JEDEC STANDARD

Coplanarity Test for Surface-Mount Semiconductor Devices

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COPLANARITY TEST FOR SURFACE-MOUNT SEMICONDUCTOR DEVICES

(From JEDEC Board Ballot JCB-02-122, formulated under the cognizance of the JC-14.1 Subcommittee on Reliability Test Methods for Packaged Devices.)

1 Scope

The purpose of this test is to measure the deviation of the terminals (leads or solder balls) from coplanarity for surface-mount semiconductor devices.

2 Apparatus

The equipment utilized in this test shall be capable of measuring the deviation of the terminals from coplanarity to specified tolerances as determined by the applicable procurement document. Equipment must be capable of measurement accuracies within +/- 10% of the specified deviation.

3 Terms and definitions

3.1 Seating plane

The plane formed by the three terminal apexes that exhibit the greatest perpendicular distance from the package substrate, provided that the triangle formed by those three apexes encompasses the projection of the center of gravity (COG) of the component.

3.2 Deviation from coplanarity

The distance between the intended contact point of the terminal and the established seating plane or regression plane.

3.3 Terminal

An externally available point of connection

3.4 Terminal apex

The point on the terminal surface that exhibits the greatest perpendicular distance from the package substrate.

3.5 Regression plane

A plane through the apex of the terminal that has the greatest perpendicular distance from the package substrate, this plane being parallel to the best-fit plane through the apexes of all terminals determined using the method of least squares.

NOTE The regression plane may be used to emulate the package coplanarity during reflow soldering at the point of surface mounting.

4 Reference

JEP 95-1, *Design Guide 4.17, BGA (Ball Grid Array) Package Measuring and Methodology*.

5 Procedure

There are two methods suitable for measurement of coplanarity. They are the seating plane method and the regression plane method. Each procedure produces a coplanarity value within the limits of error expected for this measurement. Traditionally, the seating plane method of measuring deviation from coplanarity is preferred. However, the regression plane method is an acceptable alternative provided the results obtained correlate to those of the seating plane method.

5.1 Seating plane method

The following procedures are to be used:

a) Care must be taken in handling to ensure no damage to the terminals.

b) The seating plane shall be in the horizontal position with the device placed as shown in Figure 1. It is preferable that the component terminals be measured while the component is in the dead-bug (leads-up) position.

c) When coplanarity measurements are made, there shall be no external forces applied to the device.

d) Determine the apex of each and every terminal .

e) Determine the three terminal apexes that exhibit the greatest perpendicular distance from the substrate. These form the seating plane, see Figure 1.

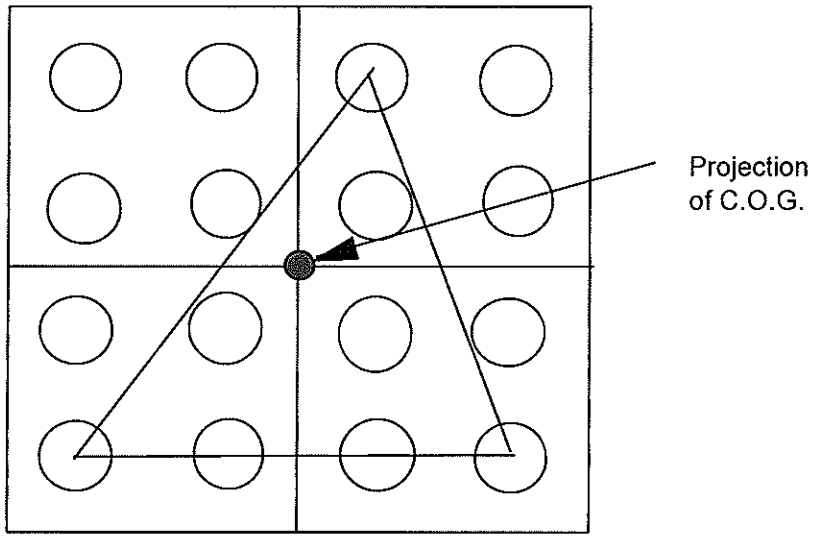

Figure 1 — Three apexes forming the seating plane and encompassing projection of C.O.G.

5 Procedure (cont'd)

5.1 Seating plane method (cont'd)

f) The triangle of terminals defining the seating plane must encompass the projection of the center of gravity (C.O.G.) in order to constitute a valid seating plane. If the plane is not considered valid, the next terminal with the greatest perpendicular distance from the substrate shall be considered as a candidate terminal to be used in forming a valid seating plane. If the seating plane triangle passes through the package center of gravity, the seating plane will be valid, but multiple seating planes could exist. If multiple seating planes do exist, the seating plane yielding the worst-case measurement shall be used for coplanarity determination.

g) Deviation from coplanarity is measured as the distance from the seating plane to the apex of each and every terminal. The largest measurement is the deviation from coplanarity; see Figure 2 and Figure 3 (BGA versus leaded terminal).

h) Report that the deviation from coplanarity was determined by the seating plane method.

Most equipment used for coplanarity measurement is programmed to automatically perform both seating and regression plane coplanarity measurements. Annex A is an illustrative example of how the seating plane on the terminals of a component is determined in the dead-bug position.

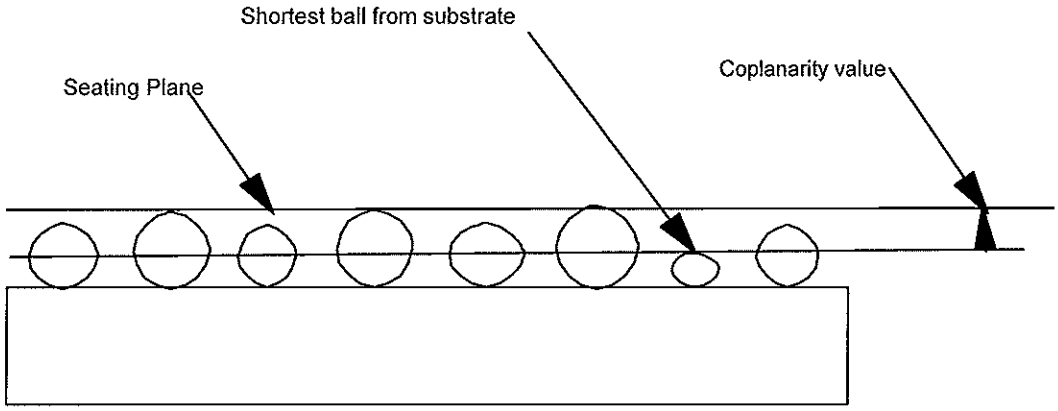

Figure 2 — Coplanarity measurement using seating plane method on ball grid array terminal

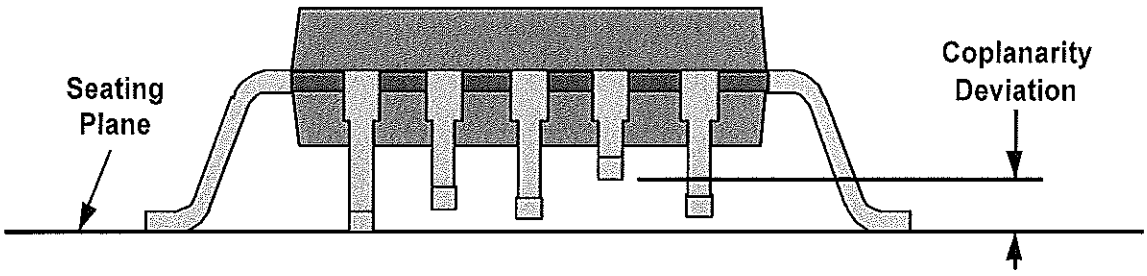

Figure 3 — Deviation from coplanarity meas urement using seating plane method on leaded terminal

5 Procedure (cont'd)

5.2 Regression plane method

The following procedures are to be used:

a) Care must be taken in handling to ensure no damage to the terminals.

b) The regression (least mean square) plane shall be in the horizontal position with the device placed as shown in Figure 4.

c) When coplanarity measurements are made, there shall be no external forces applied to the device.

d) Determine the apex of each and every terminal.

e) Determine the best-fit plane through the apexes of all terminals using the method of least squares.

f) The regression plane shall then be offset in a parallel manner to the apex of the terminal that exhibits the greatest perpendicular distance from the substrate. The distance from the offset regression plane to the terminal farthest away from the offset regression plane is the component deviation from coplanarity.

g) Report that the deviation from coplanarity was determined by the regression plane method.

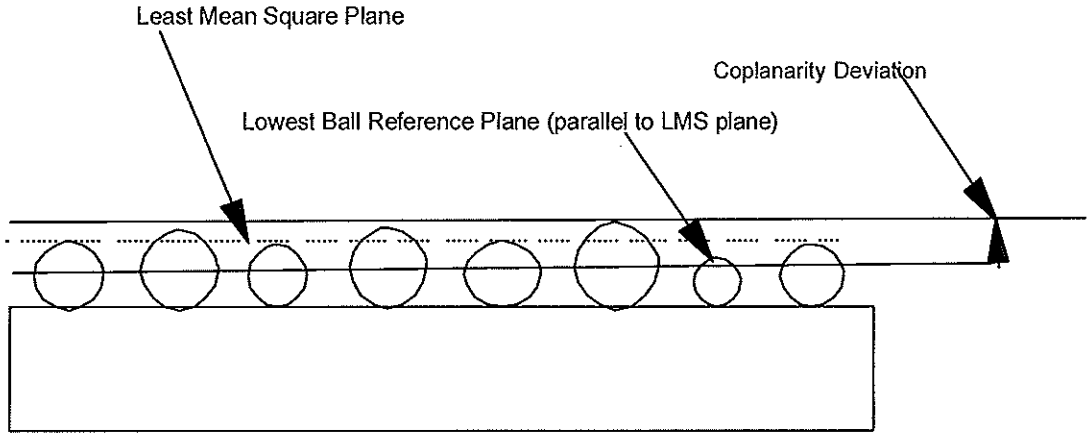

Figure 4 — Deviation from coplanarity measurement using regression plane method

6 Failure criteria

Any device with one or more terminals that exceeds the specified deviation from coplanarity shall constitute a failure.

7 Summary

The following details shall be specified in the applicable procurement document:

a) The number of parts to be tested and the acceptance number.

b) The maximum deviation from coplanarity.

c) The preferred method by which coplanarity should be measured.

Annex A

A.1 Determining seating plane

Determining a seating plane is essentially a four-step process. This process is usually programmed into the equipment used to measure coplanarity.

A.1.1 Seating plane algorithm

The first step is to determine the three points used for determining the seating plane. The algorithm used is typically like the illustration outlined in the next paragraphs.

The principle is to determine if the origin lies within the interior of the triangle. The interior of the triangle is defined as the intersection of three regions:

A.1.1.1 Each of the three regions is defined by an inequality $y>mx+b$ or $y<mx+b$, where $y=mx+b$ is the equation of the line joining two points (x1 and x2). (If the points determine a vertical line, m is undefined, see paragraph 4.) The direction of the inequality is determined for each pair by substituting the x coordinate of the remote point of the triangle into $y=mx+b$ of the pair considered, and subtracting the resulting y from the y-intercept, b. If the result is < 0, the remote point lies below the line, and vice versa. So the region that includes the triangle's interior is identified as lying above (in Excel: sign +1) or below (-1) the line.

A.1.1.2 Next, we determine whether the origin is included in this region (lies on the same side of the line as the remote point). This is done by comparing the sign obtained in step 1 to the sign of the y-intercept of the line. The y-intercept is positive if the origin lies below the line, and vice versa. When the two signs are multiplied, the result is -1 if the remote point and the origin lie on the same side of the line.

A.1.1.3 The origin lies within the triangle if (0,0) satisfies all three inequalities. This is true if and only if, for each of the three lines, the remote point lies on the same side of the line as the origin. The determination is made in Excel by adding the three comparisons. A -3 result is positive; any other result is negative.

A.1.1.4 Before executing step 1, each line is tested to see if it is vertical. (x2 - x1 = 0) If so, the comparison of remote point to origin is made in x instead of y, and simplifies to comparing the x of the remote point to the (constant) x of the line. (Excel displays error messages for m and b, but in the case of a vertical line, these values are not needed or used.)

A.1.1.5 The above requires the origin to lie within, not on the margin of, the triangle formed by the three points considered.

A.2 Method to determine seating plane

A.2.1 A Cartesian coordinate system is placed with its origin at the geometric center of the component also called the component center of gravity.

A.2.2 The X, Y, and Z of each apex is measured and tabulated. The apexes are sorted by Z, in descending order.

Annex A (cont'd)

A.2.3 The three highest (1, 2, and 3) are examined with the Seating Plane Algorithm to determine whether they form the seating plane. If they do not, apex trios are examined in order until a trio is found that determines the seating plane.

A.2.4 The order of trial is (1,2,3), (1,2,4), (1,2,5), . . . (1,2,n), (1,3,4), (1,3,5), . . .(1.3,n),. . .(1,n,n), (2,3,4), (2,3,5), . . . (n,n,n). Since the list is sorted by height, the first trio found that forms a triangle enclosing the origin will define the seating plane.

A.3 Equation for seating plane

Next the measuring equipment uses the three points determined in A1 to determine the seating plane. This is done through an equation that is preprogrammed into measurement tool.

A.4 Determining the distance to the seating plane

Once the seating plane is determined, the measurement equipment calculates the distance to the seating plane. The deviation from coplanarity is the largest distance from the seating plane to the apex of any terminal.

A.5 Passing a reason test

The deviation from coplanarity value determined in the steps above should be reviewed to verify that the value found is a reasonable one for the parts being measured.