

Description



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Method and apparatus for positioning a substrate linearly and detecting its position

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The invention relates to a method for positioning a substrate linearly and detecting its position within an assembly area of a pick-and-place robot, and to an apparatus for implementing the method.

10 In the automatic assembly of substrates (for example printed circuit boards or ceramic substrates) with components (for example SMD components, SMD = surface mounted device, or ball-grid arrays = BGA), the individual components are removed from a magazine or a
15 feed device by means of an assembly head and are then positioned in a predefined position on the substrate. In this case, the substrates are removed from a magazine, guided on two opposite sides and conveyed into the pick-and-place robot with the aid of a linear
20 transport. For precise assembly, it is necessary for the position of the printed circuit board in the transport direction to be known exactly.

The earlier German patent application DE 197 38 922 A1, which does not constitute a prior
25 publication, discloses an apparatus and a method for assembling a leadframe with integrated circuits. In this case, a stationary detector unit is used to register the position of the integrated circuits and/or the position of the leadframe before the assembly. With
30 the aid of such a detector unit, although the position of the printed circuit board can be detected, after it has already been braked, a method of braking the printed circuit board cannot be gathered.

GB 2 150 098 A discloses a machine for
35 assembling substrates with electrical components, in which the substrates are stopped in an assembly position by mechanical stoppers,



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are positioned more exactly by means of pins which can be moved telescopically and engage in holes in the substrates, and are subsequently fixed in the more exact position by clamping means. Abrupt braking when
5 moving against the mechanical stopper can undesirably move components which have already been fitted. In addition, the more exact positioning with the pins is often not sufficiently accurate for assembly processes of components with a low spacing between the
10 connections.

DE 43 25 565 discloses a method and an apparatus for conveying a leadframe from a first point to a second point, in which the leadframe is firstly braked at a first location after the first point and
15 held in a clamping mechanism, is subsequently moved in the held state into a processing space, is processed there and is subsequently moved in the held state to the second point, the fact that the respective holding points have been reached being detected by sensors. As
20 a result of stopping twice, firstly at the first location and then in the processing space, there is an undesirable loss of time compared with stopping once in the processing space. In addition, in the processing space, no further detection of the actual position of
25 the leadframe is carried out, which is too inaccurate, above all in the case of components having very low spacings between the connections.

DE 36 30 178 A1 discloses a computer-controlled assembly device which is also used for printed-circuit-
30 board assembly. In this case, the printed circuit boards are placed on workpiece carriers which are moved on transport stations to individual working stations. In this case, photosensors detect the presence of workpiece carriers, and the workpiece carrier is
35 positioned more accurately by means of an adjustment pin. No statements are made about the braking operation itself. The positioning by using the adjustment pins is to some extent too inaccurate.

In addition, to detect printed circuit boards, ultrasonic reflex sensors, for example, are used, which detect a transported printed circuit board. The linear transport is then braked and the substrate is moved at
5 low speed against a mechanical stopper which can be inserted. Instead of the ultrasonic reflex sensor, reflex light sensors are sometimes also used. Various printed circuit boards or ceramic substrates exhibit a different transparency to the light used in this case,
10 and therefore different reflection characteristics. The ultrasonic reflex sensors or reflex light sensors used cannot therefore be used for all substrates. Furthermore, it is disadvantageous that, in this method, all substrates are moved against a mechanical
15 stopper which is permanently positioned, so that to some extent, the assembly head has to be moved over relatively long transport paths than would be needed in the case of small substrates, for example on the basis of the position of the feed devices. In addition,
20 during the abrupt braking by the mechanical stopper, the substrates experience an acceleration which can lead to already assembled components slipping.

It is therefore the object of the invention to specify a method and an apparatus for implementing the
25 method to position substrates in pick-and-place robots, irrespective of their material and their spatial extent, in such a way that the smallest possible travel paths with the assembly head are necessary.

According to the invention, the object is
30 achieved with a method having the features of patent claim 1 and an apparatus for implementing the method having the features of patent claim 4.

By using a sensor with a sensor field which essentially covers the assembly field of the pick-and-
35 place robot, the position of a substrate in the entire assembly field can be determined. The sensor is initially arranged in such a way that

- 4 -

that a substrate that is transported into the assembly field is detected by the sensor at a braking position (also referred to as the braking start position). For the purpose of detection, use is made of a predefined
5 substrate feature, for example the front edge of the substrate, a bar code applied to a predefined location on the substrate, or else connections (pads) arranged on the substrate or other opaque locations on the substrate. After the sensor has detected the substrate
10 material, the linear transport is braked, so that the substrate comes to rest in an assembly position (also referred to as the rest position). The sensor detects the position of the substrate feature at the assembly position, so that the position of the substrate is
15 known.

According to claim 2, determining the position of the substrate feature at the assembly position is advantageously used to move an optical adjustment sensor into the area of adjustment marks, applied to
20 the substrate, for a still more precise determination of position.

According to claim 3, the method is configured particularly simply by the front edge of the substrate being detected as the substrate feature.

25 By using an optical sensor according to claim 5, different substrate features, such as the front edge or bar code, can be detected simply.

In a preferred refinement of the device according to patent claim 6, the sensor is firmly
30 connected to an assembly head which can be moved above the substrate, so that the sensor, and therefore the sensor field, can be set simply to the freely selectable braking position of the transport path.

The arrangement according to patent claim 7 is
35 particularly advantageous, in which the adjustment sensor normally arranged on the assembly head for detecting adjustment marks is used as a sensor for detecting

29 October 2002

- 4a -

the substrate feature, which saves the costs for an additional sensor.

The arrangement of a light source which is directed upward, according to patent claim 7 [sic], advantageously permits a simple optical sensor on the assembly head to be used for detecting the substrate features.

Exemplary embodiments of the invention will be described in more detail using the drawing, in which:

Figure 1 shows, in schematic form, a side view of a pick-and-place robot with a substrate which is being moved into the pick-and-place robot,

Figure 2 shows a schematic side view of a pick-and-place robot, in which a substrate feature of the printed circuit board is detected at a braking position, and

Figure 3 shows a schematic side view of a pick-and-place robot in which a braked substrate is being measured more accurately at an assembly position.

Figure 1 illustrates how a substrate 1 (for example a printed circuit board or a ceramic substrate) is moved in the transport direction 3 on a linear transport 2 in a pick-and-place robot. The assembly area of the pick-and-place robot is identified by x. In this example, a fixing device 6 for a number of suction pipettes 5, and a sensor 10 and an adjustment sensor 14 are fixed to an assembly head 4 which can be moved in the XY direction. The suction pipettes 5 are used to pick up components (not illustrated) from feed devices (not illustrated) and to position these components on the substrate 1. The linear transport 2, the adjustment sensor 14, the assembly head 4 and the sensor 10 are connected to a control device 7. In this case, the sensor 10 is constructed as an optical sensor, having a detector 11 and an optical imaging device 12 which produces a sensor field 13 which is positioned at a freely selectable braking position x1. A stationary, light source 8, in particular a white light source, which preferably extends over the entire

assembly area x, is arranged underneath the linear transport 2 and illuminates the substrate 1 from below. Here, light sources having a primarily linear extent, and also light sources configured to partially cover an area can be used, in order, for example, to detect substrates with cut-outs. In order to position the substrate accurately, adjustment marks 15 are provided on the substrate 1.

Figure 2 shows that the front edge of the substrate 1, as the substrate feature 9, is detected at the braking position X1 by the sensor 10. The linear transport 2 is braked, via the control device 7, so that, as illustrated in Figure 3, the substrate with the substrate feature 9 is stopped in an assembly position x2. To examine the assembly position x2 accurately, the sensor 10 is moved with its sensor field 13 up to the assembly position x2 with the aid of the assembly head 4, which can be moved in the XY direction, and measures the accurate position of the substrate 1. On the basis of this positional measurement, the position of the adjustment marks 15 on the substrate 1 can be calculated, so that the adjustment sensor 14 can be moved over the adjustment marks 15, which results in a highly accurate determination of the position of the substrate 1. The accurate determination of the position of the substrate 1 means that the latter can then be fitted highly accurately with components. Because of the lateral guidance of the substrates 1 in pick-and-place robots, accurate detection of the position in the transport direction 3 is adequate for detecting the position.

Depending on the substrate size, by using this method, the position of the substrate 1 over short assembly paths can be optimized, so that short assembly times and therefore high assembly outputs can be achieved.

Patent Claims

1. Method for positioning a substrate (1) linearly and detecting its position within an assembly field of a pick-and-place robot by means of a linear transport (2), a sensor field (13) oriented towards the substrate (1) being set to a freely selectable braking start position (x1) on the transport path of a feature (9) of the substrate (1) within the assembly field (x), the linear transport (2), after the substrate feature (9) has passed through the braking start position (x1) and the substrate feature (9) has been detected in the sensor field (13), being braked in a defined manner until it approximately reaches a rest position (x2), after the braking of the linear transport (2), the sensor field (13) being set approximately to the rest position (x2) of the feature (9) of the stopped substrate (1), and the rest position (x2) of the stationary substrate feature (9) being determined in order to detect the position.
2. Method for positioning a substrate (1) linearly and detecting its position according to Claim 1, characterized in that by using the position data about the stationary substrate feature (9), an optical adjustment sensor (14) is moved into the area of adjustment marks (15).
3. Method for positioning a substrate (1) linearly and detecting its position according to either of Claims 1 and 2, characterized in that as the substrate feature (9), the front edge of the substrate (1) is registered by the sensor (10).
4. Apparatus for positioning a substrate (1) linearly and detecting its position, in particular for

implementing the method according to one of Claims 1 to 3,

having a linear transport (2) to transport the substrate (1), having a sensor (10) whose sensor field (13) can be set to a freely selectable braking start position (x1) on the transport path of a feature (9) of the substrate (1), and to a rest position (x2) of the substrate feature (9) to detect the position of the substrate (1), and having a control device (7), connected to the linear transport (2) and the sensor (10), to brake and stop the linear transport (2) after the detection of the substrate feature (9) at the braking start position (x1) by the sensor (10), so that the substrate feature comes to rest in the rest position (x2).

5. Apparatus according to Claim 4, characterized in that the sensor (10) is constructed as an optical sensor (11, 12).

6. Apparatus according to either of Claims 4 and 5, characterized in that the sensor (10) is firmly connected to an assembly head (3) which belongs to the pick-and-place robot and can be moved above the substrate (1).

7. Apparatus according to one of Claims 4 to 6, characterized in that the adjustment sensor (14) arranged on the assembly head (4) is used as a sensor (10) for detecting the substrate feature (9).

8. Apparatus according to one of Claims 4 to 7, characterized in that a light source (8) which is arranged to be stationary underneath the substrate (1) and is directed upward illuminates the entire freely selectable positioning area of the features (9) of different substrates (1).