980419-5
IPOC15

A method of and apparatus for aligning the bonding head of a bonder or a pick and place machine

BACKGROUND OF THE INVENTION

The invention relates to a bonder, in particular to a die bonder, or a pick and place machine and to an apparatus to be used in connection with such a machine which allows a simple alignment of its bonding head.

A die bonder is a machine which sticks or bonds a semiconductor chip onto a carrier, in particular onto a lead frame. In order to ensure that the subsequent wire bonding may take place without any problems, the spatial positioning of the bonding head of the die bonder must be adjusted such that the semiconductor chip bonds onto the carrier in a plane-parallel manner within specified tolerances of approximately 10µm.

Pick and place machines are well known. They are used, for example, to bond a semiconductor chip onto another semiconductor chip. Such processes are known as flip-chip or C4. Pick and place machines are also widely used to place all sorts of electronic components on printed circuit boards.

SUMMARY OF THE INVENTION

The object of the invention is to provide means with which the bonding head of a bonder, in particular of a die bonder, or a pick and place machine may be aligned in a simple manner.

Particular and preferred aspects of the invention are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with those of the independent claims as appropriate and in combinations other than those explicitly set out in the claims.

According to a first embodiment of the invention a method of aligning the bonding head of a bonder, in particular of a die bonder, or a pick and place machine is provided. An alignment plate provided with two plane parallel surfaces is placed on a supporting surface which extends plane parallel to the bonding surface, upon which the semiconductor chip is to be bonded to the carrier material. A measuring device is calibrated, the signal of the measuring device being dependent upon the position of the alignment plate. The alignment plate is then taken hold of by the bonding head of the bonder and held above the measuring device, preferably by a small distance. Then, the bonding head is positionally aligned until the signal from the measuring device is equal to the signal after the calibration.

In a second embodiment of the present invention an apparatus for implementing the above method is provided.

The alignment plate may have a metallised or ferromagnetic surface. The measuring device has at least three coils, preferably three or four, arranged in a plane approximately parallel to the supporting surface. A display may be configured to display at least the difference between two of the signals supplied by the three or more coils. Preferably, the apparatus is designed so that, at any one time, only one of said at least three coils produces a significant signal. The apparatus may be configured to allow the coils to be operated in sequence, i.e. with time division multiplexing.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention and to show how the same may be carried into effect reference is now made by way of example to the accompanying drawings in which:

Fig. 1 shows a die bonder with an apparatus for aligning the bonding head according to the present invention.

Figs. 2A and 2B show the apparatus for aligning the bonding head in which coils serve as measuring device in accordance with the present invention.

Fig. 3 is a circuit diagram illustrating a circuit for operating the coils in the time-division multiplex.

Fig. 4 depicts voltage diagrams; and

Fig. 5 shows the apparatus for aligning the bonding head, in which an optical measuring device is used in accordance with the present invention.

DETAILED DESCRIPTION

The invention will now be described with reference to a die bonder. Fig 1 shows schematically the die bonder 1 with a bonding surface 2 on which semiconductor chips are bonded onto lead frames, or any other carrier material, one after another. The semiconductor chip may also be applied to the carrier material as a so-called flip-chip. The bonding of a semiconductor chip proceeds with the bonding head 3 of the die bonder 1 taking hold, or grasping, of the semiconductor chip by vacuum suction at the point provided for this purpose, and by placing it on the lead frame. The bonding head 3 has a rubber part 4 with a suction aperture 5 so that the semiconductor chip can form a seal with the suction aperture 5.

The bonding head 3 can be fitted with rubber parts 4 of different sizes for semiconductor chips of different sizes. After exchange of the rubber part 4, the bonding head 3 has to be realigned. After alignment the bonding head 3 must bond the semiconductor chip to the carrier material such that no point on the edge of the surface of the semiconductor chip projects by more than approximately 10µm beyond any other point on its surface. The die bonder 1 has a supporting surface 6 which is

aligned plane-parallel to the bonding surface 2. Directly below the supporting surface 6 and fixedly connected thereto there is a measuring device 7 which delivers signals dependent upon the current position of an alignment plate 10 having two plane-parallel surfaces 8 and 9. The signals are visually displayed by a display 11. The bonding head 3 may be rotated about two axes manually, by means of two screws 12 and 13, or by means of electric drives, so that a semiconductor chip which it has to position may be bonded in a plane-parallel manner to the bonding surface 2 within prespecified tolerances.

The alignment of the bonding head 3 takes place in accordance with the following steps:

a) placing the alignment plate 10 on the supporting surface 6;
b) calibrating the measuring device 7;
c) grasping the alignment plate 10 with the rubber part 4 of the bonding head 3 and holding the alignment plate 10 free at a slight distance above the measuring device 7; and
d) positionally adjusting the bonding head 3, manually or automatically, until the signal from the measuring device 7 is equal to the signal after step b.

After step a, the alignment plate 10 is located in a predetermined reference position plane parallel to the bonding surface 2. The signals supplied by the measuring device 7 when the alignment plate 10 is in this position are sensed during step b. After step c the alignment plate 10 is in an inclined position defined by the current adjustment of the bonding head 3 and by the rubber part 4. During step d the inclined position of the alignment plate 10 is moved towards the reference position until the signals of the measuring device 7 indicate that the alignment plate 10 is held by the bonding head 3 plane parallel to the bonding surface 2.

Calibration of the measuring device 7 is understood to be measuring and storing the signal or signals supplied by the measuring device 7 as reference signal or reference

signals when the alignment plate 10 is in the reference position, or to be adjusting the measuring device 7 when the alignment plate 10 is in the reference position so that its signal shows a predetermined value, for example the value "0". Step b of the method will be described in more detail hereinafter using examples.

A suitable material for the alignment plate 10 is for example polycarbonate, wherein at least the surface 9, but preferably both surfaces 8 and 9, are metallised. The weight of the alignment plate 10 of a few grams is then within the range covered by semiconductor chips of various sizes.

Conventional methods of aligning the bonding head 3 have the disadvantage that the rubber part 4 is not taken into account. The rubber part 4 itself is, however, a source of unwanted inclination (tilt) since the suction aperture 5 of such a part cannot be manufactured and mounted on the bonding head 3 with the required precision. The advantage of the method according to the invention is that the tilt of the semiconductor chip caused by the indispensable rubber part 3 of the bonding head 3 itself is also eliminated.

Usual inductive range-finding is a suitable measurement technique in which the ohmic resistance and/or the inductance of a coil excited by an alternating current changes when a metallic or ferromagnetic object is moved in its magnetic near field. Figs. 2A and 2B show in plan view and in side view respectively a preferred embodiment in which a circuit board 14, provided with at least three coils Sp1, Sp2 and Sp3, but preferably with four coils Sp1, Sp2, Sp3 and Sp4, serves as the measuring device 7. The coils Sp1, Sp2, Sp3 and Sp4 are arranged in the four quadrants of a Cartesian xy coordinate system, symmetrically with respect to the origin. The circuit board 14 is arranged plane parallel at a distance d of approximately one millimeter from the supporting surface 6. The coils Sp1, Sp2, Sp3 and Sp4 are flat coils formed from circuit board paths or tracks. The surface 9 of the alignment plate 10 facing the coils Sp1, Sp2, Sp3 and Sp4 is provided with a metallised or a ferromagnetic surface. Referring also to fig. 3 the coils Sp1, Sp2, Sp3 and Sp4 supply respective signals S1,

S2, S3 and S4 which depend upon the distance z of the corresponding coil Sp1, Sp2, Sp3 and Sp4 from the alignment plate 10. The signals S1, S2, S3 and S4 of the coils Sp1, Sp2, Sp3 and Sp4 respectively should be understood already to be the electronically preprocessed signal. When the alignment plate 10 is rotated clockwise about the imaginary axis y1 after adjustment of the bonding head 3, the signals S2 and S3 of the coils Sp2 and Sp3 respectively decrease, while the signals S1 and S4 of the coils Sp1 and Sp4 respectively increase. Consequently the difference signals S2-S1 and S3-S4 also decrease. When the alignment plate 10 is rotated clockwise about the imaginary axis x1 after another adjustment of the bonding head 3, the signals S1 and S2 decrease, while the signals S3 and S4 increase. In this case the two difference signals S2-S3 and S1-S4 decrease. When the circuit board 14 is completely flat and all the coils have the same characteristic S(z), where z denotes the direction perpendicular to the xy plane, the two difference signals D1=S2-S1 and D2=S2-S3 disappear precisely when the alignment plate 10 is held plane parallel to the circuit board 14.

Since the circuit board 14 is not necessarily oriented plane parallel to the supporting surface 6 or the bonding surface 2 (Fig. 1) with the required precision, due to unavoidable manufacturing tolerances, and since the coils Sp1, Sp2, Sp3 and Sp4 as a rule have different respective characteristics S1(z), S2(z), S3(z) and S4(z), a calibration procedure has to be carried out at least once. In this calibration procedure, the alignment plate 10 is placed on the supporting surface 6 and then either i) the difference signals $D1_{cal}=S2_{cal}-S1_{cal}$ and $D2_{cal}=S2_{cal}-S3_{cal}$ are stored, or ii) the signals $S1_{cal}$ and $S3_{cal}$ are balanced until they have the value of $S2_{cal}$, that is to say until the difference signals D1 and D2 disappear, i.e. D1 = 0 and D2 = 0.

In the case of i), the alignment of the bonding head 3 follows afterwards in accordance with step d, by adjusting the bonding head 3, that is holding the alignment plate 10 free, until the difference signals D1 and D2 have the respective values $D=D1_{cal}$ and $D2=D2_{cal}$. In the case of ii), the alignment of the bonding head 3 is performed by adjusting the bonding head 3 until the difference signals D1 and D2 disappear. For example, first the circuit is operated by applying the oscillator signal alternately to the

coils Sp1 and Sp2 and by displaying the difference signal D1=S2-S1 so that the difference signal D1 can be made to disappear by adjusting the bonding head 3 by means of the screw 12. Then, the signal is applied alternately to the coils Sp3 and Sp2 and the difference signal D2=S2-S3 is displayed so that the difference signal D2 can be made to disappear by adjusting the bonding head 3 by means of the screw 13.

Whether a calibration procedure has to be carried out each time the bonding head 3 is aligned or only occasionally depends upon the stability of the measuring device 7 with respect to external influences such as temperature, humidity and so forth.

The three coils Sp1, Sp2 and Sp3 are sufficient per se for the alignment. For reasons of redundancy, it can be useful, however, also to include the fourth coil Sp4. Since the adjacently arranged coils Sp1, Sp2 and Sp3 can influence one another, a mode of operation is preferred in which at any time only one of the coils Sp1, Sp2 and Sp3 produces a significant magnetic field. Such a mode is for example the time division multiplex procedure.

Fig. 3 shows a circuit for operating the coils Sp1, Sp2 and Sp3 in time division multiplex. The coils Sp1, Sp2 and Sp3 are arranged in parallel paths 15 - 17. The circuit comprises an oscillator 18, a control device 19 and a difference former 20, the output of which is supplied to the display 11. Each path 15 - 17 has on its input side a switch 21 and on its output side a switch 22, which switches can be actuated by the control device 19. The switch 21 is connected to the oscillator 18. The output of each path 15 - 17 is supplied to the difference former 20. A resistor 23 and a capacitor 24 are connected after the switch 21, wherein the capacitor 24 is located parallel to the corresponding coil Sp1, Sp2 or Sp3. One connection of the coil and of the capacitor 24 is connected to ground m, while the connection connected to the resistor 23 is supplied to a detector 25 and to a subsequent sample-and-hold module 26. The output of the sample-and-hold module 26 forms the output of the path. Each of the sample-and-hold modules 26 is activated by the control device 19 for obtaining and storing a new value. For the detector 25, a peak amplitude detector or a synchronous detector

may be used, for example. The difference former 20 may be, for example, an operational amplifier configured as a differential amplifier, the inverting input of the operational amplifier being supplied with either the signal S1 or the signal S3, and the non-inverting input of the operational amplifier being supplied with the signal S2, so that the difference signal D1=S2-S1 or the difference signal D2=S2-S3 is displayed on the display 11 connected thereafter.

Switches 21 and 22 are switched on and off cyclically by the control device 19, so that at any one time only one path 15 - 17 is in operation. Fig. 4 illustrates, for the case where the bonding head 3 is to be aligned by means of the difference signal D1=S2-S1, the development of the following voltages U as a function of time t:

a) voltage at the output of the oscillator 18,
b) voltage following the switch 21 of the path 15 with the coil Sp1,
c) voltage following the switch 21 of the path 16 with the coil Sp2,
d) voltage at the input of the detector 25 of the path 15,
e) voltage at the input of the detector 25 of the path 16,
f) voltage at the output of the detector 25 of the path 15,
g) voltage at the output of the detector 25 of the path 16,
h) voltage at the output of the sample-and-hold module 26 of the path 15,
i) voltage at the output of the sample-and-hold module 26 of the path 16, and
j) voltage at the output of the difference former 20.

The times at which the control device 19 directs the sample-and-hold module 26 to obtain a new measured value are also shown. The frequency which the oscillator 18 applies to the flat coils Sp1 - Sp3 is between approximately 1 and 10 MHz, and is preferably 4 MHz. The capacitance of the capacitors 24 is to be matched so that the resonance frequency of the resonating circuit formed by the capacitor 24 and the corresponding coils Sp1, Sp2 or Sp3 corresponds approximately to the oscillator frequency. The oscillator frequency is preferably chosen so that it lies in the middle of the rising edge of the resonance peak, where the derivative of the signal from the coils

Sp1, Sp2 or Sp3 to the oscillator frequency is large. The signal produced by the oscillator 18 is advantageously a square wave. Instead of the oscillator 18 a microprocessor with a suitable output may also be used. By stepping down the frequency generated by the oscillator 18, the control device 19 derives the frequency with which the switches 21 and 22 of the three paths 15 - 17 are to be opened and closed, and with which the sample-and-hold modules 26 are to be controlled.

The components of the circuit are advantageously mounted directly on the underside of the circuit board 14, which greatly increases tolerance to interference from external influences.

Fig. 5 shows an embodiment in which an optical system serves as the measuring device 7. The surface 9 of the alignment plate 10 is, in this case, a surface with optically good reflectivity, for example, a mirror surface. The optical system is provided with a light source 30, a semi-transparent mirror 31, a lens 32 and a photodetector 33. The light source 30 and the photodetector 33 are located in the focal point f, or focal plane, of the lens 32. The light 34 emitted from the point light source 30 is incident upon the surface 9 of the alignment plate 10 as a plane wave 35, because of the lens 32, and is reflected there and at least partially by the semi-transparent mirror 31 onto the photodetector 33, whereupon the lens 32 focuses the reflected parallel light 36 back onto the photodetector 33. A two-dimensional array of photosensors is advantageously used as the photodetector 33, for example a CCD (charge coupled device) or a PSD (photosensitive device). A normal screen 37 can be used as the display 11 for the display signals supplied by the photosensors. For calibration of the optical system in accordance with point b) of the method, the position of the photodetectors in the y1 and z directions is changed until the light spot corresponding to the reflected light beam 36 appears in the center of the screen 37. The direction y1 is perpendicular to the surface of the drawing. For alignment according to point d) of the method, the bonding head 3 is adjusted until the light spot corresponding to the reflected light beam 36 again appears in the center of the screen 37.

The apparatuses described for aligning the bonding head 3 of the die bonder 1 can be integrated in the die bonder 1 or be provided as accessories so that existing die bonders 1 can be retrofitted. In the latter case, the supporting surface 6 must be orientated plane-parallel to the bonding surface 2 before the alignment of the bonding head can be carried out.

It will be appreciated that although particular embodiments of the invention have been described, many modifications/additions and/or substitutions may be made within the spirit and scope of the present invention.

CLAIMS

1. A bonder or a pick and place machine for placing a semiconductor chip or an electronic component onto a bonding surface of a carrier, including:

a supporting surface parallel to the bonding surface;

an alignment plate;

a measuring device designed to generate at least one signal based on the position of said alignment plate;

a bonding head designed to grasp said alignment plate and hold said alignment plate free at a small distance above said measuring device; and

said bonding head further designed to be positionally adjusted until said at least one signal generated by said measuring device is equal to a reference signal.

2. The bonder or pick and place machine of claim 1, wherein said reference signal is generated by said measuring device and stored when said alignment plate is placed on said supporting surface.

3. The bonder or pick and place machine of claim 1 or 2, wherein said alignment plate has a metalized or ferromagnetic surface, said measuring device has at least three coils arranged in a plane approximately parallel to said supporting surface, said coils supply each a signal based on the position of said alignment plate and said signals of said coils are used to generate said at least one signal of the measuring device.

4. The bonder or pick and place machine of claim 3, wherein said at least one signal of the measuring device is the difference between two of the signals supplied by said at least three coils.

5. The bonder or pick and place machine of claim 3 or 4, wherein said at least three coils are operated in time division multiplex.

6. The bonder or pick and place machine of claim 1 or 2, wherein said alignment plate has an optically reflective surface and said measuring device is an optical system arranged to illuminate said alignment plate with a beam of parallel light.

7. An apparatus for aligning a bonding head of a bonder or pick and place machine, wherein the bonder or pick and place machine places a semiconductor chip or an electronic component onto a bonding surface of a carrier, the apparartus including:

a supporting surface configured to be positioned parallel to said bonding surface;

an alignment plate;

a measuring device designed to generate at least one signal based on the position of said alignment plate.

8. The apparatus of claim 7, wherein said alignment plate has a metalized or ferromagnetic surface, said measuring device has at least three coils arranged in a plane approximately parallel to said supporting surface, said coils supply each a signal based on the position of said alignment plate and said signals of said coils are used to generate said at least one signal of the measuring device.

9. The apparatus of claim 7, wherein said alignment plate has an optically reflective surface and said measuring device is an optical system arranged to illuminate said alignment plate with a beam of parallel light.

10. A method for aligning a bonding head of a bonder or a pick and place machine, wherein the bonder or pick and place machine places a semiconductor chip or an electronic component onto a bonding surface of a carrier, the method comprising the steps of:

grasping an alignment plate and holding said alignment plate free at a small distance above a measuring device; and

positionally adjusting said bonding head until at least one signal generated by said measuring device is equal to a reference signal.

* C L M S *

11. The method of claim 10, further including the step of placing said alignment plate on a supporting surface extending parallel to said bonding surface and storing the signal or signals generated by said measuring device as reference signal or reference signals, respectively.

12. The method of claim 10 or 11, wherein said alignment plate has a metalized or ferromagnetic surface, said measuring device has at least three coils arranged in a plane approximately parallel to said supporting surface, said coils supply each a signal based on the position of said alignment plate and said signals of said coils are used to generate said at least one signal of the measuring device.

13. The method of claim 10 or 11, wherein said alignment plate has an optically reflective surface and said measuring device is an optical system arranged to illuminate said alignment plate with a beam of parallel light.