

SEMI G93-0412

MEASUREMENT METHOD FOR SOLDER SPHERE SIZE FOR BALL GRID ARRAY PACKAGE

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NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

1 Purpose

1.1 The purpose of this Document is to define a procedure for the size measurement method of solder spheres used for ball grid array (BGA) packages.

2 Scope

2.1 This measurement method is applicable for solder spheres which are used for electrical interconnect between the package and printed circuit boards (PCBs).

2.2 This measurement method is used to measure the size of solder spheres, and these measurement data are used in the test report as a Certificate of Analysis.

2.3 This Standard can be used as a specification when purchasing these solder spheres.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 ISO Standard¹

ISO 3290 — Balls for Rolling Bearings

3.2 JIS Standards²

JIS B1501 — Rolling Bearings-Balls

JIS B0621 — Definitions and Designations of Geometrical Deviations

JIS B7451 — Instruments for the Assessment of Departure from Roundness – Measurement of Variations in Radius

3.3 Other Documents

JCT20116-01 — JCSS Technical Requirement Guideline³

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 BGA — ball grid array

4.1.2 CCD — charge coupled device

¹ International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

² Japanese Standards Association, 4-1-24 Akasaka, Minato-ku, Tokyo 107-8440, Japan; Telephone: +81.3.3583.8005, Fax: +81.3.3586.2014, <http://www.jsa.or.jp>

³ National Institute of Technology and Evaluation (NITE) 2-49-10 Nishihara, Shibuya-ku, Tokyo, 151-0066 Japan; Telephone: 81.3.3481.1633, Fax: 81.3.3481.1937, <http://www.iajapan.nite.go.jp/jcss/en/index.html>

4.1.3 *CNC* — computerized numeric control

4.1.4 *Cp* — process capacity

4.1.5 *Cpk* — process capability

4.1.6 *CSV* — comma separated value

4.1.7 *LSC* — least squares circle

4.1.8 *MCC* — minimum circumscribed circle

4.1.9 *MIC* — maximum inscribed circle

4.1.10 *MZC* — minimum zone circle

4.1.11 *PCB* — printed circuit boards

4.2 Definitions

4.2.1 *circularity* — circularity considers the degree to which a shape deviates from a perfect circle. Circularity of solder spheres is measured using any one of several methods. One measurement reviews the difference between the diameters of the circumscribed and inscribed circles. Another method compares the ratio of *x*-axis to *y*-axis using a 3-point measurement method.

4.2.2 *conjugated plane* — there are two sets of principal conjugate focal planes that occur along the optical pathway through the microscope. One set consists of four field planes and is referred to as the field or image-forming conjugate set, while the other consists of four aperture planes and is referred to as the illumination conjugate set. Each plane within a set is said to be conjugate with the others in that set because they are simultaneously in focus and can be viewed superimposed upon one another when observing specimens through the microscope.

4.2.2.1 *imaging equipment* — a two dimension (2-D) projection of a three dimension (3-D) solder sphere is imaged. The edges of the projected circle are then detected. The distances between the edges are measured and an algorithm programmed into the equipment obtains the sphere diameter by review of the minimum inscribed circle (MIC) and the maximum circumscribing circle (MCC).

4.2.2.2 *microscope equipment* — a diameter of the circle through solder sphere contact with at least three points is measured directly by microscope. The diameter of a circle fit through three edge points. The three points are selected from the contact points with adjacent solder spheres.

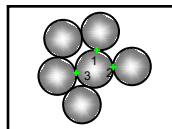


Figure 1
Circle with Three Points of Contact

4.2.3 *production lot* — a group of solder spheres all produced through the manufacturing equipment at the same time.

4.2.4 *solder sphere (solder ball)* — solder is a metal alloy used to fuse together two or more objects with terminations having a metallic surface. A solder sphere is used to create an interconnection between a package and a printed circuit board. These solder spheres may include leaded (Pb) or lead-free (Pb-free) alloys and metal alloy coated resin solder balls.

4.2.5 *solder sphere diameter* — the diameter of a circle is the length of the horizontal line formed between the directly opposite outer circumference and passing through the center. The sphere diameter in this Standard is defined as the distance determined by either of the two following measurement equipment.

4.2.6 *sphericity* — sphericity is a measurement of sphere's total roundness, given as the ratio of the surface area of an ideal sphere (with the same volume as the given solder sphere) to the surface area of the solder sphere. In this

Standard, sphericity of solder sphere will be approximated by measuring the circularity of the sphere projection, as defined by ¶ 4.1.3.

4.2.7 *support tray* — a tray is utilized to keep balls at a fixed location during the measurement. This tray is to be placed on the measurement instrument stage board.

5 Measurement System

5.1 *Typical Measurement Mechanism* — Solder sphere measurement is made via a noncontact image processing system. This system in general consists of a light source, a stage holder which can move in the X and Y directions, an optical lens, a charged coupled device (CCD) camera and an image processing unit. Commercial CNC equipment is available equipped with all of these functions.

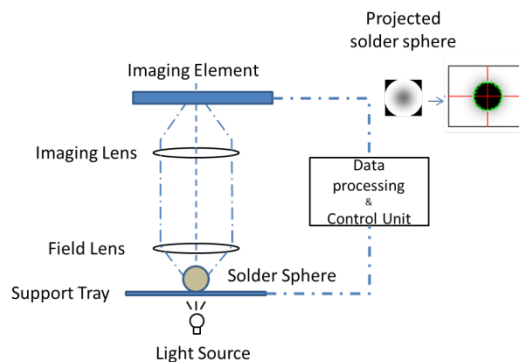


Figure 2
Sketch of Measurement Mechanism

5.2 Measurement Methodology

5.2.1 Measurement Methodologies

5.2.1.1 2-D projection of the solder sphere is measured by an image sensor such as CCD or microscope. The nature of the material characteristic of a solder sphere would determine the measurement points with multiple location or a few select points. The selection of the measurement method can be chosen based on the solder sphere manufacturing method or solder sphere material itself. Two measurement methodologies are defined in this section which is multi-point measurement methodology and another is 3-point measurement method.

5.2.1.2 *Multi-Point Measurement Methodology* — This methodology can be used when the solder sphere is formed by way of controlling the surface tension of molten metal. In this case, the sphericity error is rather variant during the process of manufacturing. This methodology requires collection of multiple points for the measurement in order to estimate the circularity of the projected solder spheres.

5.2.1.3 *3-Point Measurement Methodology* — This methodology can be used when the solder sphere material is made of a resin core or similar material. In this case, the final sphere shape is controlled by the manufacturing process of resin ball, and there is a rather small variation in the circularity. This method allows for the 3-points measurement, and microscope can be quickly used for these locations.

5.2.2 Multi-Point Measurement

5.2.2.1 A noncontact size measurement technique is used to capture the projected image of the sample as the support tray is moved in both X and Y directions.

5.2.2.2 During solder sphere measurement, the light source can be either transmitted through the bottom of the support tray, or transmitted through the top of the support tray. In either case, a two dimensional projected image of the solder sphere is created.

5.2.2.3 The projected image is enlarged through an optical lens system and then captured by the image sensor.