

Semiconductor mounting apparatus with a Chip Gripper

The invention concerns a semiconductor mounting apparatus with a chip gripper of the kind named in the preamble of Claim 1.

A device of this kind, described as a "Pick-and-Place", is used as a component of automated assembly machines called "Die Bonders" for semiconductor assembly. It serves to mount the numerous uniform chips of a wafer which are located next to each other on a carrier one after the other onto a substrate, eg, a metal leadframe. Coordinated with each Pick and Place movement, the wafer table on which the chip carrier is located makes the next chip available and the substrate is likewise shifted in order to make a new substrate position available at the second location. In order to raise and subsequently place the chip, the chip gripper can be raised and lowered in a known way either together with the entire device or on its own relative to the device.

Extremely high demands are set on assembly devices of this kind. For the further processing of the mounted chips, they must be accurately positioned on the substrate which requires the correspondingly accurate reaching of the second location by the chip gripper and already presupposes the accurate approach to the first location for picking up the chip. On the other hand, high speeds or low cycle times are demanded which cause correspondingly high accelerations and inertial forces to occur on the moved parts.

Up to now, in order to produce the alternating movements of the chip gripper, different lever mechanisms were used which partly contained crank guides. Such guides are disadvantageous for a precise movement sequence because of the considerable lateral forces occurring on them and must be correspondingly maintained. With another known mechanism the chip gripper sits on the end of a lever which slews back and forth, ie, it moves in a curved motion according to the slewing deflections of the lever which must be stopped in the final positions whereby there is a strong tendency to oscillation. One disadvantage of such lever-operated mechanisms lies in that they only allow the transport of the chip along a fixed, predetermined distance from a location A to a location B. Drive mechanisms are also known with which the chip gripper is driven by means of a toothed belt. The disadvantage here is the great inaccuracy of placing the chip on the substrate.

The object of the invention is to propose a semiconductor mounting apparatus which enables the transport of the chip with high accuracy placement over any distance.

This object is solved in accordance with the invention through the characteristics of claims 1 and 5.

In the following, an embodiment of the invention is described in more detail based on the drawing.

It is shown in: Fig. 1, 2 sectional presentations of a semiconductor mounting apparatus,

Fig. 3 the arrangement of magnets in a stator of a drive device,  
 Fig. 4A, B the vertical orientation of the coil in the stator in two different positions, and  
 Fig. 5 a voice coil motor.

Figs. 1 and 2 show schematically two sectional presentations of a semiconductor mounting apparatus with a chip gripper 1, whereby the sections lie in the yz or xz planes of a cartesian coordinate system. For the sake of clarity, only those parts are drawn which are necessary for understanding the invention. The semiconductor mounting apparatus comprises a wafer table 3, preferably rotatable around its centre axis 2 and movable along the x-axis, for the acceptance of a wafer sawn into chips 4, a slide 6 movable in y direction on a frame 5, a first drive device 7 for moving the slide 6 in y direction, a second drive device 8 for moving the frame 5 in vertical z direction and a device 9 for acceptance and transport of a substrate 10. The two drive devices 7, 8 are arranged stationary on the semiconductor mounting apparatus. Preferably, a third, also stationary mounted drive device 11 is foreseen for moving the frame 5 and thereby also the slide 6 with the chip gripper 1 by a relatively short distance in x direction. The chips 4 are typically located on an adhesive foil known as Nitto Tape which is clamped in a frame.

The slide 6 rolls free of play on wheels 12 or glides on air bearings on the frame 5. For the precise acquisition of the position of the slide 6, a glass scale 13 is mounted on the frame 5 which works together with a measuring head arranged on the slide 6.

The drive device 7 for moving the slide 6 in y direction is a U-shaped stator 14 into the interior space 15 of which protrudes a coil part 16 which is secured to the slide 6. The stator 14 has magnets 17 arranged along the y direction on both sides of the interior space 15 which alternately present a north pole N or south pole S. Opposing magnets 17 form a pair of magnets with one north pole N and one south pole S. The arrangement of the magnets 17 in the xy plane is presented in Fig. 3. The pole of the magnets 17 facing towards the interior space 15 is marked with N for "north pole" and S for "south pole". The coil part 16 has several electrical windings 18 (Fig. 4A) which, seen in z direction, are oblong. By means of the frame 5, the coil part 16 is movable in z direction by a distance d of typically 3 cm. The drive force effective in y direction is determined by the direction and strength of the magnetic field produced by the magnets 17 in the interior space 15 of the stator 14 and by the direction and strength of the currents which flow through the windings 18 in vertical z direction. The windings 18 are now formed longer than the magnets 17 in z direction and in such a way that, with a movement of the coil part 16 by a distance d in z direction, the geometry between the magnets 17 and the windings 18 determining the drive force does not change. In operation, the drive force effecting the coil part 16 in y direction is therefore independent of the z position of the coil part 16 or the slide 6. Fig. 4A shows the relative position of the windings 18 to the magnets 17 when the coil part 16 is located in a z position  $z_1$  at which the chip gripper 1 just picks up a chip 4 from the wafer table 3. Fig. 4B shows the relative position of the windings 18 to the magnets when the coil part 16 is located in a z position  $z_2 = z_1 + d$  in which the chip 4 is lifted from the wafer table 3 and is transported in y direction.

The windings 18 are preferably formed in a rectangular shape as presented in Figs. 4A and 4B and arranged on the coil part 16 so that the horizontally running phases 19 of the windings 18 are located outside of the magnetic field produced by the magnets 17 in the interior space 15 of the stator 14. In this way, it is guaranteed that, in operation, no force is exerted on the slide 6 in vertical z direction. For flawless operation, the drive device 7 is preferably formed as a 2-phase or 3-phase linear motor. With a 2-phase linear motor, pairs of windings 18a, 18b are foreseen whereby the two windings 18a, 18b of a pair partly overlap and whereby the two windings 18a, 18b of a pair are supplied from different energy sources 20, 21. A considerable advantage of the multi-phase linear motor can be seen in that it can be built as long as desired whereby it must only be ensured that the stator 14 is either formed sufficiently solid or is sufficiently anchored on the base structure of the semiconductor mounting apparatus so that the strong forces produced by the magnets 17 can not bend the stator 14.

The position measuring system formed by the glass scale 13 (Fig. 1) and the measuring head is used for control of the linear motor. The windings 18 are firmly connected to the energy sources 20, 21 via flexible wires. Mechanical commutators for changing the poles of the windings 18 can be omitted. In place of these, a regulator controls the direction, phase and amplitude of the currents flowing through the windings 18 corresponding to the position and possibly the instantaneous speed of the coil part 16 relative to the magnets 17 of the stator 14, whereby this information is available or derivable as a result of the position measuring system.

With a different embodiment, as is illustrated in a perspective presentation in Fig. 5, a voice coil motor is foreseen as drive device 7. This motor has only one single winding 18 which, because of its abundant winding 18 in z direction, is freely movable in z direction by the predetermined distance d. The voice coil motor preferably has two E-shaped stators 14a, 14b separated in y direction by the distance L, whereby the winding 18 is wider than L so that a part of the winding 18 is always located in the magnetic field produced by the magnets 17. The separation into two stators 14a, 14b extends the drive range in y direction with no perceptible loss in the efficiency of the motor. The slide 6 and the frame 5 are only sketched schematically. In the example drawn, the winding 18 secured to the slide 6 forms the coil part 16.

The semiconductor mounting apparatus serves to remove one chip 4 after the other from the wafer table 3 (Fig. 1) and place them onto the substrate 10.

With a preferred embodiment, the wafer table 3 (Fig. 1) is movable in one single horizontal direction, namely the x direction. Even the device 9 for transporting the substrate 10 only allows the substrate 10 to be transported in x direction. The slide 6 takes over the transport of the chip 4 in y direction. Advantageous is however the foreseen third drive device 11 which enables the movement of the frame 5 and therefore also the slide 6 with the chip gripper 1 in x direction by some ten micrometres. The transport arrangement 9 for the substrate moves the substrate 10 stepwise forwards in x direction by a predetermined distance. Likewise, the wafer table 3 is moved in x direction in order to supply the next

chip 4 to be processed. By means of the second drive device 8, the slide 6 is raised in vertical z direction and is moved in y direction by means of the first drive device 7 until the chip gripper 1 is located in a foreseen position above a chip 4 accurately measured with regard to its xy orientation by a camera which is not shown. The frame 5 guiding the slide 6 is lowered by means of the drive device 8 until the chip gripper 1 can raise the chip 4 from the adhesive foil by means of vacuum. Subsequently, the frame 5 is raised, the slide 6 transported in y direction and the frame 5 lowered again until the chip 4 is placed onto a substrate 10 measured by means of a second camera or a sensor. A slight deviation of the x position of the chip 4 from its set position on the substrate 10 is already corrected during the movement of the slide 6 by means of the third drive device 11. Because the distances which must be travelled by the slide 6 are of varying length depending on the y position of the chip 4 on the wafer table 3, this gives rise to cycle times of different lengths.

If the wafer table 3 can be rotated around its centre axis 2, then, after processing the chips of the first half of the wafer, the wafer table can be turned by  $180^\circ$  and then the second half of the wafer can be processed. This enables a particularly compact construction of the semiconductor mounting apparatus which is also designed for the processing of wafers with a large diameter.

The proposed drive devices combine high placement accuracy of the chip on the substrate with greater freedom in the selection of the substrate. In particular, very narrow as well as very wide substrates can be processed without difficulty at higher average cycle times. In addition, the drive devices are largely maintenance free as the stator and coil part do not touch. Furthermore, neither the arrangement for transporting the substrate nor the wafer table necessarily require a drive to move them in y direction.

A solution is also conceivable with which the magnets 17 (Fig. 4A) are formed longer than the windings 18 by at least the distance d whereby the horizontal phases 19 of the windings 18 are always located in the magnetic field produced by the magnets 17 in the interior space 15 of the stator 14. Here also, the drive force effecting the coil part 16 is invariant with regard to movement of the coil part 16 in z direction. This solution however has the disadvantage that the forces produced by the magnets 17 are stronger with the same drive performance than with the solution where the windings 18 are formed longer than the magnets 17.



## PATENT CLAIMS

1. Semiconductor mounting apparatus with a first drive device (7) for movement of a slide (6) on a frame (5) in a horizontal direction, whereby a chip gripper (1) is secured to the slide (6) and whereby the frame (5) is movable in vertical direction by means of a second drive device (8), **characterized in that**  
5 the first drive device (7) comprises a stator (14) having magnets (17) and a coil part (16) with electrical windings (18), that the coil part (16) is secured to the slide (6) and projects in vertical direction into the stator (14) and that the windings (18) are formed oblong in vertical direction in such a way that the geometry between the magnets (17) and the windings (18) determining the drive force does not change on movement of the coil part (16) by a predetermined distance (d) in vertical direction.
- 10 2. Semiconductor mounting apparatus according to Claim 1, **characterized in that** the stator (14) is U-shaped and that the coil part (16) projects into its interior space (15).
3. Semiconductor mounting apparatus according to Claim 1 or 2, **characterized in that** the coil part (16) comprises at least two electrical windings (18a, 18b) electrically supplied from different energy sources (20, 21).
- 15 4. Semiconductor mounting apparatus according to Claim 1, **characterized in that** the first drive device (7) is formed as a voice coil motor.
5. Semiconductor mounting apparatus according to Claim 4, **characterized in that** the first drive device (7) has two separate stators (14a, 14b).
6. Semiconductor mounting apparatus according to one of the Claims 1 to 5, further comprising a  
20 wafer table (3) and a device (9) for transporting substrates (10), both being horizontally movable in a single direction only.
7. Semiconductor mounting apparatus with a first drive device (7) for moving a slide (6) on a frame (5) in a horizontal direction, whereby a chip gripper (1) is secured to the slide (6) and whereby the frame (5) is movable in vertical direction by means of a second drive device (8), **characterized in that** the first  
25 drive device (7) comprises a stator (14) with magnets (17) and a coil part (16) with electrical windings (18), that the coil part (16) is secured to the slide (6) and projects into the stator (14) in vertical direction and that the magnets (17) are formed longer than the windings (18) in vertical direction so that the geometry between the magnets (17) and the windings (18) determining the drive force does not change on movement of the coil part (16) by a predetermined distance (d) in vertical direction.
- 30 8. Semiconductor mounting apparatus according to Claim 6, **characterized in that** the stator (14) is U-shaped and that the coil part (16) projects into its interior space (15).
9. Semiconductor mounting apparatus according to one of the Claims 7 or 8, further comprising a



wafer table (3) and a device (9) for transporting substrates (10), both being horizontally movable in a single direction only.