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# Semi-conductor mounting apparatus for applying adhesive to a substrate

The invention relates to a semi-conductor mounting apparatus for applying adhesive to a substrate in the area of a chip mounting surface.

The very widespread mounting of semi-conductor chips using adhesive (mostly epoxy-based) assumes a metered application of the adhesive in a certain distribution on the mounting surface so that when the chip is subsequently applied, there is a layer of adhesive spread as evenly as possible over the entire surface of the chip, free from trapped air. In order to obtain this, according to the format of the chip, type of adhesive and further parameters, different "figurative" patterns of application are used, ranging from a simple diagonal cross to line patterns with a plurality of branches.

Within an automated mounting means, known as a "die bonder", a particular apparatus is used for the application of adhesive, which moves a dispenser over the substrate. The desired pattern of application can thus be produced in different ways: For example, a die-type dispensing tool is used, which is provided with a large number of nozzles arranged in rows corresponding to the pattern (multitube dispenser); such tools must be individually manufactured and changed for each pattern. Another application apparatus is provided with a single nozzle, which is guided over the substrate in a programmed movement corresponding to the pattern and thus "draws" the pattern of lines (programmable dispenser). A considerable advantage of this apparatus is in that any pattern can be produced using the same, relatively simple tool, simply by amending the software. Nevertheless, it is necessary to carry out the programmed movements with sufficient precision, and above all at high speed, so that even branched patterns can be "drawn" with short cycle times.

Known apparatus of the type described hereinabove have the following features:
- an adhesive dispensing head moveable in three coordinate directions (x, y, z),
- a first carriage which is moveable in two directions (x, y) parallel to the mounting surface by means of associated first and second actuators, and

- a second carriage which is moveable, on a guide connected to the first carriage, in the third direction (z) perpendicular to the mounting surface, by means of a third actuator, and which carries the dispensing head.

One of the known embodiments is a "standard" three-axis control unit with three overlying carriages, each provided with an actuator, and in another case although the x and y actuators of the first carriage are not coupled together, the third (z) actuator together with its carriage is mounted on the first x/y carriage and is moved along with it. With such apparatus according to the prior art, it is difficult to obtain the required mechanical stability and precision of control over the whole three-axis working surface. Above all, however, the acceleration and speeds of the controlling movements obtainable are limited because the weight of powerful positioning motors in turn requires correspondingly stable carriage guides, which as a whole results in ever greater masses being moved.

The object of the invention is to overcome the disadvantages and limitations of the prior art, and to improve the dynamic properties of such apparatus in order to obtain faster accelerations and control speeds of the dispensing head and thereby shorter cycle times for "drawing" the pattern of adhesive.

This object is solved according to the invention in that with an apparatus of the type described hereinabove, the third actuator is provided with a positioning motor mounted in a stationary manner and an auxiliary carriage driven by it, which is displaceable in the third direction (z) on a stationary guide, and is provided with a positioning surface parallel to the mounting surface, and in that furthermore the second carriage is provided with a stop which is kept in constant contact with the positioning surface of the auxiliary carriage.

In particular, a drastic reduction in the mass moved and thereby in the forces of acceleration in the area of the dispensing head are achieved with the manner of construction according to the invention. Because the positioning motor and the auxiliary carriage of the third actuator are arranged in a stationary manner, the second (z) carriage carrying the dispensing head is relieved

of the mass of these and is correspondingly light. This allows increased acceleration in all three coordinate directions without losses of precision or of long-term stability.

Further advantageous embodiments of the apparatus defined in claim 1 are described in the dependent claims.

The invention will be described in more detail hereinafter with reference to different embodiments together with the drawings.

Fig. 1 shows a first example in perspective and as a simplified diagram, with an indication of the three coordinate directions,

Fig. 2 is the end-face view (seen in the y direction), and

Fig. 3 is the side view (seen in the x direction) of a second embodiment, also shown simplified, although with more constructional details.

The apparatus shown in Fig. 1 for applying adhesive during mounting of semi-conductors is constructed as a component of a die bonder on a stationary base structure 8. In the die bonder, in a manner known per se, a substrate 1, for example a metallic, strip-shaped "lead frame", is advanced on a backing 4 by means of a transport device (not shown) stepwise in the direction of the arrow. The substrate 1 is provided with chip mounting surfaces 2 (also known as "chip islands"), to each of which an adhesive pattern 3 is applied by means of a dispensing head 5 moveable in three coordinate directions, x, y and z. The flowable adhesive, typically epoxy-based, is supplied by means of a flexible line 6 and metered, for example, by means of a known volumetric pump, which is not shown. In a known manner, the substrate 1, further advanced in the die bonder, then has a chip placed on each adhesive pattern 3, whereby the adhesive spreads over the surface of the chip and bonds it to the substrate.

The adhesive is often applied as a branched line pattern going from the diagonals of the mounting surface 2. For this, the dispensing head 5 must be moved in a programmed sequence in the x and y directions, while the dispenser aperture is kept at a precisely pre-determined distance above the

mounting surface 2; when the line is interrupted, and also when the substrate is moved on, the dispensing head must be lifted up (direction z). All these movements must be carried out with a high degree of precision and be done as quickly as possible to obtain short cycle times.

A first carriage 10 mounted on the base 8, with associated (first and second) actuators 12 and 14, serves to move the dispensing head 5 in directions x and y, that is to say parallel to the respective mounting surface 2. These components are only shown schematically and could be produced in different ways, known per se. There could be, for example, a compound table with longitudinal and cross carriages (wherein, for example, only the x actuator is mounted in a stationary manner, and the y drive travels with it in direction x); preferably, however, the x and y directions are not "coupled" and both the drives 12 and 14 are stationary.

Connected to the carriage 10 is a guide 16, which guides a second carriage 20 displaceable in the direction z, perpendicular to the mounting surface 2. The substantially corner-shaped carriage 20 has one arm arranged at 22 for retaining the removable dispensing head 5, while the other arm 24 is provided with guide ways running into the guide 16.

The following arrangement serves as the (third) actuator for the movements of the carriage 20 in the direction z:

A positioning motor 30 is mounted in a stationary manner on the base 8. An auxiliary carriage 32, driven by the motor 30, is moveable in a guide 36, which is also stationary, in the z direction, that is to say again perpendicular to the mounting surface 2. In the present example, a spindle mechanism is provided as the drive connection, with a screw spindle 31 which engages without clearance in the nut 33 on the auxiliary carriage 32. The latter is provided with a horizontal arm 34 and a vertical arm 35 sliding in the guide 36. The underside of the horizontal arm forms a positioning surface 38 which is machined to be exactly planar and is aligned parallel to the mounting surface 2 of the substrate 1 (and respectively to the supporting surface of the substrate backing 4). The extension of the positioning surface 38 corresponds to at least the range of travel of the carriage 10 in the x and y directions and to the operating area of the dispensing head 5,

respectively. A stop 25, 26 provided on the carriage 20, kept constantly in contact with the positioning surface 38, cooperates with said positioning surface 38. Permanent contact is ensured from below by means of a tension spring 28 which is tensioned between the carriage 20 and its guide 16.

As shown, the stop is configured here as a gliding head with a (preferably replaceable) insert 26 made of gliding material which glides over the positioning surface 38. By suitable selection of the gliding material (for example, a graphite based solids mixture) and/or of the pairing of materials, it is ensured that the positioning surface 38 is not subject to wear. It would also be conceivable to construct the stop with a rolling ball or the like instead of with a gliding head.

During operation of the apparatus according to Figure 1, the programmed, rapid "writing" movements of the dispensing head 5 in directions x and y are carried out by the actuators 12 and 14 via the carriage 10; the height position of the head 5 (z value) is then given by the position of the auxiliary carriage 32 via the stop 25, 26. Apart from the head 5, the carriage 10 has only to move the relatively light carriage 20, unencumbered by the actuator in the z direction, as the motor 30 and the auxiliary carriage 32 are mounted in a stationary manner and consequently no acceleration forces occur on the carriage 20 resulting from their mass.

For the vertical movements of the carriage 20 with the head 5, the motor 30 must (additionally) move the auxiliary carriage 32 and overcome the force of the spring 28. With the motor 30 mounted in a stationary manner, this can be managed without any particular problems. Taking dynamics into account, and for adjusting the z position, constant contact of the gliding insert 26 with the positioning surface 38 must be ensured. In the arrangement described, stopping of the carriage 20 after rapid lowering to the specified height is crucial. With regard to this, it is advantageous that the force of the tension spring 28 increases with lower positions of the carriage 20, and thus more strongly counters the tendency of the surface 38 to rise up.

The dispensing head 5 is replaceable, as described hereinabove. In particular, the apparatus can be operated with a die-type ("multitube") head instead of with a "writing" dispensing head according

to Fig. 1. Such a "multitube" head generally necessitates movements only in the z direction (but in x and y if necessary, for centering the head over the mounting surface 2 or for temporary removal from the operating position). In order to take account of different sizes of dispensing heads, the spring 28 can be replaced or the pre-tensioning thereof adjusted.

In the further embodiment according to Figs. 2 and 3, those parts which have the same function as parts in the first example are given the same references as in Fig. 1, even when they are somewhat differently configured or arranged. The actuators and the mounting of the x-y carriage 10 is not shown further.

With the apparatus according to Figs. 2 and 3, it is above all the drive connection between the positioning motor 30 and the auxiliary carriage 32 which is solved differently to that in Fig. 1.

A cam plate 40 is mounted in a torsion resistant manner on the rotor shaft 39 of the motor 30. A roller head 44 cooperates with the cam 41 of the cam plate, which roller head is mounted on an axle bolt 42 held in the auxiliary carriage 32. The clearance-free resting of the roller head on the cam is maintained in this case by the force of the spring 28 which transfers via the gliding insert 26 to the auxiliary carriage 32 and thereby to the roller head 44. It would also be possible, however, to provide a separate spring tensioned between the auxiliary carriage 32 and the base structure 8 for this purpose.

A direct current motor or a stepping motor of a known construction are particularly suitable as the positioning motor 30 (this is also the case with the x and y positioning motors 12 and 14, Fig. 1). As, in the arrangement described, the bearing force of the roller head 44 on the rising cam 41 effects a torque on the rotor axle 39, a corresponding counter-torque must be applied by the motor 30 in order to be able to maintain a particular z position. As small a rise as possible of the cam 41 should be provided for a low motor holding torque. In this connection, a linear spiral has proved advantageous for the cam (radius increasing with the angle of rotation); as can be seen in Fig. 2, it is advantageous when the spiral extends over more than 360°, in order to produce the necessary lift stroke in the z direction with a small degree of rise.

As the spring 28 stretches increasingly, that is to say with lower positions of the carriage 20, the force of the spring, and thereby the supporting power of the roller head 44 on the cam 41, increases. A corresponding increase in the motor holding torque necessary is, however, partially compensated for in that with the spiral described, the angle between the tangent thereof and the radius becomes smaller as the radius increases. When dimensioning the cam 41 and the spring 28, care should be taken that during all accelerations of the carriage 20 with the dispensing head 5 during operation, the contact between the stop 25, 26 and the positioning surface 38 is maintained.

The incorporation of a sensor 46 with measuring line 47 on the carriage 20, that is to say in the arm 24 thereof, is shown in Fig. 2. These are components of a measuring arrangement known per se and not shown in further detail, for continuous determination of the position of the carriage in the z direction (for example, a photo-transistor as a pulse generator together with a glass measuring rod incorporated into the guide 16; naturally the reverse arrangement is also possible). A measuring arrangement at this site is particularly advantageous as an actual value sensor in a position control loop for controlling the actuating motor 30, in that it measures directly "right up front" the z position of the dispenser aperture (after calibration according to the height of the substrate 1). By virtue of the feedback control of the z position of the carriage 20, or alternatively of the positioning surface 38, by means of the signals from the sensor 46, any possible wear of the gliding head is compensated for.

The apparatus can also be used for applying adhesive with a die, that is to say without writing movements of the dispensing head, in the x and/or y direction, to the chip mounting surface 2. For this usage, adjustment means, not shown, are provided with which the base structure 8 is adjustable such that the edges of the die are plane-parallel to the chip mounting surface 2 and therefore lie in a form-fitting manner on the chip mounting surface.

* C L M S *

**Claims**

1. Semi-conductor mounting apparatus for applying adhesive to a substrate (1) in the area of a chip mounting surface (2), with

- an adhesive dispensing head (5) moveable in three coordinate directions (x, y, z),
- a first carriage (10), which is moveable in two directions (x, y) parallel to the mounting surface (2) by means of associated first and second actuators (12, 14), and
- a second carriage (20) which is moveable on a guide (16) connected to the first carriage (10) in a third direction (z) perpendicular to the mounting surface (2) by means of a third actuator, and carries the dispensing head (5), characterised in that the third actuator is provided with a positioning motor (30) mounted in a stationary manner, and an auxiliary carriage (32) driven by said motor (3), which auxiliary carriage (32) is displaceable on a stationary guide (36) in the third direction (z), and is provided with a positioning surface (38) which is parallel to the mounting surface (2), and in that the second carriage (20) is provided with a stop (26, 28) which is kept in constant contact with the positioning surface (38) of auxiliary carriage (32).

2. Apparatus according to claim 1, characterised in that the positioning surface (38) is formed by the underside of the auxiliary carriage (32) facing the substrate (1), and the stop (26, 28) is held from below against the positioning surface (38) by means of a spring (28) tensioned between the second carriage (20) and the guide (16) thereof.

3. Apparatus according to claim 1 or 2, characterised in that the stop (26, 28) is formed by a gliding head and is provided with an insert (26) made from gliding material which ensures gliding movements along the positioning surface (38) without abrasion of said surface.

4. Apparatus according to claim 1, characterised in that the third actuator comprises a cam plate (40) driven by the positioning motor (30) and a roller head (44) mounted on the auxiliary carriage (32) cooperating with the cam (41) of said cam plate.

5. Apparatus according to claim 4, characterised in that the cam (41) is a spiral and its angle of rotation extends over more than 360°.

6. Apparatus according to claim 5, characterised in that the spiral is a linear spiral.

7. Apparatus according to claim 1, characterised by path measuring means (46, 47) on the second carriage (20) for determining the actual position thereof in the third direction (z).