

LEAD INSPECTION APPARATUS ✓1 pos's
copy**FIELD OF THE INVENTION**

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The present invention relates generally to the field of electronic component inspection tools, and particularly to a method and device for inspecting a lead of an electronic component, and especially surface mount devices such as quad-flat packages (QFPs).

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BACKGROUND OF THE INVENTION

The importance of lead inspection of leads of electronic components, and particularly of semiconductor devices such as the surface mount devices is well appreciated in the art. Various lead inspection systems, therefore, currently are found in the semiconductor industry. Some of these systems are described in patent documents such as U.S. Patent No. 4,875,778, 4,875,779, 5,212,390, 5,257,714, 5,402,505, 5,414,458, and 5,440,391. Generally, all of these patents describe a system or apparatus which detects a lead of a device which is out of its intended position. The lead of an electronic component may be out of position in many different ways. It may be bent, angled, out of the plane with the others, or out of position in a combination of ways.

To properly inspect the leads, it is important to check for all of these parameters. It is not complete to simply check for coplanarity, for instance, and ignore the pitch (which can be off if the lead is bent within the plane).

Although there currently exists a number of systems which can properly inspect the leads of a semiconductor device, they usually involve complex set of parts or take up undue amount of space. Simplicity and space efficiency always being desirable goals, it would be therefore highly desirable to have a lead inspecting apparatus which is not only complete in its ability to inspect all of the pertinent parameters, but is simple in design, and is space-efficient.

OBJECT OF THE INVENTION

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It is therefore an object of the present invention to provide a lead inspection apparatus which can reliably inspect for all of the pertinent parameters of lead inspection.

It is another object of the present invention to provide a lead inspection apparatus which is simple in design.

It is yet another object of the present invention to provide a lead inspection apparatus which is space-efficient.

SUMMARY OF THE INVENTION

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The present invention includes a pedestal which is mounted on a transparent base plate. The pedestal has a mirror surface on its slanted edge. The electronic component to be inspected sits on top of the pedestal. The leads of the electronic component point downward and hang to the side of and away from the pedestal, but it is preferred that the leads do not touch

the surface of the base plate. A diffused light source is located near the pedestal to illuminate of the leads.

When the leads are illuminated, the light rays reflecting off the leads and the rays reflecting off the angled mirror surface are reflected off the angled mirror and are captured by the CCD camera. The angle of slant for
5 the mirror here is forty-five degrees; however, other angles are possible. It should be appreciated however that the use of the mirror is for convenience only, that is, to be able to place the camera in a horizontal position. If it is convenient to do so, the camera may be positioned directly underneath the
10 light rays and capture the image directly without the use of the mirror. The captured image can then be displayed on video and/or recorded in digital memory form so that various measurements can be made.

The image generated from the combined lights rays and can be used to measure at least three important parameters relevant to lead inspection:
15 1) pitch: distance of separation between the leads of a surface mount device; 2) coplanarity: height of the leads above the plane on which the electronic device sits; and 3) lead angle: angle subtended by the tip of the lead to the base plane. The parameters which can be measured, however, are not limited to just these three.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating the general structural arrangement of the present invention.

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FIG. 2 is a schematic diagram illustrating the principles by which the pertinent lead-inspection parameters are measured.

FIG. 3 illustrates an alternative embodiment of the present invention
5 which is particularly adapted for inspecting PLCC devices.

FIG. 4 is an actual image of the leads generated by the present invention.

10 DETAILED DESCRIPTION OF THE INVENTION

The FIG. 1 illustrates the principles employed by the preferred embodiment of the present invention. As shown in FIG. 1, a pedestal 5 is mounted on a transparent base plate 10. The pedestal 5 has a mirror surface on its slanted edge 12. Although other angles are possible, it is preferred that the edge be slanted at forty-five degrees to base plate. The electronic component to be inspected, in this case a quad-flat package (QFP) 15, sits on top of the pedestal 5. The leads of the QFP 15 point downward and hang to the side of and away from the pedestal 5, but it is preferred that the leads do not touch the surface of the base plate 10. A
15 diffused light source 20 is located near the pedestal to illuminate of the leads 17.

When the leads are illuminated, the light rays 25 reflecting off the leads 12 and the rays 27 reflecting off the angled mirror surface 12 are
25 reflected off the angled mirror 30 and are captured by the CCD camera 40. The angle of slant, β , for the mirror 30 here is forty-five degrees; however,

other angles are possible. It should be appreciated however that the use of the mirror 30 is for convenience only, that is, to be able to place the camera in a horizontal position. If it is convenient to do so, the camera may be positioned directly underneath the light rays 25 and 27 and capture the image directly without the use of the mirror 30. The captured image can then be displayed on video and/or recorded in digital memory form so that various measurements can be made.

The image generated from the combined lights rays 25 and 27 can be used to measure at least three important parameters relevant to lead inspection: 1) pitch: distance of separation between the leads of a surface mount device; 2) coplanarity: height of the leads above the plane on which the electronic device sits; and 3) lead angle: angle subtended by the tip of the lead to the base plane. The parameters which can be measured, however, are not limited to just these three.

FIG. 2 illustrates in detail how the parameters discussed above can be measured from the image captured by the camera. FIG. 2 illustrates the generated image (the bottom half of the figure), and how it corresponds to the various parameters of the actual lead of the QFP device (the upper half of the figure). Here, H is defined as the height of the lead end 17a above the reference plane 50. Height, H, is used to measure the coplanarity of the leads. Pitch is the distance between the leads as shown in the image, here marked as P1, P2, P3, and P4. The lead angle, θ , is defined as the angle between the lead tip 17a and the reference line 51 which is parallel with the base plane.

To be able to measure these parameters, the variables, W1, W2, d1, d1', d2, d2' must be known. All of these are physical measurements which

can be ascertained from the generated image. The distances that these variables represent are illustrated in FIG. 2. Here the pedestal angle, ϕ , is fixed at forty-five degrees (though other angles can be used), and all of the calculations are done in light of this fixed value.

5 The pitch, P1, P2, P3, and P4, are measured directly from the image, and the measured distance corresponds to the actual pitch. The height, H, is simply equaled to the measurement d1. The lead angle, θ , can be calculated using the following formula: $\theta = \tan^{-1}(W1/W2)$. Once these parameters are known, the values can be compared against the norm to
10 complete the inspection process.

 The calculations shown above were somewhat simplified by the fact that the pedestal angle, ϕ , was fixed at 45 degrees. Where a value other than 45 degrees is used for ϕ , a more general set of formulas can be used to calculate the parameters. However, for simplicity, these formulas are valid
15 for angle values near 45 degrees, e.g., 48 degrees. For angles which deviate much from 45 degrees, the formulas need to be modified slightly. For the pitch, it is still the measured distance. For the height, H, the new formula is the following:

$$H = d1 \tan \phi + (d2 - d1) \tan (2\phi - 90)$$

20 For the lead angle, θ , the new general formula is the following:

$$\theta = \tan^{-1}[(W1 \tan \phi)/W2].$$

Of course, while these measurements, calculations, and the comparisons can be done manually, it is more convenient to automate the process via a computer.

25 The embodiment of the present invention described above is applicable for QFPs and other similar devices. For another type of surface

mount device, PLCC, with leads shaped like the letter "J", some slight modification needs to be made. As shown in FIG. 4, here additional mirror blocks 60 are added adjacent to the PLCC device 62. The rest of the components, e.g., pedestal 63, transparent base plate 64, light source 65, 5 mirror 66, and camera 67, of this alternative embodiment are identical as those described for FIG. 1. Moreover, it should be clear those skilled in the art that the principles by which the calculations are done are also identical to those described for and illustrated in FIG. 1 and FIG. 2.

The present invention may be embodied in other specific forms 10 without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are, therefore, to be 15 embraced therein.

**CLAIMS**

We Claim:

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- 1 1. A lead inspection apparatus for an electronic component having at
2 least one lead, said apparatus comprising:
 - 3 a means for illuminating said lead;
 - 4 a means for capturing an image of said lead, said image being
5 formed from views of said lead from at least two different directions, said
6 image of both of said views being captured from a single direction,
 - 7 a means for calculating values defining a position of said lead from
8 said image; and
 - 9 a means for comparing said values with an accepted value.
- 1 2. The lead inspection apparatus as recited in claim 1 wherein said
2 means for illuminating is a diffused light source.
- 1 3. The lead inspection apparatus as recited in claim 1 wherein said
2 means for capturing an image is a CCD camera.
- 1 4. A lead inspection apparatus for an electronic component having at
2 least one lead, said apparatus comprising:
 - 3 a base plate;
 - 4 a pedestal mounted on said base plate, said pedestal having an
5 angled mirror on its edge, said electronic component placed on top of said
6 pedestal with said lead hanging adjacent to said angled mirror;
 - 7 a diffused light source for illuminating said lead;
 - 8 a means for capturing an image of said lead, said image being
9 formed from views of said lead from at least two different directions, said



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10 image of both of said views being captured from a single direction, one view
11 being generated from lights reflected from the lead to said angled mirror and
12 another view being generated from lights reflected directly off said lead;
13 a means for calculating values defining a position of said lead from
14 said image; and
15 a means for comparing said values with an accepted value.

1 5. The lead inspection apparatus as recited in claim 1 wherein said
2 means for capturing an image is a CCD camera.

1 6. A method of inspecting a -lead of an electronic component
2 comprising:

3 illuminating said lead;

4 capturing an image of said lead, said image being formed from views
5 of said lead from at least two different directions, an image of both of said
6 views being captured from a single direction,

7 calculating values defining a position of said lead from said image;

8 and

9 comparing said values with an accepted value.

1 7. A lead inspection apparatus for a PLCC device having at least one
2 lead, said apparatus comprising:

3 a base plate;

4 a pedestal mounted on said base plate,

5 a mirror block, said mirror block having an angled mirror on its edge,
6 said electronic component placed on top of said pedestal with said lead
7 hanging adjacent to said angled mirror;

8 a diffused light source for illuminating said lead;





9 a means for capturing an image of said lead, said image being
10 formed from views of said lead from at least two different directions, said
11 image of both of said views being captured from a single direction, one view
12 being generated from lights reflected from the lead to said angled mirror and
13 another view being generated from lights reflected directly off said lead;
14 a means for calculating values defining a position of said lead from
15 said image; and
16 a means for comparing said values with an accepted value.

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