

Device for Positioning Electronic Circuits Arranged on a Foil

The invention relates to a device for positioning electronic circuits arranged on a foil, for example chips, on a circuit card, ceramic substrate or the like, using the flip-chip method, whereby the chips are lifted from the foil by needles located under the said foil, and are further picked up by a needle with a suction cup or by a suction cup that rotates the chips by 180°, and they are then received by another needle with a suction cup and positioned on the circuit card for direct connection of the contact lines.

Normally, the electronic circuits or the chip are fixed to the circuit card on the side facing away from the contacts, and the contacts and contact lines are connected with microwires. The wires are connected to the contacts by means of ultrasonic welding, for example. This method is also referred to as wire bonding. The disadvantages of this method are clear. On the one hand, too many work steps were required to manufacture the finished circuit board, and on the other hand with this method of chip fixation the scattering effects are difficult to control.

An alternative to wire bonding is the flip-chip method. Thereby, the contacts of the chip are connected directly to the contact lines of the circuit card, as shown above. This method provides a higher contact reliability, shorter contact paths, especially at high frequencies, and it eliminates the costly wire bonding. In order to balance the different strain coefficients, the space between the chip and the circuit card is filled with glue or filler after contacting.

With this method, it is important that the contacts on the chip and circuit card are positioned exactly on top of each other. In order to achieve this, the position of each chip and each circuit card must be measured and a corrective movement calculated. If the circuit card geometry is precise enough, it is sufficient to measure two reference points on the circuit card, and to calculate the individual positioning points. Otherwise, each individual positioning point has to be measured individually.



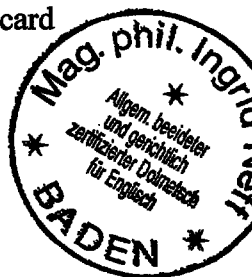
A particular problem is the programming of the target position for a chip, since visual correction of the result is not possible. The structures of the chip and the circuit card are located directly on top of each other. The accuracy of this positioning of the contacts can only be verified with destructive methods.

- 5 The objective of this invention is therefore to create a device of the type mentioned above, which on the one hand avoids the disadvantages of the state of the art, and on the other hand offers a high degree of user comfort due to programmability and reproducibility of the various settings, and which has a simple structure.

- 10 The device according to the invention is characterised by the fact that both the needles used for lifting the chip from the foil and the receiving needle with a suction cup are capable of a synchronous and mainly rectilinear or vertical movement, that the needle with a suction cup is placed in a holder that is mounted in an arm so as to be capable of movement, wherein the said arm is driven by a drive in order to carry out the 180° rotation movement, and that the additional needle with a suction cup is also mounted in
15 a holder that provides it with four degrees of freedom, namely along the axes x, y, z and rotation.

- With this invention, it is for the first time possible to realise both the rotation of 180° and the vertical chip pick-up movement with a motor, and to control the chip pick-up in such a way that it is synchronous with the movement of the needles. This synchronous
20 pick-up means a significant quality improvement, since the chip is held between the lifting needles and the needle with a suction cup with constant force throughout the entire procedure. Moreover, there is no horizontal relative movement between the lifting needles and the needle with the suction cup, which would inevitably destroy the chip surface.

- 25 Furthermore, the invention makes it possible to produce a mechanical device for extremely rational manufacture and for an increase in the automation of circuit card



printing. In addition, the invention makes it possible to improve the quality of the circuit card thus produced enormously. Another significant advantage is the fact that the structure of the device according to the invention is very simple due to the arrangement of only one drive for the movements to position the chip, and thus very economical. The freedom of movement of the second needle with a suction cup guarantees a high quality of positioning of the chips on the circuit card.

In accordance with a special feature of the invention, two stereometric cameras are provided, whereby one stereometric camera is used to measure the circuit card and the other stereometric camera is used to measure the chip, and both stereometric cameras are connected to a computer, and the two stereometric cameras are calibrated by overlaying the two images until they match, and this calibrated position can be stored on a computer. With the two stereometric cameras, a further increase in quality is achieved. Each circuit card or each substrate is held in position and measured at two points using a stereometric camera. Thereby, a difference from the programmed original substrate may already occur. The recorded definitive values of the circuit card are entered into the computer and stored. The second stereometric camera measures each chip, whereby these values are also entered into the computer. Of course the calibrated position, which is obtained by overlaying the two images, is also stored in the computer.

In accordance with a further feature of the invention, the computer calculates or detects possible deviations from the calibrated position after measuring the chip, and controls the second needle with a suction cup in accordance with this difference. With the measurement and registration of the chip data by the second stereometric camera and the corresponding evaluation using suitable software, a programming aid is provided for the positioning of the chip on the circuit card. The second needle with a suction cup is controlled in accordance with the values calculated by the computer. The main advantage thereby is the programmability of control for the device, whereby for example the path, the speed and / or the time or the like can be programmed. Moreover, it is of great advantage that all the values or data are reproducible, especially via the computer



unit. The reproducibility of settings is an imperative in such highly specialised technology, in particular in order to guarantee perfect quality.

- As already mentioned, the programming of the target position of the chip is particularly difficult in the state of the art, since visual correction of the result is not possible.
- 5 order to make this process as simple as possible for the operator, the method according to the invention has been developed, whereby it is sufficient to overlay the image of the chip structure taken by one camera and the image of the circuit card taken by the second camera until they match. Thereby, the computer automatically calculates the target position for the chip.
- 10 In a further embodiment of the invention, a stepper motor is provided as a drive for the 180° rotation movement of the arm. The advantage thereby is that the stepper motor is a mature drive component that requires very little maintenance on the one hand, and that on the other hand it can be controlled very accurately with the smallest units of measurement.
- 15 In accordance with a further embodiment of the invention, the arm is arranged radially on a shaft, whereby this shaft is mounted in a concentric tubular shaft, and the tubular shaft has a slit for the arm to pass through, with an angle greater than 180°, preferably 191°, and the tubular shaft can be driven by the stepper motor via a belt drive. The angle being greater than 180° advantageously guarantees that a vertical movement of the
- 20 needle with a suction cup is possible when picking up the chip from the foil. Moreover, with the arrangement of the arm on a shaft that is mounted in a tubular shaft, a simple and functional design is guaranteed.

- In accordance with a special design of the invention, both the shaft and the tubular shaft are fitted with a radial bolt, whereby the bolt in the shaft juts out through the slit or a
- 25 hole in the tubular shaft and the two bolts are connected by a tension spring. The



advantage of this design lies in the fact that the technically simple components guarantee reliable and low-maintenance operation.

In accordance with a further feature of the invention, the radial arm arranged on the shaft performs a rotation movement of exactly 180° , limited by stoppers. For the exact
5 hand-over of the chip, on the one hand from the lifting needles to the needle with a suction cup, and on the other hand from one needle with a suction cup to the next, the accurate 180° rotation movement is an advantageous basic requirement that guarantees a trouble-free process.

In accordance with a further embodiment of the invention, the tubular shaft has an
10 additional radial bolt and the holder is fitted with a stopper, whereby the radial bolt sits on this stopper when the arm is in horizontal position. The advantage thereby is that with a simple construction the rectilinear, precise vertical movement of the needle with a suction cup can be performed in a controlled manner.

In accordance with another feature of the invention, the holder is mounted in the arm so
15 as to be capable of movement, against the tension of a spring. The advantage of this design is that a highly technical work process can be performed with technically simple components.

In accordance with a further feature of the invention, the holder is mounted in the arm so as to be capable of movement, whereby a spring is provided that is connected to the
20 holder on the one hand and the radial bolt on the other hand. The advantage of this design is that a highly technical work process can be performed with technically simple components. In particular, the force acting on the chip via the needle with a suction cup can be defined precisely via the angle of the radial bolt when the arm is lying on the stopper, i.e. the angle in excess of 180° . This is of advantage since it is more or less a
25 technological necessity to apply greater force to larger chips than to smaller chips. Moreover, the defined application of force is of advantage when different tools are used



When using a rubber tool, greater force will be applied than when using a steel tool. In addition, the force acting on the chip during the pick-up process can be kept more or less constant.

- In accordance with another advantageous embodiment, the spring is a tension spring.
- 5 This offers the advantage that the distance between the radial bolt and the stopper for the holder on which the radial bolt lies is virtually zero. This also means that the spring always has the same length, so that the force is constant.

- In accordance with a further embodiment of the invention, the tubular shaft can be further rotated counter to the force of the tension spring. By driving the tubular shaft
- 10 with the stepper motor, an accurate and precise control of the movement is possible, whereby the tension spring supports the basic striving of the invention for simplicity, reliability and economy.

The invention is explained in more detail based on the design examples illustrated in the figures.

- 15 Fig. 1 shows a sketch of the principle of the device,

Fig. 2a to 2d illustrate the movement of the needle with a suction cup, and

Fig. 3a to 3d illustrate the movement of the needle with a suction cup with a tension spring arrangement on the holder.

- In accordance with Fig. 1, the device for positioning electronic circuits, generally referred to a chips 1, has a machine frame (not shown), on which the following
- 20 components are arranged, either fixed or capable of movement depending on their function.



In the flip-chip method, the chips 1, which are on a foil 2, are arranged within reach of a needle with a suction cup 3. Beneath the foil 2 with the chips 1, there is a device with lifting needles 4. In order to lift the chips 1 from the foil 2, the needles pierce through the foil 2, whereby the needle with a suction cup 3 – indicated by the dotted line in this Fig. – lies on the opposite side of the chip 1. The chip 1 is lifted by an exact, rectilinear, vertical and synchronous movement of the needles 4 and the needle with a suction cup 3, whereby an exact vertical movement – as described later – is performed. The needle with a suction cup 3 is placed in a holder 5, whereby this holder 5 is mounted in an arm 6. After the chip 1 is picked up from the foil 2 by the needle with a suction cup 3, the needle with a suction cup 3 is rotated by 180°, preferably along a horizontal axis. This swivel or rotation movement is controlled by a rotation mechanism 7, which is connected to a drive 9 by a belt drive 8. The chip 1 is then picked up by another needle with a suction cup 10 for positioning on a substrate, in particular a ceramic substrate or a circuit card 11. The needle with a suction cup 10 is also arranged in a holder 12, whereby this holder 12 provides the needle with a suction cup 10 four degrees of freedom. The four degrees of freedom are along the axes x, y, z and rotation. These four degrees of freedom are necessary for positioning the chip 1 on the circuit card 11. In addition, each needle with a suction cup 3, 10 has a vertical range of spring in its holder 5, 12, in order to be able to pick up or hand over the chip 1 very gently.

Before the chip 1 is positioned on the circuit card 11, the chip 1 is measured by a stereometric camera. Equally, the circuit card 11 is measured by the stereometric camera 14 first. Both stereometric cameras 13, 14 are connected to a computer 15, which stores the measured data.

The two stereometric cameras 13, 14 are calibrated by overlaying the two images, whereby this calibrated position is stored in the computer 15. By measuring the chip 1 with the stereometric camera 13, the computer can calculate or detect any deviations from the calibrated position. The computer 15 then controls the needle with a suction



cup 10 in accordance with the difference, and positions the chip 1 on the circuit card 11. The software 15 on the computer also serves as a programming aid.

Fig. 2a to 2d illustrate the movement of the needle with a suction cup 13 from picking up the chip until handing it over to the second needle with a suction cup 10.

- 5 In accordance with Fig. 2a the needle with a suction cup 3 is placed in the holder 5, whereby the holder 5 is mounted in the arm 6 so as to be capable of longitudinal movement against the pressure of a spring 16. The foil 2 with the chips 1 arranged upon it is positioned within the range of the needle with a suction cup 3, whereby the lifting needles 4 are arranged on the side of the foil 2 facing away from the needle with the
10 suction cup 3.

The arm 6 is capable of rotation of exactly 180° by means of the rotation mechanism 7. In order to achieve a precise rotation of 180° , there are stoppers 17 on both sides of the axis of rotation, which limit the rotation movement of the arm 6. The rotation mechanism 7 consists of a shaft 18, placed in a concentric tubular shaft 19. The arm 6 is
15 mounted radially or tangentially on the shaft 18, whereby the tubular shaft 19 has a slit 20 through which the arm 6 passes. This slit 20 is dimensioned so that the arm 6 can move relative to the tubular shaft 19 with an angle of rotation greater than 180° . In particular, the arm 6 should be able to move with an angle of 191° relative to the tubular shaft. The rotation between 180° and 191° is transformed into vertical movement of the needle
20 with a suction cup 3. In addition, both the shaft 18 and the tubular shaft 19 have a radial bolt 21, 22, which are connected by a tension spring 23. The bolt 21 of shaft 18 also passes through the slit 20 of the tubular shaft. Naturally, the tubular shaft 19 can also have a separate hole for the bolt 21 to pass through. Moreover the tubular shaft 19 has a radial bolt 24 that lies on a stopper 25 positioned on the holder 5. The rotation
25 mechanism 7 is moved by a belt drive 8, whereby the belt drive 8 drives the tubular shaft 19. The drive 9 for the belt drive 8 is a stepper motor.



- Fig. 2b illustrates the lifting of a chip 1 from the foil 2. As already mentioned, synchronous movement of the needle with a suction cup 3 and the lifting needles 4 is necessary for lifting the chip 1 from the foil 2, in order to maintain a constant force between the lifting needles 4 and the needle with a suction cup 3 during the lifting process. The precise vertical movement of the lifting needles 4 is fairly easy to perform. In order to achieve a rectilinear, in this case vertical, synchronous movement of the needle with a suction cup 3 to the lifting needles 4, the tubular shaft 19 is rotated beyond the point where the arm 6 lies on the stopper 17, thereby moving the radial bolt 24 in the direction of the foil 2. At the same time, the tension spring 23 between the bolts 21, 22 is stretched. The holder 5 with the stopper 25 lying on the radial bolt 24 is moved by contraction of the spring 16 towards the foil 2 and the chip 1, where the suction of the needle with a suction cup 3 takes effect. The lifting needles 4 penetrate the foil 2 and press against the chip 1. The direction of rotation of the drive 9 is reversed easily by the arrangement of a stepper motor.
- 15 In accordance with Fig. 2c, the tubular shaft 19 with the radial bolt 24 is rotated counter-clockwise until the slit limit lies on the bolt 21 of the shaft 18. The tension spring 23 is stretched and the radial bolt 24 moves the holder 5 up against the force of the spring 16 in a rectilinear manner. Synchronously, the lifting needles 4 perform a rectilinear movement until the chip 1 is lifted off the foil 2. When the chip 1 is picked up by the needle with a suction cup 3, the 180° rotation movement of the arm 6 is performed and the lifting needles 4 are lowered. At this point, the lifting needles 4 must not be in contact with the back of the chip any more, since the chip 1 makes a 180° rotation movement around the centre-point of the axis of rotation, i.e. it does not move vertically. Otherwise, the lifting needles 4 would damage the back of the chip 1.
- 25 In accordance with Fig. 2d, the arm 6 lies on the second stopper 17, and the chip 1 can be picked up by the second needle with a suction cup 10. The needle with the suction cup 10 moves the chip into place for measurement by the stereometric camera 13, then positions it on the circuit board in accordance with the computerised control data.



Fig. 3a to 3d illustrate the movement of the needle with a suction cup 13 from picking up the chip until handing it over to the second needle with a suction cup 10.

In accordance with Fig. 3a the needle with a suction cup 3 is placed in the holder 5, whereby the holder 5 is mounted in the arm 6 so as to be capable of longitudinal movement. The foil 2 with the chips 1 arranged upon it is positioned within the range of the needle with a suction cup 3, whereby the lifting needles 4 are arranged on the side of the foil 2 facing away from the needle with the suction cup 3.

The arm 6 is capable of rotation of exactly 180° by means of the rotation mechanism 7. In order to achieve a precise rotation of 180° , there are stoppers 17 on both sides of the axis of rotation, which limit the rotation movement of the arm 6. The rotation mechanism 7 consists of a shaft 18, placed in a concentric tubular shaft 19. The arm 6 is mounted radially or tangentially on the shaft 18, whereby the tubular shaft 19 has a slit 20 through which the arm 6 passes. This slit 20 is dimensioned so that the arm 6 can move relative to the tubular shaft 19 with an angle of rotation greater than 180° . In particular, the arm 6 should be able to move with an angle of 191° relative to the tubular shaft. The rotation between 180° and 191° is transformed into vertical movement of the needle with a suction cup 3. In addition, both the shaft 18 and the tubular shaft 19 have a radial bolt 21, 22, which are connected by a tension spring 23. The bolt 21 of shaft 18 also passes through the slit 20 of the tubular shaft. Naturally, the tubular shaft 19 can also have a separate hole for the bolt 21 to pass through. Moreover the tubular shaft 19 has a radial bolt 24 that lies on a stopper 25 positioned on the holder 5. The rotation mechanism 7 is moved by a belt drive 8, whereby the belt drive 8 drives the tubular shaft 19. The drive 9 for the belt drive 8 is a stepper motor.

The longitudinal displacement of the holder 5 in arm 6 is determined indirectly by the radial bolt 24. A spring 26, in particular a tension spring, is provided which is connected on the one hand to the connection point 27 on the radial bolt 24 and on the other hand to the connection point 28 on the holder 5.



Fig. 3b illustrates the lifting of a chip 1 from the foil 2. As already mentioned, synchronous movement of the needle with a suction cup 3 and the lifting needles 4 is necessary for lifting the chip 1 from the foil 2, in order to maintain a constant force between the lifting needles 4 and the needle with a suction cup 3 during the lifting process. The precise vertical movement of the lifting needles 4 is fairly easy to perform. In order to achieve a rectilinear, in this case vertical, synchronous movement of the needle with a suction cup 3 to the lifting needles 4, the tubular shaft 19 is rotated beyond the point where the arm 6 lies on the stopper 17, thereby moving the radial bolt 24 in the direction of the foil 2. At the same time, the tension spring 23 between the bolts 21, 22 is stretched. The holder 5 with the stopper 25 lying on the radial bolt 24 is moved by force of the spring 26 towards the foil 2 and the chip 1, where the suction of the needle with a suction cap 3 takes effect. The lifting needles 4 penetrate the foil 2 and press against the chip 1. The direction of rotation of the drive 9 is reversed easily by the arrangement of a stepper motor.

In accordance with Fig. 3c, the tubular shaft 19 with the radial bolt 24 is rotated counter-clockwise until the slit limit lies on bolt 21 of the shaft 18. The tension spring 23 is released and the radial bolt 24 moves the holder 5 up in a rectilinear manner, whereby the stopper 25 always lies on the radial bolt 24 due to the force of the spring 26. Synchronously, the lifting needles 4 perform a rectilinear movement until the chip 1 is lifted off the foil 2. When the chip 1 is picked up by the needle with a suction cup 3, the 180° rotation movement of the arm 6 is performed and the lifting needles 4 are lowered. At this point, the lifting needles 4 must not be in contact with the back of the chip any more, since the chip 1 makes a 180° rotation movement around the centre-point of the axis of rotation, i.e. it does not move vertically. Otherwise, the lifting needles 4 would damage the back of the chip 1.

In accordance with Fig. 3d, the arm 6 lies on the second stopper 17, and the chip 1 can be picked up by the second needle with a suction cup 10. The needle with the suction



cup 10 moves the chip into place for measurement by the stereometric camera 13, then positions it on the circuit card in accordance with the computerised control data.

In conclusion, it is noted that in the various described embodiments the same parts are allocated the same reference numbers and the same component names, whereby the disclosures contained throughout the description can be applied by analogy to the same parts with the same reference numbers or same component names. Furthermore, position details given in the description, e.g. top, bottom, side, etc., relate to the figure being described and illustrated at the time and with a change of position should be transferred accordingly to the new position. Moreover, individual features or combinations of features from the different embodiments illustrated and described can represent independent inventive solutions or solutions according to the invention in themselves.

The problem forming the basis of the separate solutions according to the invention can be taken from the description.

For form's sake, it is noted that for a better understanding of the structure of the device, the components are illustrated partly untrue to scale and/or are enlarged and/or made smaller.



PATENT CLAIMS

1. Device for positioning electronic circuits arranged on a foil, such as chips, on a circuit card, a ceramic substrate or the like using the flip-chip method, whereby the chips are lifted from the foil by needles located under said foil and are picked up by a needle with a suction cup or by a suction cup that rotates the chips by 180° , and are then received by another needle with a suction cup and positioned on the circuit board for direct connection of the contact lines, characterised by the fact that both the lifting needles (4) for lifting the chip (1) from the foil (2) and the needle with a suction cup (3) perform a synchronous, mainly rectilinear or vertical movement, that the needle with a suction cup (3) is placed in a holder (5) which is mounted in an arm (6) so as to be capable of movement, and this arm (6) is driven by a drive (9) in order to carry out the 180° rotation movement, and that the additional needle with a suction cup (10) is also arranged in a holder (12) that provides the needle with a suction cup (12) with four degrees of freedom, namely along the axes x, y, z and rotation.
2. Device in accordance with Claim 1, characterised by the fact that there are two stereometric cameras (13, 14), whereby one stereometric camera (14) is used to measure the circuit card and the second stereometric camera (13) is used to measure the chip (1), and both stereometric cameras (13, 14) are connected to a computer (15), and calibration of the two stereometric cameras (13, 14) is performed by overlaying the two images until they match, and that this calibrated position can be stored in the computer (15).
3. Device in accordance with Claim 2, characterised by the fact that the computer (15) can after measuring a chip (1) calculate or detect any deviation from the calibrated position and control the second needle with a suction cup (10) according to the difference.



4. Device in accordance with one or more of Claims 1 to 3, characterised by the fact that a stepper motor is provided as a drive (9) for the 180° rotation movement of the arm (6).
5. Device in accordance with one or more of Claims 1 to 4, characterised by the fact that the arm (6) is arranged radially on a shaft (18), whereby this shaft (18) is placed in a tubular shaft (19) and the tubular shaft (19) is fitted with a slit (20) for the arm (6) to pass through, with an angle greater than 180°, preferably 191°, and the tubular shaft (19) is driven the stepper motor via a belt drive (8).
6. Device in accordance with one or more of Claims 1 to 5, characterised by the fact that both the shaft (18) and the tubular shaft (19) have a radial bolt (21, 22), whereby the bolt (21) of the shaft (18) passes through the slit (20) or a hole in the tubular shaft (19), and the two bolts (21, 22) are connected by a tension spring (23).
7. Device in accordance with one or more of Claims 1 to 6, characterised by the fact that the radial arm (6) placed on the shaft (18) performs a precise 180° rotation movement limited by stoppers (17).
8. Device in accordance with one or more of Claims 1 to 7, characterised by the fact that the tubular shaft (19) has a further radial bolt (24), and the holder (5) is fitted with a stopper (25), whereby the radial bolt (24) lies against this stopper (25) when the arm (6) is in horizontal position.
9. Device in accordance with one or more of Claims 1 to 8, characterised by the fact that the holder (5) is placed in the arm (6) so as to be capable of movement against the force of a spring (16).



* C L M S *



10. Device in accordance with one or more of Claims 1 to 9, characterised by the fact that the holder (5) is placed in the arm (6), whereby a spring (26) is provided which is connected on the one hand to the holder (5) and on the other hand to the radial bolt (24).
- 5 11. Device in accordance with one or more of Claims 1 to 10, characterised by the fact that the spring (26) is a tension spring.
12. Device in accordance with one or more of Claims 1 to 11, characterised by the fact that the tubular shaft (19) can be further rotated against the force of the tension spring (23).

