Simultaneous measurement of Roundness and Diameter of Solder Balls for BGA

Introduction

BGA

Solder Spheres (or Solder Balls as they are often called) are used in BGA (Balls Grid Array) devices as the connectors between the package and the electrical board where it will be used.

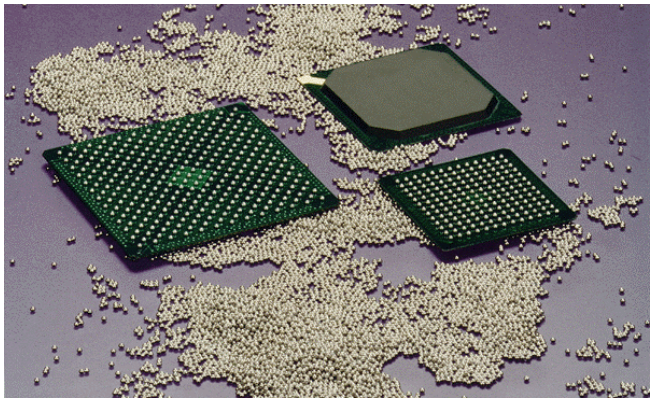


Fig. 1 – Solder balls

The most common diameters are: 750µ, 500µ, 400µ, 350µ and 300µ.

Quality:
The quality of the Solder Spheres depends on the consistency and tight tolerance of two main dimension factors

1. **Size Distribution** (diameter of the Spheres):
   Typical specification- 99% of the Spheres should lie within the size range: ±10 ìm
2. **Sphericity** (roundness of the Spheres):
   Typical specification- 99.95% of the Spheres should lie within the range: ±4.0 ìm

Using spheres with properties outside these tolerances may cause problems in the ball placement process and in the final device performance.

Quality Control:
The Diameter and Sphericity of the Solder Spheres are normally measured by Microscope or by close loop DSP (Digital Signal Processing). Both methods measure stationary spheres and are both time consuming and labor intensive. Consequently the traditional methods support relatively small samples from each production lot (usually less than 100 spheres). Measuring roundness by optical mean where spheres are laying stationary on a surface is both inefficient and inaccurate as the spheres will tend to settle on the least round part on their surface (the hidden side from the camera).

Instrumentation

Requirement

Equipment for measuring Size (Diameter) and Shape (Roundness) in an Automatic, Accurate and Fast method.

Solution

DSA-10 – Dynamic Shape Characterization System

The Ankersmid Dynamic Shape Analyzer, DSA-10, is a complete shape characterization system for particles in motion. Comprehensive particle analysis is obtained through the unique combination of a synchronous strobe light source and video microscope technology. All particles are fully classified by numerous shape parameters including Diameter and Aspect Ratio* (roundness).
An automatic flow controller (LFC-101) is used to flow the particles through the measuring cell. A video microscope camera synchronized with strobe light captures "still" images continuously while particles are in dynamic flow. The images are enhanced, processed, and analyzed automatically to ensure full representation of the sample. Accurate results are produced in a fraction of the time normally required for microscopic observation.

- Aspect Ratio – Shape parameter of an object given as the ratio between the min ferret diameter to the max ferret diameter. The factor is 1 for a perfect circle and close to 0 for a line.
  Aspect Ratio = (Min Ferret) / (Max Ferret)

Table 1 - Measurement set-up configuration

Illumination	Synchronized strobe light with adjustable intensity and duration.				
Video camera	High resolution B&W CCD camera, 768x493 pixels.				
Shape range	**Lenses**	**Objective magnification**	**F.O.V**	**m/Pix**	**Range [m]**
	Lens DW	6x	1500x1200µ	2.3	10-600
	Lens EW	1.4x	6200x4500µ	9.5	20-3000

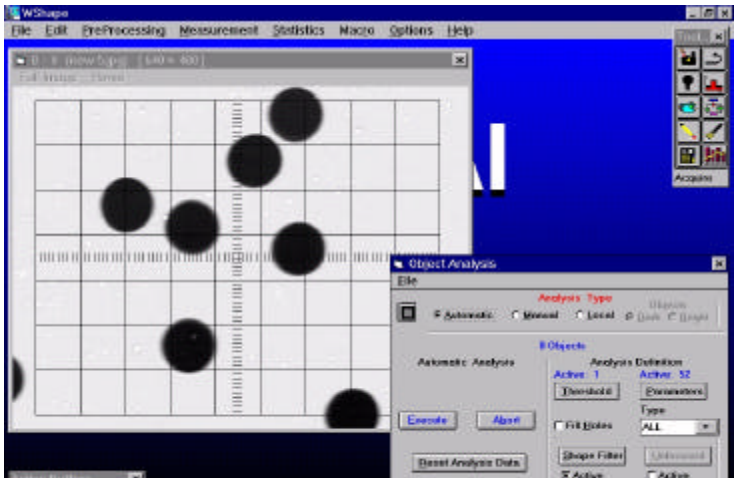
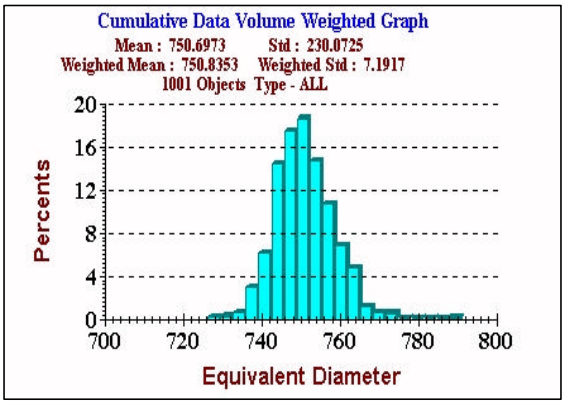


Fig. 2 – Solder Balls while being examined by the DSA-10

DSA-10 produces variety of output presentation: Tables, Graphs, as shown in the figures below:



Volume Ranges Table

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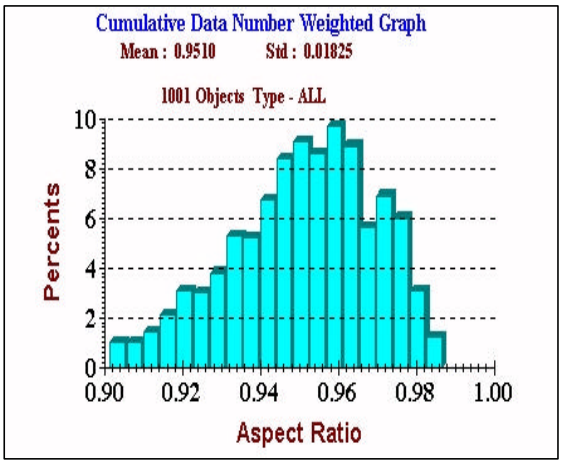
Equivalent	Local(%)	Undersize(%)	Oversize(%)
726.00 - 729.00	0.090	0.090	99.91
729.00 - 732.00	0.28	0.37	99.63
732.00 - 735.00	0.37	0.74	99.26
735.00 - 738.00	1.48	2.22	97.78
738.00 - 741.00	4.32	6.54	93.46
741.00 - 744.00	10.19	16.74	83.26
744.00 - 747.00	14.24	30.98	69.02
747.00 - 750.00	16.95	47.93	52.07
750.00 - 753.00	16.82	64.74	35.26
753.00 - 756.00	12.45	77.19	22.81
756.00 - 759.00	9.71	86.90	13.10
759.00 - 762.00	6.15	93.05	6.95
762.00 - 765.00	4.42	97.48	2.52
765.00 - 768.00	1.18	98.66	1.34
768.00 - 771.00	0.68	99.34	0.66
771.00 - 774.00	0.44	99.77	0.23
774.00 - 777.00	0.11	99.88	0.12
777.00 - 780.00	0.00	99.88	0.12
780.00 - 783.00	0.00	99.88	0.12
783.00 - 786.00	0.00	99.88	0.12
786.00 - 789.00	0.00	99.88	0.12
789.00 - 792.00	0.12	100.00	0.00

Fig. 3 - Equivalent Diameter distribution of 1000 Solder Spheres of diameter 750µm.



Number Percentage Table

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Undersize(%)	Aspect Ratio(µ)	Oversize(%)
1.00	0.91	99.00
3.00	0.91	97.00
5.00	0.92	95.00
10.00	0.92	90.00
15.00	0.93	85.00
20.00	0.93	80.00
25.00	0.94	75.00
30.00	0.94	70.00
35.00	0.95	65.00
40.00	0.95	60.00
45.00	0.95	55.00
50.00	0.95	50.00
55.00	0.96	45.00
60.00	0.96	40.00
65.00	0.96	35.00
70.00	0.96	30.00
75.00	0.96	25.00
80.00	0.97	20.00
85.00	0.97	15.00
90.00	0.97	10.00
95.00	0.98	5.00
97.00	0.98	3.00
99.00	0.98	1.00
100.00	0.99	0.00

Fig. 4 – Aspect Ratio distribution of 1000 Solder Spheres

Summary

Measurement Methodology			
	Microscope	**DSP**	**DSA-10**
1	Stationary particles	Stationary particles	Particles in dynamic flow
2	Long measuring duration.	Long measuring duration.	Fast & Automatic Analysis
3	Human dependant	Human dependant	Automatic computer control measurement
4	small sample (usually < 100 particles)	small sample (usually < 100 particles)	Shape measurements on tens of thousands of particles

References

1. Aharonson; Karasikov, N.; *J. Aerosol Science, **1986**,* 17, 530-536

2. Karasikov, N.; Krauss, M.; Barazani, G., In *Particle Size Analysis,* Lloyd, P.J Ed.; John Wiley & Sons: New York **1988.**

3. Weiner, B. B.; Tscharnuter, W. W.; and Karasikov, N.; *Improvements in Accuracy and Speed Using the Time-of-Transition Method and Dynamic Image Analysis for Particle Sizing,* Theodore Provder, American Chemical Society, **1998**