

Description

Method and device for measuring the height at which object edges of components are positioned

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The invention relates to a method and a device for measuring the height at which object edges of components are positioned.

When SMD components (SMD = Surface Mounted
10 Device) are being mounted on printed circuit boards or ceramic substrates, the individual components are removed from a magazine or a feed device with the aid of a mounting head and then positioned in a prescribed position on the printed circuit board or the ceramic
15 substrate. Since the components in the magazine or in the pick up position of a feed device have a positional tolerance of approximately one millimeter but must be positioned with a high degree of accuracy on the printed circuit board or the ceramic substrate, there
20 is a need for automatic position detection and correction. Furthermore, particularly in the case of multipole SMD components, it is necessary to check the spacing and the coplanarity, that is to say the uniform height positioning of the terminals. Such checking is
25 also to be carried out, for example, as quality control when producing the SMD components.

Known arrangements for detecting the position and testing the spacing of the terminals of components use a lens to image the component or sections of the
30 component on a planar CCD camera, and determine by digital image processing the position of the component terminals and the spacing of the terminals.

For the measurement of coplanarity, US 5 440 391 discloses a triangulation method in which
35 the height at which a terminal of an SMD component is positioned is determined by virtue of the fact that the terminal is illuminated with laser light from two directions,

and the two cast shadows of the terminal are detected with the aid of CCD cameras. The height at which the terminals are positioned is determined therefrom in an image evaluating unit connected downstream of the cameras. In the event of an impermissible deviation in the coplanarity, which would have the effect that not all the terminals would produce a contact when mounted on the printed circuit board, it is possible for the defective component to be identified in this way and removed from the mounting process. The disadvantage of this method is the high sensitivity of the reflections of the laser light to the nature of the surface of the terminals, which leads to erroneous measurements.

A shadow-casting method for measuring the coplanarity of components is disclosed in WO 93/19577. In this case, the terminals are illuminated by transmitted light, and the shadow image of the terminal end of an SMD component is projected onto a sensor. The optical axis of the image has a defined angle not equal to 90° to the horizontally arranged object. The height at which the terminal is positioned can be calculated from the angle, the spacing of the terminal from the sensor and the position of the shadow image on the sensor. With this method, unsharp images of the shadow of the terminals are produced on the sensor because of varying component size and, resulting from this, a varying component position in the arrangement. Moreover, in this case the position of the shadow on the sensor can be displaced when the component is at a greater distance from the sensor, thus rendering it more difficult to evaluate the height at which the component is positioned.

US 4 875 779 discloses an imaging method for measuring coplanarity of terminals on components. For this purpose, the terminals are mounted on a reference surface and the mounting region is illuminated. In the event of defective coplanarity, a gap is produced between the reference surface and the terminal, and this gap is imaged on a sensor and evaluated in an

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image evaluating unit connected downstream for the purpose of determining the coplanarity. Mounting on the reference surface leads to an undesired loss of time in the mounting

process, and in addition, the process of a reference surface leads to complicated and expensive structures, for example, on the mounting head. Moreover, only a slight depth of focus can be achieved by the prescribed
5 imaging on the sensor, with the result that components of different size must be expensively positioned at the point of optimum imaging before the measurement.

It is the object of the invention to develop a method and a device for measuring the coplanarity of
10 terminals on components which produces for components of different size a shadow image of the terminals which can be evaluated, without exhibiting the surface sensitivity of the triangulation method.

The object is achieved according to the
15 invention by means of a method and a device having the characterizing features of claims 1 to 10.

By means of the method according to the invention, the shadows of the terminals of components are advantageously imaged on the sensor in a fashion
20 which can be evaluated even when the position of the terminals changes in a prescribed region between the lens and collimator. In the known, direct shadow-casting method, sharp shadows which can be evaluated are obtained when the component is located in the
25 immediate vicinity of the sensor. The image remains sufficiently sharp for evaluation when the terminals are removed from the sensor within a permitted region. The length of this region is doubled in terms of order of magnitude by the method according to the invention,
30 since the region in which an image of the shadow is produced which can be evaluated now extends from the optimum imaging point both away from the sensor and in the direction of the sensor. Consequently, components of different size can be measured.

A further advantage in using the method according to the invention consists in that given the telecentric imaging used, the position of the image shadow on the sensor does not change even when the terminals are positioned remotely on at a distance from the optimum imaging point.

Further advantageous embodiments are outlined in the subclaims. Thus, for example, it is advantageous to be able to image the terminals in an enlarged fashion on the sensor by means of the selected telecentric imaging, so that even small structures can still be adequately resolved.

Moreover, as described in claim 14, it is advantageous to be able, owing to the greater distance according to the invention between the sensor and component, to be able to encapsulate the sensor against environmental influences in order to achieve greater independence from, for example, dust. Pollutants on the encapsulation, which is transparent to light in the direction of the optical axis, disturb the imaging properties only slightly.

The invention is explained in more detail with the aid of exemplary embodiments represented in the drawing, in which:

Figure 1 shows a diagrammatic side view of a device for carrying out the method, the terminals being illuminated from two different angles,

Figure 2 shows a diagram of a side view of a device for carrying out the method, in which the terminals are illuminated only with one light source,

Figure 3 shows a diagram of a plan view of a device for carrying out the method, having only one light source, and

Figure 4 shows a diagrammatic cross section through a sensor for measuring coplanarity.

It is represented in Figure 1 how a component 1 having a plurality of terminals 2 situated in the direction of an object horizontal 3

is illuminated and imaged. The beam emanating from the light source 4 is converted in this case by a collimator 5, for example, into parallel light which illuminates the terminals 2 of the component 1. A lens 6 images the shadow of the terminal 2 on a line sensor 7. In addition to this illumination at an angle α to the object horizontal 3, there is provided a further illumination at a second angle β to the object horizontal 3. In this case, the beam which emanates from a second light source 10 is likewise converted into parallel light by a second collimator 11, and the terminal 2 is imaged on a second line sensor 13 by a second lens 12. With the aid of an image evaluating unit (not represented in the drawing), the images on the line sensor 7 and the second line sensor 13 can be further processed such that the height at which the terminal 2 is positioned can be calculated. Moreover, it is possible using this method to determine the distance of the terminals 2 from the sensor 7 and from the second sensor 13.

Figure 2 represents a method which manages with only one illumination in the case of small angles (up to approximately 10°) between the object horizontal 3 and the optical axis. In this case, the beam emanating from a light source 4 is likewise converted into parallel light by a collimator 5, and the shadow of the terminal 2 is imaged on a line sensor 7 by means of a lens 6. The small angle ensures that a changed height at which the terminals 2 are positioned is converted into a changed height position on the sensor 7. In order to measure all the terminals 2, the position of the component 1 is displaced, as represented in Figure 3, relative to the optical axis, which can be done by moving either the component or the illuminating device. If those object edges on the terminals 2 which are to be imaged are not located at the point of optimum imaging between the lens 6 and collimator 5, a wide light/dark transition is produced as the edge of the shadow on the sensor 7. The

vertical position for which the average brightness of the light/dark transition is detected varies only insignificantly in the method according to the invention, however, doing so as a function of the
5 distance of the terminals 2 from the optimum imaging point.

A device for carrying out the method is represented by way of example in Figure 4. This device can be attached, for example, as a separate station in
10 automatic component mounting machines or devices for quality inspection, or else on the mounting head in automatic component mounting machines. Located in a housing 15 is a light source 4 (for example an infrared-emitting light-emitting diode or laser diode),
15 whose beam is converted into parallel light by a collimator 5. The light is deflected by a mirror 17, illuminates the terminal 2 of a component 1, which is fastened on a suction pipette 18 of a mounting head (not represented), and is deflected by a further mirror
20 17 onto a lens 6 which images the shadow of the terminal 2 on the line sensor 7. Connected downstream of the line sensor 7 is an image evaluating unit 14 with the aid of which it is possible to determine the height at which the terminal 2 is positioned. Instead
25 of the line sensor 7, it is also possible to use a position-sensitive detector (PSD). The line sensor 7 can be protected against environmental influences (dust, pollutants) by an additional encapsulation which is designed to be transparent to light in the direction
30 of the optical axis. The quality of the imaging is only negligibly impaired, by comparison with the direct shadow-casting method, by pollutants on the encapsulation which is transparent to light.

The arrangement is arranged in a housing 15
35 which is moved by a drive (not represented) such that all the terminals 2, situated in a row, of the component 1 are imaged successively on the line sensor 7 and the testing of coplanarity is performed in the image evaluating unit 14.

The horizontal movement of the component 1 perpendicular to the optical axis also permits the distance of the terminals 7 from one another to be measured, and thus a so-called spacing check to be carried out. The arrangement supplies a 4σ accuracy of the determination of height position of approximately $6\text{ }\mu\text{m}$ when the terminals 2 are located at a position in a 26 mm long region between the lens 6 and collimator 5 (focal length 80 mm in each case). It is thereby possible to determine the height at which the terminals of components of different size (usually 6 mm to 60 mm) are positioned in this device without complicated adjustment. The extent of the region in which the terminals 2 can be positioned so that their shadow is imaged in a way which can be evaluated is doubled in order of magnitude by comparison with the shadow-casting method. The component 1 can be moved from its optimum imaging position both in the direction of the sensor 7 and away from the sensor 7, something which is not possible in the case of the direct shadow-casting method, because of the position of the component 1 there directly on the sensor 7.

Patent claims

1. A method for measuring the height at which object edges (2) of components (1) are positioned, in which the object edges (2) are illuminated by parallel light beams of at least one light source (4), the shadows of the object edges (2) are imaged telecentrically by means of a lens (6) on a sensor (7), and the height at which the object edges (2) are positioned is determined in an image evaluating unit (14) connected downstream of the sensor (7).
2. The method for measuring the height at which object edges are positioned as claimed in claim 1, characterized in that the object edges are the edges of the terminals (2) of the components (1), and the coplanarity of the terminals (2) is investigated using the method.
3. The method for measuring the height at which object edges (2) are positioned as claimed in one of claims 1 or 2, characterized in that the parallel light beams are produced by a collimator (5) arranged in the beam path between the light source (4) and object edge (2).
4. The method for measuring the height at which object edges (2) are positioned as claimed in claims 1 to 3, characterized by a small angle between the light beams and an object horizontal (3) of the component.
5. The method for measuring the height at which object edges (2) are positioned as claimed in claims 1 to 3, characterized in that an additional shadow image of the object edges (2) of the component (1) is produced by illumination with parallel light from a second light source (10) with the aid of a second collimator



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(11), and imaging by means of a second lens (12) on a second sensor (13), the angles (α , β) between the object horizontal (3) of the component and the respective light beams being different, and in that the height at which the object edges (2) are positioned is checked from the two images on the sensors (7, 13) in the image evaluating device (14).

6. The method for measuring the height at which object edges (2) are positioned as claimed in claim 5, characterized in that the distance of the object edges (2) from the sensor (7) is additionally determined.

7. The method for measuring the height at which object edges (2) are positioned as claimed in one of claims 1 to 6, characterized in that the position of the component (1) is varied relative to the optical axis in order to measure different object edges (2).

8. The method for measuring the height at which object edges (2) are positioned as claimed in one of claims 1 to 7, characterized in that the spacing between different object edges (2) is measured.

9. The method for measuring the height at which object edges (2) are positioned as claimed in one of claims 1 to 8, characterized in that the shadows of the object edges (2) are imaged in an enlarged fashion on the sensor (7).

10. A device for measuring the height at which object edges (2) of components (1) are positioned, having at least one light source (4) for illuminating the object edges (2), and having at least one sensor (7) with an image evaluating unit (14) connected downstream,



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characterized in that at least one collimator (5) and at least one lens (6) are arranged in the beam path such that the object edges (2) of the component (1) are illuminated with parallel light, and the shadows of the object edges (2) are imaged telecentrically on the sensor (7).

11. The device for measuring the height at which object edges (2) are positioned as claimed in claim 10, characterized in that a second light source (10), a second collimator (11), a second lens (12) and a second sensor (13), which is likewise connected to the image evaluating unit (14), are arranged in such a way that the object edges (2) are illuminated and imaged from a second direction.

12. The device for measuring the height at which object edges (2) are positioned as claimed in claim 10 or 11, characterized in that the device is accommodated in a housing (15).

13. The device for measuring the height at which object edges (2) are positioned as claimed in one of claims 10, 11 or 12, characterized in that the housing (15) is provided with a drive for varying the position of the device relative to the component (1), in order to image different object edges (2) of the component (1) on the sensor (7).

14. The device for measuring the height at which object edges (2) are positioned as claimed in one of claims 10 to 13, characterized in that there is arranged around the sensor (7) an encapsulation which is transparent to light in the direction of the optical axis.

15. The device for measuring the height at which object edges (2) are positioned as claimed in one of claims 10 to 14,



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characterized by a line sensor arranged perpendicular to the optical axis and perpendicular to the object edges (2) as sensor (7).

16. The device for measuring the height at which
5 object edges (2) are positioned as claimed in one of
claims 10 to 15, characterized by a position sensitive
detector (PSD) arranged perpendicular to the optical
axis and perpendicular to the object edges (2) as
sensor (7).
- 10 17. The device for measuring the height at which
object edges (2) are positioned as claimed in one of
claims 10 to 16, characterized by an infrared-emitting
light-emitting diode as light source (4).
18. The device for measuring the height at which
15 object edges (2) are positioned as claimed in one of
claims 10 to 16, characterized by an infrared-emitting
laser diode as light source (4).



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