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Semi-conductor mounting apparatus with a chip gripper travelling back and forth

The invention relates to a semi-conductor mounting apparatus with a chip gripper which is moveable back and forth between a first location and a second location by means of a lever mechanism, in order to lift a chip from a chip carrier at the first location and to lay the chip on a substrate at the second location. Such an apparatus, described as a "pick and place" apparatus is used as a component of a mounting machine known as a "die bonder" in semi-conductor mounting. It serves to mount the numerous similar chips of a wafer, which are located next to one another on a carrier, one after another on a substrate, for example, a metal lead frame. Coordinated with each pick and place movement, the wafer table on which the chip carrier is located makes available a next chip at said first location, and the substrate is also advanced in order to make available a new substrate location at the second location. For lifting up and subsequent laying down of the chips, the chip gripper can be raised and lowered in a known manner, either together with the whole apparatus or on its own relative to the apparatus.

Extremely high demands are made on mounting apparatus of this type. For the further processing of the mounted chips (contacting of the integrated circuit in the wire bonder), the chips must be accurately positioned on the substrate, which requires a correspondingly accurate arrival at the second location by means of the chip gripper, and also necessitates the previous precise transporting to the first location for lifting up the chip. On the other hand, high speeds and short cycle times of the movement sequences are required, which cause correspondingly high accelerations and inertial forces to occur on the parts moved.

Up until now different lever mechanisms have been used to produce the alternating movements of the chip gripper, which sometimes include guide slots (for example, in the manner of the known maltese transmission arrangement). Such slots are disadvantageous for achieving precise movement because of the considerable shearing forces occurring with them, and have to be serviced accordingly. With another known mechanism, the chip gripper is seated at the end of a lever pivoting back and forth, that is to say it performs a curve-shaped movement corresponding to the swinging displacements of the lever, which must always be stopped in the end positions, wherein there is a strong tendency for vibration. With the known arrangements it is therefore difficult to satisfy the demands existing in practice with respect to accuracy as well as to speed.

The object of the invention is to overcome the existing disadvantages of the prior art with a semi-conductor mounting apparatus of the type described in the introduction. The pick and place mechanism must, above all, ensure accurate positioning of the chip gripper in both end positions, but along with this also make possible rapid back and forth movements, that is to say short cycle times.

This object is solved in accordance with the invention with the characterising features of claim 1. According to this, the lever mechanism of the apparatus is provided with a first pivoted lever which is seated on a shaft mounted equidistantly between the first and second locations and is driven in alternating pivoting directions between two end positions, in which it is directed towards one or the other end position. A second pivoted lever is mounted on the end of the first pivoted lever. It is driven the opposite way around with respect to the direction of pivoting of the first pivoted lever, and with a certain gear ratio with respect to the pivoting movement thereof; at its end it is connected to the chip gripper. Said gear ratio, as well as the lengths of the two pivoted levers are matched to each other in a particular manner, that is to say that in the two end positions of the first pivoted lever, the two pivoted levers are in an extended position with respect to one another and the chip gripper has arrived over one or the other location.

Such matching is produced when, respectively:

$n = 360°/\Phi$; $h1/h2 = n-1$; $h1+h2 = S$,

wherein: n = gear ratio

Φ = pivoting range of the first pivoted lever between the end positions

$h1$ = length of the first pivoted lever

$h2$ = length of the second pivoted lever

S = distance between the pivoting axis of the first pivoted lever and the first or the second location

As can be seen (also with reference to concrete examples described later on), different embodiments with different, matched pivoting ranges, gear ratios and lever proportions are possible. With respect to the object of the invention, with this type of lever mechanism, of primary importance is the condition that at the end of each movement cycle the chip gripper always reaches its end position (that is to say the first or the second location) in the direction of the extended pivoted lever, that is to say the movement components at right-angles to the

longitudinal direction of the levers disappear in the end positions. The inertial force of the accelerated chip gripper then acts in the direction of the extended levers and contributes in a certain way to the stabilising of the extended position. Lastly, an occasional over-swing of the first pivoted lever in the extended positions (which must be stopped at the end of its pivoting range) is of diminishing influence on the end positions of the chip gripper. Such advantageous kinematic and dynamic properties of the lever mechanism endow the mounting apparatus according to the invention with high and long-term stable positioning accuracy and at the same time allow short cycle times.

A particularly simple and advantageous embodiment of the invention is produced where the pivoting range $\Phi = 180°$, the gear ratio $n = 2$, and the lever proportions $h1/h2 = 1$. A lever mechanism with these parameters is known per se as a so-called straight-line mechanism, which means that a body moved by it - in this case the chip gripper - moves in a straight line.

As described hereinabove, the apparatus according to the invention can, in principle, also be produced using other parameters (even with values of n which are not integer numbers). Particular further configurations of the apparatus according to the invention defined in claim 1 are described in the dependent claims.

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

Fig. 1	is a simplified diagram of the view from the side of a first embodiment of the semi-conductor mounting apparatus according to the invention,
Fig. 2	is the plan view of the apparatus according to Fig. 1 (wafer and substrate omitted),
Figs. 3 and 4	are timing diagrams of the apparatus according to Figs. 1 and 2,
Fig. 5	shows a plan view of a further embodiment, and
Fig. 6	shows delimiter means.

The semi-conductor mounting apparatus according to Figs. 1 and 2 is a component of a mounting machine called a "die bonder", not shown in more detail and known per se. Its purpose is, by

means of a chip gripper 20, repetitively to lift a semi-conductor chip 30 from a chip carrier 32 at a first location A and, after displacing the chip gripper, to lay the chip on a substrate 38 at a second location B ("pick and place"). The chip carrier 32 (typically an adhesive foil) with the chips of a wafer 35, is located on a displaceable wafer table 34 which makes available a next chip 30 at location A. The substrate 38, for example, a metallic lead frame, lies on a displacement means 36 described as an "indexer", which advances the substrate in a step-wise manner in order to make available a free substrate location for receiving the subsequent chip at location B. The wafer table and indexer are components known per se and, as they are not the subject-matter of the invention, are not shown in more detail (and completely omitted in Fig. 2). For the lifting and subsequent laying down of the chip 30, the chip gripper 20 (a component of a so-called bonding head) can be moveable up and down relative to the pick and place apparatus, as shown schematically in Fig. 1 by means of arrows, but the apparatus can also be configured to be moveable vertically as a whole (seen in Fig. 1).

The pick and place apparatus according to Figs. 1 and 2 comprises a first pivoted lever 10 which sits on a shaft 4. The shaft 4 is hold centrally between locations A and B (bearing 3, Fig. 2), that is to say, the pivoting axis of the lever 10 is at the same distance S from A and from B. A second pivoted lever 12 is mounted by means of a shaft 14 at the end of the first pivoted lever. The end of the second lever is in turn connected by means of an axle 16 to a slide 18. This carries the chip gripper 20 and slides along a linear guide 19 which extends between A and B.

A stationary rotary actuator, for example, composed of a motor 1 and toothed belt mechanism 2 (shown only in Fig. 2) drives the first lever 10 by means of the shaft 4 with an alternating direction of pivoting. The lever 10 thus sweeps a pivoting range Φ between two end positions Ea, Eb, in each of which respectively it faces towards on the one hand location A and on the other hand, location B. In Fig. 1 the end positions of the pivoted lever and of the chip gripper are shown in dashed lines, and an intermediate position (with the pivoting angle $\varphi 1$ of the lever 10) is shown, on the other hand, in solid lines. The end positions Ea and Eb of the first angled lever 10 are determined and maintained by appropriate drive control of the motor 1.

The second pivoted lever 12 is not carried along "passively" by the first lever 10, but instead is subject to being driven with a predetermined gear ratio relative to the first lever 10 and in the opposite direction to the direction of pivoting of the first lever 10. In accordance with the

example shown, this drive is produced by means of a toothed belt 6 which loops around a fixed toothed wheel 5 coaxial to the shaft 4 and a toothed wheel 7 fitted onto the shaft 14 (instead of the toothed belt 6, an intermediate toothed wheel mounted on the lever 12, which meshes with the toothed wheels 5 and 7, could be provided). In this way the pivoting movements of the two levers 10 and 12 (pivoting angles $\varphi 1$ and $\varphi 2$) are coupled together in a particular way.

In the case of the given pivoting range Φ of 180°, the gear ratio n between the levers 10 and 12 equals 2, that is to say, in each position of the levers, the angle $\varphi 2$ of the lever 12 relative to the lever 10 is always twice the angle of pivoting $\varphi 1$ of the lever 10. It is also important that the levers 10 and 12 have the same length h1 and h2 and the sum of the two lever lengths h1 + h2 equals the distance S. In this way the gear ratio n and the lever lengths h1, h2, corresponding to the proportions described hereinabove, are matched to the pivoting range $\Phi = 180°$. As a result of this, in each end position Ea and Eb of the first pivoted lever 10, the two pivoted levers 10 and 12 are in an extended position with respect to one another, and the chip gripper 20 is located over either location A or the other location B.

The lever mechanism according to Figs. 1 and 2 has the properties of a straight-line mechanism, that is to say the end of the second pivoted lever 12 (axle 16) moves in a straight line G. This means that no shearing forces or moments are exerted by the slide 18 on the linear guide 19. This guide and the articulated connection between the slide 18 and the lever 12 essentially have only the function of maintaining the orientation of the chip gripper during its displacement (when there is a rigid connection between the lever 12 and the chip gripper 20 the latter is turned together with the transported chip 30 respectively by 180° - with respect to the planes of the chip carrier 32 and the substrate 38). As can easily be seen from Fig. 1, the chip gripper arrives with a high degree of accuracy over locations A or B by virtue of the extended positions of the two pivoted levers, in that their longitudinal axes, that is to say the axes 4, 14 and 16 lie on the straight line G. In these extended positions the arrangement has a high degree of rigidity. In this way, essential conditions for precise lifting of the chip 30 from the chip carrier and the accurate mounting thereof on the substrate are satisfied.

Fig. 3 shows the characteristic over time of the path s, the speed v and the acceleration a at the end of the second pivoted lever (axle 16) during a cycle of movement from A to B, or vice-versa, with the idealised assumption that the pivot angle $\varphi 1$ varies linearly with time t. As can be seen,

with the lever mechanism according to Figs. 1 and 2, all three values s, v and a vary according to harmonic functions. With the alternating movement, however, sudden starting and stopping of the drive, as assumed in Fig. 3 is not realistic. The diagram according to Fig. 4 shows a corresponding characteristic of s, v and a in practical conditions with "gentle" initiation and braking of the drive in the area of the end positions.

In the embodiment according to Fig. 1 and 2, the pivoting movements of the levers 10 and 12 take place in vertical planes, that is to say perpendicular to the chip carrier 32 and to the substrate 38. Other embodiments are thus also conceivable, in which the pivoting axles of the levers are perpendicular and the levers move in corresponding horizontal planes which lie parallel to the planes of the chip carrier and the substrate. The chip gripper can then be rigidly connected to the end of the second pivoted lever, and a longitudinal guide (corresponding to the linear guide 19 in Figs. 1 and 2) is then in principle not required. Concerning the orientation of the chip carrier on the wafer table it must, however, be taken into account that the chips are rotated by 180° in their planes along the path from A to B. With such variations of embodiments, it can also be advantageous to provide end stops for the vertical and lateral position of the chip gripper (and of the second pivot lever).

In Fig. 5 there is shown in plan view a further example of a semi-conductor mounting apparatus according to the invention, with pivoted levers 10' and 12' arranged to be horizontally pivotable, and parameters changed compared to the example according to Figs. 1 and 2. With this configuration, the range of pivoting Φ' is 120°, correspondingly the gear ratio $n = 3$, and the ratio of the lever lengths $h1/h2 = 2$; the sum of $h1 + h2$ of the levers of different lengths is again equal to the distance S between the axle 4' of the first pivoted lever 10' and the location A or the location B.

The axle 4' of the first pivoted lever 10' is mounted on the central perpendicular M between A and B such that in the end positions Ea and Eb the lever 10', and the second pivoted lever 12' in the extended position with respect to it, face the location A or B. The chip gripper 20', here rigidly connected to the end of the second lever 12', is then located over the location A or B. The alternating pivoting drive (not shown) of the lever 10' can then be configured in an analogous manner to that according to Fig. 2, wherein, however, the pivoting range is, as described, only 120°. The end positions Ea and Eb are again determined by appropriate controlling of the drive

motor. A toothed belt 6' which loops around the stationary toothed wheel 5' and the toothed wheel 7' again serves for coupled drive in the opposite direction of the second pivoted lever 12'. Said toothed wheel 7' is connected via the shaft 14' to the lever 12', and its number of teeth is 1/3 that of the wheel 5'. Therefore, the angle of pivoting $\varphi 2$ of the lever 12' relative to the lever 10' is always three times the angle of pivoting $\varphi 1$ of the lever 10'.

Each chip 30 undergoes a rotation of 120° along the path from A to B. The wafer 35 must therefore correspondingly be orientated with the edges of the chip parallel and perpendicular to Ea, and also the displacements of the wafer table 34 must naturally be orientated as shown by the arrows in Fig. 5.

The parameters described hereinabove thus also satisfy the extended position criteria for the two pivoted levers in the end positions Ea and Eb with this variant. In this case the chip gripper 20' does not move in a straight line between A and B, but instead in a curved path T. The end positions Ea and Eb in A and B are tangential to this path T, which means that in this case too, when the chip gripper arrives at A or B, the movement components at right-angles to Ea and Eb disappear. The arrangement described hereinabove thus has similar advantageous properties to the example previously described.

The construction of the pick and place apparatus with the two pivot levers 10' and 12' further allows the use of delimiters which guide the movement of the chip gripper 20 in the end positions Ea and Eb and thus efficiently prevent the swinging of the pivot lever 12' and the chip gripper 20 at their quick stops. Fig. 6 shows the pivot lever 12' in a position shortly before it reaches its end position Eb. The pivot lever 12' has a T-shaped end 41 with two end faces 41a and 41b. The center of the chip gripper 20 moves along the dashed line 42. The end faces 41a and 41b move along the curves 43a and 43b, respectively. The pick and place apparatus has delimiter means 44 arranged laterally to the direction of movement of the chip gripper 20. The faces 44a and 44b of the delimiter means 44 are adapted to the curves 43a and 43b, respectively, so that the faces 41a and 41b of the pivot lever 12' slide along the faces 44a and 44b of the delimiter means 44.

In the embodiment according to fig. 1 and 2 delimiter means could replace the linear guide 19.

The advantages of a pick and place apparatus with two pivot levers versus a pick and place apparatus with a single pivot lever are in particular that the stopping of the chip gripper 20 in the end positions Ea or Eb can be improved by the use of delimiter means and that during the pivoting movement smaller centrifugal forces show up because of the shorter lengths of the lever arms which also results in reduced power consumption of the drive.

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CLAIMS

1. Semi-conductor mounting apparatus with a chip gripper (20) which is moveable back and forth between a first location (A) and a second location (B) by means of a lever mechanism, in order to lift a chip (30) from a chip carrier (32) at the first location and to lay the chip on a substrate (38) at the second location, characterised by a first pivoted lever (10) which is seated on a shaft (4) mounted equidistantly between the first location (A) and the second location (B), and is driven in alternating pivoting directions between two end positions (Ea, Eb), in which the pivoted lever (10) is directed towards one (A) or the other location (B);

and by a second pivoted lever (12) seated on the end of the first pivoted lever (10) and driven the opposite way around with respect to the direction of pivoting thereof and with a predetermined gear ratio (n) with respect to the pivoting movement thereof, and which at its end is connected to the chip gripper (20);

wherein said gear ratio (n) and the lengths (h1, h2) of the two pivoted levers (10, 12) are matched to each other such that in the two end positions (Ea, Eb) of the first pivoted lever (10), the two pivoted levers (10, 12) are in an extended position with respect to one another and the chip gripper (20) has arrived over one (A) or the other location (B).

2. Semi-conductor mounting means according to claim 1, characterised in that the two pivoted levers (10, 12) pivot in planes which are perpendicular to the substrate (38).

3. Semi-conductor mounting apparatus according to claim 1 or 2, characterised in that the range of pivoting (Φ) between the end positions (Ea, Eb) of the first pivoted lever (10) equals 180°, the gear ratio (n) between the two pivoted levers (10, 12) equals 2, and the ratio of lengths (h1, h2) of the two pivoted levers (10, 12) equals 1.

4. Semi-conductor mounting means according to claim 2, characterised in that on the end of the second pivoted lever (12) there is coupled a slide (18) which can be displaced along a guide member (19) and carries the chip gripper (20).

5. Semi-conductor mounting means according to claim 1, characterised in that the two pivoted levers (10', 12') pivot in planes which lie parallel to the substrate (38).

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6. Semi-conductor mounting means according to claim 5, characterised in that the pivoting range (Φ) between the end positions (Ea, Eb) of the first pivoted lever (10') equals 120°, the gear ratio (n) between the two pivoted levers (10', 12') equals 3, and the ratio of lengths (h1, h2) of the two pivoted levers (10', 12') equals 2.

7. Semi-conductor mounting means according to claim 5, characterised in that the chip gripper (20') is rigidly connected to the end of the second pivoted lever (12').

8. Semi-conductor mounting means according to claim 5, characterised in that at the end positions (Ea, Eb) delimiter means 44 for the second pivot lever (12') are arranged laterally to the direction of movement of the chip gripper 20.

9. Semi-conductor mounting means according to claim 1, 2, 5 or 6, characterised in that the second pivoted lever (12) is seated on a shaft (14) upon which a toothed wheel (7) is seated, which is driven by a toothed wheel (5) fixed on and coaxial to the drive shaft (4) via a toothed belt (6) or an intermediate wheel mounted on the first pivoted lever (10).

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