

Apparatus for Mounting of Semiconductor Chips

The invention concerns an apparatus for mounting of semiconductor chips of the type named in the preamble of claim 1.

For the mounting of semiconductor chips, so-called die bonders are used as automatic assembly machines with which a bondhead picks up the semiconductor chip to be mounted at a first location and places it on a substrate at a second location. The bondhead has a pick-up tool with a vacuum nozzle with which the semiconductor chip is held during transport. Different measuring systems have been developed for checking whether the semiconductor chip has been successfully picked. With a first measuring system, a photosensor is located in the bondhead at the upper end of the vacuum nozzle. On the way from the first location to the substrate the pick-up tool passes over a light source which then produces a light-induced pulse in the photosensor when no semiconductor chip is located on the pick-up tool. Because of space reasons, an optimum development of the measuring system is not possible as the bondhead must fulfil various functions with the lowest possible mass.

With another known measuring system, the semiconductor chip is led through a light barrier during transport. The disadvantage with this system is that the light barrier must be adjusted exactly at the transport height.

Measurement of the strength of the vacuum in the vacuum nozzle which should be greater when the semiconductor chip has been picked and the nozzle sealed has only partially proved to be suitable because the sealing by means of the semiconductor chip is often very poor with die collet pick-up tools.

The object of the invention is to develop a measuring system which reliably detects whether a semiconductor chip is located on the pick-up tool and which does not have to be adjusted.

The named task is solved in accordance with the invention by means of the features of claim 1.

Solving of the task is achieved with a measuring system with which the light emitted from a light source which, in the absence of a semiconductor chip, accesses the longitudinal drill hole of the pick-up tool is deflected by means of an optical deflection element orthogonally radial to the longitudinal drill hole and led to a photosensor for detection. Furthermore, the measuring system is preferably envisaged with a reflector in order to deflect as large a portion of the laterally emerging light as possible onto the photosensor.

In the following, embodiments of the invention are explained in more detail based on the drawing. The figures are not to scale.

It is shown in: Fig. 1 an apparatus for the mounting of semiconductor chips with a bondhead with a

pick-up tool,

Fig. 2 a cross-section of the bondhead with a measuring system in accordance with the invention,

Fig. 3 a plan view of a first embodiment of the measuring system,

Fig. 4 details of the pick-up tool,

Fig. 5 a second embodiment of the measuring system, and

Fig. 6 a light source for producing parallel beams.

Fig. 1 shows the parts necessary for understanding the invention of an apparatus for the mounting of semiconductor chips as is known, for example, from the European patent application EP 923 111. The apparatus comprises a so-called Pick and Place system 1 movable in two cartesian co-ordinate directions 2, 3 with a bondhead 5 which can be raised and lowered in vertical direction 4 with a pick-up tool 6 for transporting a semiconductor chip 7 from a first location A to a second location B where the semiconductor chip 7 is placed on a substrate 8.

The pick-up tool 6 has a longitudinal drill hole 9 to which vacuum can be applied in order to grip the semiconductor chip 7. On the way from location A to location B, the bondhead 5 passes over a rigidly arranged light source 10. When the semiconductor chip 7 adheres to the pick-up tool 6 no light from the light source 10 accesses the longitudinal drill hole 9 when passing over the light source 10. If no semiconductor chip 7 is present on the pick-up tool 6, then light from the light source 10 accesses the longitudinal drill hole 9.

Fig. 2 shows a cross-section of the bondhead 5 with the pick-up tool 6 and a measuring system for detecting the light from the light source 10 which accesses the longitudinal drill hole 9 on absence of the semiconductor chip 7. The pick-up tool 6 can be moved in vertical direction 4 in relation to the bondhead 5 and is rotatable on its longitudinal axis. The pick-up tool 6 comprises an upper part 11 and a lower part 12 which are both impervious to light. The upper part 11 and the lower part 12 are connected by means of a coupling piece 13 which is pervious to the light of the light source 10. The coupling piece 13 is inserted into the longitudinal drill hole 9 in the upper part 11 and into the longitudinal drill hole 9 in the lower part 12. The coupling piece 13 has a body 15 with a reflective tip 16 centred on the symmetrical axis 14 of the longitudinal drill hole 9. The tip 16 is rotationally symmetrical in relation to the longitudinal axis 14 of the longitudinal drill hole 9. The surface forming the tip 16 is, for example, conical in shape and has an angle of 45° to the vertical direction 4 so that the light shining from the light source 10 into the longitudinal drill hole 9 from underneath is deflected at the tip 16 into the horizontal plane 17 and emerges from the pick-up tool 6 laterally. A photosensor 18 for measuring the laterally emerging light and at least one optical element 19 for deflecting and/or concentrating the light emerging in the horizontal plane 17 onto the photosensor 8 are arranged on the bondhead 5. For reasons of illustrative clarity, the optical element 19 is only indicated schematically; details concerning its position

and extension can be taken from the following Figures 3 and 5. The photosensor 18 is, for example, a photodiode or a phototransistor.

With the first embodiment, the optical element 19 is a reflector with an elliptical shape whereby the reflective tip 16 is located in one focal point 20 (Fig. 3) of the ellipse and the photosensor 18 in the other focal point 21 (Fig. 3) of the ellipse. In this way, the light emerging in the horizontal plane 17 is deflected onto the photosensor 18 regardless of the direction it takes up in the horizontal plane 17.

Fig. 3 shows the elliptical reflector 19', the reflective tip 16 and the photosensor 18 in a section through the horizontal plane 17. The two focal points 20 and 21 of the ellipse are also drawn as well as different beam paths 22 of the light deflected at the tip 16. The elliptical reflector 19' is not completely closed because the light reflected on it must fall on the photosensor 18 from the front. With the elliptical reflector 19', around 80% of the laterally emerging light can be concentrated onto the photosensor 18.

Fig. 4 shows a second embodiment with which two optical elements 19.1 and 19.2 are present in order to lead the light deflected in the horizontal plane 17 onto the photosensor 18. The first optical element 19.1 is a lens which focuses a part of the light deflected on the tip 16 onto the photosensor 18. The numerical aperture of the lens is as large as possible. With a numerical aperture of 0.5, the aperture angle amounts to 60° so that around 17% of the light emerging in the horizontal plane 17 is led to the photosensor 18. The symmetrical axis 14 penetrates the focal point 20 of the lens. The photosensor 18 is located in the focal point 21 of the lens. The second optical element 19.2 is a reflector with almost cylindrical shape and with an angle at circumference of also around 60° which reflects the light falling on it back so that it also arrives at the photosensor 18 via the lens. The reflector should reflect the light so that it passes the tip of the body 15 and reaches the lens. Because of the shadowing caused by the tip 16 of the body 15, a certain loss must be taken into account which can amount to around 10 - 40%. For the lens, for example, a bi-aspherical plastic lens with an anti-reflex coating can be used.

In a third embodiment, the measurement system comprises only the first optical element 19.1, i.e. the lens, but not the second optical element 19.2, i.e. the reflector, of the second embodiment. However this allows only a small fraction of the light deflected at the tip 16 to be focused on the photosensor 18.

The light emitted by the light source 10 and accessing the longitudinal drill hole 9 has a certain beam width. The light sensitive area of the photosensor 18 must therefore extend sufficiently in vertical direction in order to acquire all if possible of the light originating from the light source 10. The extension of the photosensor 18 in vertical direction 4 can however be reduced when the light deflecting tip 16 of the body 15 and/or the reflectors are adapted to the characteristics of the light beams 23 (Fig. 5) emitted by the light source 10.

If, for example a commercial light-emitting diode without additional optical elements is used as the light

source, then the light beams emitted from it do not run parallel but divergent.

The surface forming the tip 16 of the body 15 is therefore preferably curved in shape, as is shown in Fig. 5, in order to focus the light beams 26 reflected on the body 15 onto the photosensor 18 in vertical direction. With the first embodiment, the curvature must be adapted on the one hand to the divergence of the light beams 23 and, on the other hand, to the length of the beam paths 22 (Fig. 3) from the body 15 up to the photosensor 18. With the second embodiment, the curvature must be adapted on the one hand to the divergence of the light beams 23 and, on the other hand, to either the length of the path of the light beams which arrive directly at the photosensor 18 or the length of the path of the light beams which arrive via the reflector indirectly at the photosensor 18. With this example it is preferred that the surface forming the tip 16 of the body 15 is curved so that the reflected beams leave the tip of the body 15 as parallel beams 24. The advantage with this is that varying path lengths between the light beams which reach the photosensor 18 directly after reflection on the body 15 and the light beams which only reach the photosensor 18 after reflection on the reflector make no difference.

Another possibility exists, as is shown in Fig. 6, in using a light source 10 which emits light of almost parallel beams 23. Such a light source 10 comprises, for example, a light-emitting diode 24 and a lens 25, whereby the light-emitting diode 24 is located in the focal point of the lens 25. The reflecting surface of the body 15 is then preferably formed as a cone point so that the light 23 consisting of parallel incidence beams also leaves the body 15 as light of parallel beams 26. The reflecting surface of the body 15 can however also be curved in order to focus the light on the photosensor 18 with regard to the vertical.

With the embodiments described, the reflectors consist, for example, of mirror-finished aluminium.

In order to avoid errors caused by external light, the optical element or elements 19 and the photosensor 18 are preferably installed in light-impervious housing. Furthermore, the known lock-in technique is preferably used with which the light from the light source 10 is modulated. In addition, the light source is preferably operated in pulse mode, ie, it is only switched on for short periods when the pick-up tool 6 passes the light source 10. In pulse mode, a higher current can be applied to the light source 10 than in continuous operation which increases the measuring sensitivity.

Thanks to the rotational symmetry of the tip 16, the measurement result is independent of the actual rotational position of the pick-up tool 6.

While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art having the benefit of this disclosure that many more modifications than mentioned above are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the appended claims and their equivalents.



PATENT CLAIMS

1. Apparatus for the mounting of semiconductor chips, with a bondhead (5) with a pick-up tool (6) with a longitudinal drill hole (9) to which vacuum can be applied for the gripping and transport of a semiconductor chip (7), and with a light source (10) and a photosensor (18) to detect whether the pick-up tool (6) has gripped the semiconductor chip (7), whereby on the absence of the semiconductor chip (7) light from the light source (10) accesses into the longitudinal drill hole (9) of the pick-up tool (6) and to the photosensor (18), **characterised in that** a body (15) formed with a reflective surface is arranged in the longitudinal drill hole (9) of the pick-up tool (6) which deflects light shining from underneath into the longitudinal drill hole (9) of the pick-up tool (6) into a horizontal plane (17), that the pick-up tool (6) has locations pervious to the light of the light source (10), and that at least one optical element (19; 19.1, 19.2) is arranged on the bondhead (5) which concentrates at least a part of the deflected light emerging laterally from the pick-up tool (6) onto the photosensor (18).
2. Apparatus according to claim 1, **characterised in that** the optical element (19) is a reflector in the form of an ellipse, whereby the reflecting surface of the body (15) is arranged in the first focal point (20) and the photosensor (18) is arranged in the second focal point (21) of the ellipse.
3. Apparatus according to claim 1, **characterised in that** the optical element (19.1) is a lens and that a second optical element (19.2) in the form of a reflector is present.
4. Apparatus according to claim 1, wherein the optical element (19.1) is a lens and wherein the photosensor (18) is arranged in a focal point (21) of the lens.
5. Apparatus according to one of claims 1 to 4, **characterised in that** the optical element or elements (19) and the photosensor (18) are installed in a housing which is impervious to light.
6. Apparatus according to one of claims 1 to 5, **characterised in that** further a lens (25) is provided in order to produce a light beam of almost parallel light beams (23), whereby the light source (24) is arranged in a focal point of the lens (25).