignment system shown in FIG. 3, whilst FIG. 4B shows a grey scale image of a die with surface protective coating.

[0018] FIG. 5A shows a perspective view of a die ejector having an illuminating unit in accordance with one embodiment of the present invention whilst FIG. 5B shows a cross-sectional view of the upper part of the die ejector.

[0019] FIG. 6A shows a perspective views of the cap of the ejector housing as shown in FIG. 5; FIG. 6B a side view; FIG. 6C a top view; FIG. 6D a bottom view; and 6E a cross-sectional view.

[0020] FIG. 7A shows an exploded view of a subassembly of the ejector housing and the illuminating unit as shown in FIG. 5 whilst FIG. 7B shows a partially broken away front perspective view of the cap, illustrating the surface to which the light reflective coating is applied.

[0021] FIG. 8 shows a cross sectional view the die ejector with illuminating unit as shown in FIG. 5, illustrating the optical path of the light emitted by the light sources and reflected by the light reflective coating.

[0022] FIG. 9A and 9B show diagrams of an alignment system in cooperation with the die ejector as shown in FIG. 5 in semiconductor chip processing, in accordance with one embodiment of the present invention.

[0023] FIG. 10A shows a grey scale image captured by the vision inspection unit and processed by the control unit of the alignment system as shown in FIG. 9 during the semiconductor chip processing in cooperation with the die ejector; whilst FIG. 10B shows an image obtained by the same system except that the die ejector is without the light reflective coating.

Detailed Description of the Invention

[0024] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0025] Now referring to FIG. 5, there is provided a die ejector having an illuminating unit in accordance with one embodiment of the present invention. FIG. 5A shows a perspective view of the die ejector **300**; FIG. 5B shows a cross-sectional view of the upper part of the die ejector **300**. The die ejector **300** comprises an ejector housing **320**, an illuminating unit **370** attached to the ejector housing **320**, a needle holder **340** housed in the ejector housing **320**, and a single or a plurality of ejector needles **360** disposed on the needle holder **340**. The ejector needles **360** and needle holder **340** are identical to those in the conventional die ejectors **100** as shown in FIG. 1.

[0026] The ejector housing **320** comprises a shaft **321** mounted on a support base **301**, and a translucent cap **331** disposed on top of the shaft **321**. The shaft **321** has a cylindrical body **322** defining a hollow inner chamber **323** for housing the ejector needles **360** and needle holders **340**, a cap resting shoulder **324** and a cylindrical nose **325** fitting into an inner chamber **339** of the cap **331**. The cap **331** has a circular top surface **332,** and a sidewall **335** with a step-tapered cylindrical outer surface, defining a hollow inner chamber **339**. The cap **331** will be described in greater detail further below.

[0027] In accordance with one embodiment of the cap, the translucent cap **331** is transparent. In accordance with another embodiment of the cap, the translucent cap **331** is made of plastic. In accordance with yet another embodiment of the cap, the translucent cap **331** is made of Engineering Plastic Stock Shapes with Static Dissipative (ESD) Properties.

[0028] In accordance with another embodiment of the ejector housing, the ejector housing **320** further comprises a cover **310**, disposed on top of the cap **331** for protection against dirt and damage when the die ejector **300** is not in use.

[0029] Still referring to FIG. 5, the illuminating unit **370** comprises a plurality of light sources **372** attached to the sidewall **335** of the cap **331**, and a light-reflective coating **374** applied to the inner surface of the cap **331**. The light sources **372** are electronically connected to a power through wires. The detailed features of the illuminating unit **370** will be described later.

[0030] Now referring to FIG. 6, there are provided details of the cap **331** as shown in FIG. 5. FIG. 6A shows a perspective views of the cap **330**; FIG. 6B a side view; FIG. 6C a top view; FIG. 6D a bottom view; and 6E a cross-sectional view. The top surface **332** is provided with a network of grooves **333** and holes **334**, the configuration of which are identical to those carved on the top surface **132** of the conventional ejector housing **100** as shown in FIG. 1. The lower portion of the sidewall **335** has two resting shoulders **336a, 336b** on the outer surface for supporting the cover **310** (not shown in FIG. 6), interconnection means **337a** for mounting the cap **331** onto the shaft **321** and an aperture **337b** for housing the wires connecting the light sources **372** to the power. The upper portion of the sidewall **335** has an array of recesses **338** on the outer surface for housing the plurality of light sources **372.** The dimension of the recesses **338** is configured to fit the outer contour of the light sources **372** disposed within.

[0031] In one embodiment of the recesses, the recesses **338** are cylindrical in shape.

[0032] Now referring to FIG. 7, there are provided details of a subassembly of the ejector housing **320** and the illuminating unit **370** as shown in FIG. 5. FIG. 7A shows an exploded view of the subassembly; FIG. 7B a partially broken away front perspective view of the cap **331**, illustrating the surface to which the light reflective coating **374** is applied. The cap **331** is secured to the shaft **321** by the pair of interconnection means **337a** (not shown in FIG. 7) and **327a**. The light sources **372** are disposed in the recesses **338** of the cap **331** and positioned in such a way that most of the light emitted from the light sources **372** will be delivered towards the top surface **332** of the cap **331** either directly or after being reflected by the light reflective coating **374**. The wires connecting the light sources **372** to the power is disposed in the passage formed by the aligned apertures **337b** and **327b**.

[0033] In accordance with one embodiment of the present invention, each light source **372** is positioned in a vertical orientation, emitting light towards the top surface **332** of the cap **331**. In accordance with another embodiment, each light source **372** is positioned in a horizontal orientation, emitting light towards the inner chamber **339** of the cap **331**.

[0034] The light sources **372** may be any type that is of proper size to be attached to the cap **331** and of sufficient light intensity for illumination. In accordance with one

embodiment of the light sources, the light sources **372** are light emitting diode (LED). In accordance with another embodiment, the light sources comprise optical fibers.

[0035] The light reflective coating **374** is applied to the inner surface of the cap **331** as shown in FIG. 7B, effective to specularly reflect the light from the light sources **372** so as to direct the light towards the top surface **332** of the cap **331**. And the light reflective coating may be applied for multiple layers to increase the coating thickness for higher light reflectance.

[0036] In one embodiment of the light reflective coating, the light reflective coating **374** comprises aluminum. In another embodiment, the light reflective coating **374** is metallic. In yet another embodiment, the light reflective coating **374** comprises white pigments mixed in a synthetic binder resin. In one embodiment of the white pigment, the white pigment is barium sulfate. In another embodiment, the white pigment is titanium dioxide. In yet another embodiment, the light reflective coating consists of both barium sulfate and titanium as white pigments.

[0037] Now referring to FIG. 8, there is provided a cross-sectional view of the die ejector **300** as shown in FIG. 5, illustrating the optical path of the light emitted by the light sources **372** and reflected by the light reflective coating **374** in accordance with one embodiment of the present invention. The open arrows denote the emitted light whilst the close arrows the reflected light. The light sources **372** disposed in the recesses are in a horizontal orientation, emitting light towards the inner chamber **339** of the cap **331**. The light transmits though the translucent sidewall **335** of the cap **331** and strikes the light reflective coating **374** on the inner surface of the cap **331**, where the light is reflected and directed towards the top surface **332**. The reflected light is subsequently transmits through the translucent top surface **332** of the cap **331** and the transparent adhesive film **303** (not shown in FIG. 8), and strikes the lower side of the singulated wafer **307** (not shown in FIG. 8). Most of the light is then reflected or absorbed by the die surface or the protective coating on the die surface, whilst the rest of the light goes through the saw streets **306** between the dies **302** and transmits further upward.

[0038] Now referring to FIG. 9A and 9B, there are provided diagrams of the die ejector **300** in cooperation with an alignment system in semiconductor chip processing, in accordance with one embodiment of the present invention. The die ejector with an illuminating unit **300** has the identical configuration to that of the earlier embodiment

shown in FIG. 5. The alignment system **400** comprises a vision inspection unit **480** and a control unit **490**, but not any light sources as shown in FIG. 1. The vision inspection unit and the control unit have identical features as those in the conventional alignment system **100** shown in FIG. 3. The die ejector with an illuminating unit **300** is located beneath the wafer table **304**, whilst the vision inspection unit **480** is located on the opposite site of the wafer stable **304** in alignment with the die ejector **300**. In operation, a singulated wafer **307** on an adhesive film **303** is input onto the wafer table **304** (not shown in FIG. 9). The plurality of light sources **372** emit light, providing bottom lighting. Most of the emitted light is directed towards the top surface **332** of the cap **331** by the light reflective coating **374**, thereby illuminating the dies **302 a, b, c** positioned above the ejector housing **320**. The vision inspection unit **480** captures the image of the exposed dies **302a, 302b, 302c** and transfers the information to the remote connected control unit **490** (not shown in FIG. 9). Based on the processed information of the position and orientation of the saw streets **306** embodied in the captured image, the control unit **490** sequentially instructs the wafer table **304** to align the center die **302b** with the die ejector **300** at the pre-determined picking location, and the die ejector **300** to raise the ejector needle **360** in order to lift the die **302b** off the adhesive film **303.**

[0039] FIG. 10A shows a grey scale image captured by the vision inspection unit **480** and processed by the control unit **490** of the alignment system as shown in FIG. 9 during the semiconductor chip processing in cooperation with the die ejector **300**; whilst FIG. 10B shows an image obtained by the same system except that the light reflective coating **374**, in this case Nippon paint 102, is not applied to the cap **331**. For easy interpretation, grey values of the image are rated from 0 to 255; with 0 and 255 corresponding to the lowest and highest light intensity respectively. When the grey values of the dies **302** in FIG. 10A and B are adjusted to the same grey value 16, the saw streets **306**, visualized as open space between the adjacent dies **302**, have dramatically different grey values, 255 for FIG. 10A whilst 100 for FIG. 10B. The higher grey value of the saw streets **306** in the captured image in FIG. 10A indicates a sharper contrast between the dies **302** and the saw streets **306** when the light reflective coating **374** is applied to the cap **331** of the ejector housing **320** as shown in FIG. 7B. The improved contrast contributes to more precise information of the position and orientation of dies **302** being

extracted by the control unit **490** (not shown in FIG. 10) to orchestrate the die alignment and ejection.

[0040] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

Claims

1. A die ejector for semiconductor chip processing, the die ejector comprising:

an ejector housing having a shaft and a translucent cap mounted on the shaft, wherein the cap has a sidewall and a planar top surface with a plurality of holes that extend through the thickness of the top surface;

a needle holder housed in the ejector housing;

a plurality of ejector needles disposed on the needle holder, each aligned with one hole of the cap; and

an illuminating unit having a plurality of light sources attached to the cap, and a light reflective coating applied to the inner surface of the cap;

wherein the needle holder together with the plurality of ejector needles is operable to be raised or lowered with respect to the ejector housing, so that in the raised position, each ejector needle projects through the hole of the cap by a pre-determined amount, and wherein the light reflective coating is operable to reflect the light emitted by the plurality of light sources towards the top surface of the cap.

2. The die ejector of claim 1, wherein the translucent cap is transparent.

3. The die ejector of claim 1, wherein the cap is made of plastic.

4. The die ejector of claim 1, wherein the cap is made of ESD materials.

5. The die ejector of claim 1, wherein the plurality of light sources are LED.

6. The die ejector of claim 1, wherein the plurality of light sources are attached to the sidewall of the cap.

7. The die ejector of claim 6, wherein the sidewall of the cap has a plurality of recesses for holding the plurality of light sources.

8. The die ejector of claim 7, wherein each light source is disposed in one recess with a horizontal orientation, emitting light towards the inner surface of the cap.

9. The die ejector of claim 7, wherein each light source is disposed in one recess with a vertical orientation, emitting light towards the top surface of the cap.

10. The die ejector of claim 1, wherein the light reflective coating comprises white pigments mixed in a synthetic binder resin.

11. The die ejector of claim 10, wherein the white pigment comprises barium sulfate.

12. The die ejector of claim 10, wherein the white pigment comprises titanium dioxide.

13. The die ejector of claim 1, wherein the light reflective coating comprises aluminum.

14. The die ejector of claim 1, wherein the light reflective coating is metallic reflection plate.

15. An ejector housing for semiconductor die processing, the ejector housing comprising:

a shaft having a hollow inner chamber for housing a needle holder and a plurality of ejector needles, wherein the needle holder together with the ejector needles is operable to be raised or lowered with respect to the shaft ;

a translucent cap mounted on top of the shaft, the cap comprising:

a sidewall having interconnection means for connecting with a plurality of light sources;

a top surface having a plurality of holes extending through the thickness of the top surface, wherein each hole is aligned with each of the ejector needles, so that when the needle holder is raised with respect to the shaft, the ejector needles project through the holes over the top surface of the cap; and

a light reflective coating on the inner surface of the cap.

16. The ejector housing of claim 15, wherein the translucent cap is transparent.

17. The ejector housing of claim 15, wherein the cap is made of plastic.

18. The ejector housing of claim 15, wherein the cap is made of ESD materials.

19. The ejector housing of claim 15, wherein the light reflective coating comprises white pigments mixed in a synthetic binder resin.

20. The die ejector of claim 19, wherein the white pigment comprises barium sulfate.

21. The die ejector of claim 19, wherein the white pigment comprises titanium dioxide.

22. The die ejector of claim 15, wherein the light reflective coating comprises aluminum.

23. The die ejector of claim 15, wherein the light reflective coating is metallic reflection plate.

24. A method for die alignment and ejection in semiconductor chip processing, the method comprising the steps of:

disposing a singulated wafer held on an transparent adhesive film onto a wafer table;

moving the wafer table for indexing a die to a pre-determined location where a die ejector is located beneath the wafer table in alignment with a vision inspection unit located above the wafer table, wherein the die ejector comprises:

an ejector housing having a shaft and a translucent cap mounted on the shaft, wherein the cap has a sidewall and a planar top surface with a plurality of holes that extend through the thickness of the top surface;

a needle holder housed in the ejector housing;

a plurality of ejector needles disposed on the needle holder, each aligned with one hole of the cap; and

an illuminating unit having a plurality of light sources attached to the sidewall of the cap, and a light reflective coating applied to the inner surface of the cap;

wherein the needle holder together with the plurality of ejector needles is operable to be raised or lowered with respect to the ejector housing, so that in the raised position, each ejector needle projects through the hole of the cap by a pre-determined amount, and wherein the light reflective coating is operable to reflect the light emitted by the plurality of light sources towards the top surface of the cap;

illuminating the wafer from beneath by the illuminating unit of the die ejector;

capturing the image of the singulated wafer by the vision inspection unit and transferring the captured image to a connected control unit;

processing the received image by the control unit, determining the position and orientation of the dies based on the information of the exposed saw streets and calculating the movement of the wafer table in order to align the die to be ejected with the die ejector;

sending instructions by the control unit to move the wafer table according to the calculation; and

raising the needle holder and ejector needles of the die ejector, thereby ejecting the die from the adhesive film.