Micro SMD Wafer Level Chip Scale Package

National Semiconductor
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Introduction

Micro SMD is a wafer level CSP (WLCSP) with the following features:

1. Package size equal to die size.
2. Smallest footprint per I/O count.
3. No need for underfill material.
4. Interconnect layout at 0.5 mm pitch.
5. No interposer between the silicon IC and the printed circuit board.
6. Both Lead-free and Eutectic solder versions available.

Package Construction

Figure 1 shows typical micro SMD products. They have solder bumps located on the active side of silicon IC. The micro SMD is offered in the standard and thin version. The micro SMD manufacturing process steps include standard wafer fabrication process, wafer re-passivation, deposition of solder bumps on i/o pads, backgrinding (for thin version), application of protective encapsulation coating, testing using wafer sort platform, laser marking, singulation and packing in tape and reel. The package is assembled on PCB using standard surface mount assembly techniques (SMT).

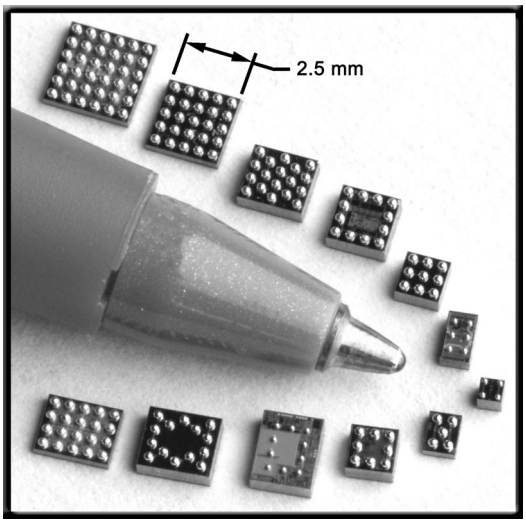

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FIGURE 1. Micro SMD 4-20 Bump

Micro SMD Package Data

Package Arrays

Bump Count	Array Outline
4	2 x 2
5	2 x 1 x 2
6	3 x 2
8	3 x 3 (perimeter)
9	3 x 3 (area)
10	4 x 3 (perimeter)
12	4 x 3 (area)
12	4 x 4 (perimeter)
14	5 x 4 (stagger perimeter)
16	4 x 4 (area)
18	5 x 4 (stagger area)
20	4 x 5 (area)
25	5 x 5 (area)
30	5 x 6 (area)
36	6 x 6 (area)

Bump Size Options

	Small bump size (0.17 mm diameter)	Large bump size (0.3 mm diameter)
I/O Count Range	4 - 9	4 - 36
Pitch (mm)	0.5	0.5
Standard Package Thickness Max. (mm)	0.95	1.05
Thin Package Thickness Nominal (mm)	0.5	0.6
Ultra-Thin Package Thickness (mm)	0.35	N/A
Bump Height (mm)	0.11 - 0.15	0.21 - 0.26
Bump Coplanarity within package (mm)	< 0.03	<0.05
Shipping Media	Tape & Reel	Tape & Reel
Moisture Sensitivity Level	Level 1	Level 1

Surface Mount Assembly Considerations

Micro SMD surface mount assembly operations include,

- Printing solder paste on PCB.
- Component placement using standard pick and place equipment.
- Solder reflow and cleaning (depending on flux type).

Advantages of micro SMD during SMT assembly include,

- Standard tape and reel shipping media eases handling issues (per EIA-481-1)
- Uses standard SMT pick and place equipment.
- Standard reflow process (both Lead-free and Eutectic compatible).

PCB Layout

Two types of land patterns are used for surface mount packages,

1. Non-solder mask defined (NSMD)
2. Solder mask defined (SMD).

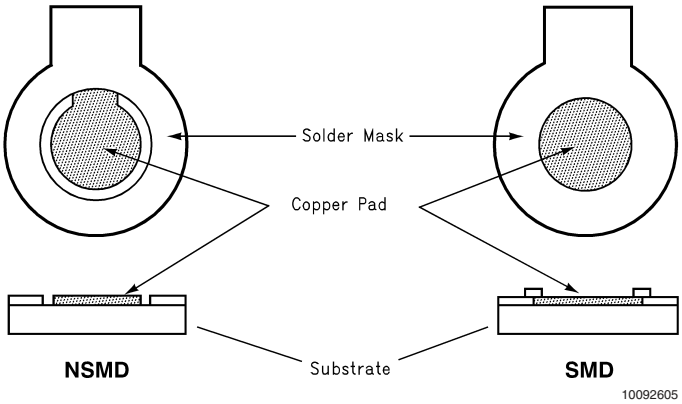

FIGURE 2. NSMD and SMD Pad Definition

1. NSMD configuration is preferred due to its tighter control on copper etch process and a reduction in the stress concentration points on the PCB side compared to SMD configuration.
2. A copper layer thickness of less than 1 oz is recommended to achieve higher stand-off. A 1 oz. (30 micron) or greater copper thickness results in a lowering of the effective stand-off, which may compromise solder joint reliability.
3. For the NSMD pad geometry, the trace width at the connection to the land pad should not exceed 2/3 of the pad diameter.

The recommended pad geometry is shown in *Table 1*.

TABLE 1. Recommended PCB Pad Geometry

	Small Bump Size (0.17 mm Diameter)		Large Bump Size (0.3 mm Diameter)	
Pad Definition	**Copper Pad**	**Solder Mask Opening**	**Copper Pad**	**Solder Mask Opening**
NSMD	0.175 +0.0/–0.025 mm	0.350 ± 0.025 mm	0.275 +0.0/–0.025 mm	0.375 ± 0.025 mm
SMD	0.350 ± 0.025 mm	0.175 ± 0.025 mm	0.375 +0.0/–0.025 mm	0.275 ± 0.025 mm

For PCB layouts employing via-in-pad structures (micro-via), NSMD pad definition should be used, since this ensures adequate wetting area on the copper pads and hence a better joint. It is recommended that the wall thickness of the microvias be a minimum of 15 microns.

Organic solderability preservative coating (OSP) as well as Ni-Gold board finish is used for internal characterization.

- For Ni-Au (electroplated Nickel, immersion Gold) gold thickness must be less than 0.5 microns to avoid solder joint embrittlement.
- The fan-out for the traces should be symmetrical across X and Y directions to avoid part rotation due to surface tension of solder.
- HASL (Hot Air Solder Leveled) board finish is not recommended.

Stencil Printing Process

- Use laser cutting followed by electro-polishing for stencil fabrication.
- The recommended stencil apertures are shown in *Table 2*.
- If possible, offset apertures from land pads to maximize separation and minimize possibility of bridging for micro SMD packages with less than 10 bump counts and using small bump size. No print offset is required for higher bump counts and larger bump size.
- Use Type 3 (25 to 45 micron particle size range) or finer solder paste for printing.

Stencil Printing Process (Continued)

TABLE 2. Recommended Stencil Apertures

	0.17 mm Diameter Solder Bump	0.3 mm Diameter Solder Bump
Recommended Stencil Aperture Size	0.3 x 0.3 mm square, 0.125 mm thick	0.25 x 0.25 mm square, 0.125 mm thick

Component Placement

Standard pick-and-place machines can be used for placing the micro SMD. Either of the following methods can be used for recognition and positioning.

1. Vision system to locate package silhouette.
2. Vision system to locate individual bumps. It is recommended that the side-lighting option on the pick and place machine's vision system be used when attempting to use a individual bump recognition approach to ensure greater clarity in bump recognition.

Other features of micro SMD placement are,

1. It is preferable to use IC placement/fine pitch placement machines over chip-shooters for better accuracy.
2. Micro SMD solder bumps self-align when placed at an offset due to selfcentering nature of solder bumps.
3. Though micro SMD can withstand a placement force of up to 1 kg for 0.5 seconds, little or no force needs to be exerted during placement. It is recommended that bumps be dipped into solder paste on PCB to greater than 20% of paste block height.

Solder Paste Reflow And Cleaning

- Micro SMD is compatible with industry standard reflow process for both Lead-free and Eutectic processes.
- Micro SMD is qualified for up to three reflow operations (260˚C peak) per J-STD-020.
- Use of Pb-free MSMD with eutectic solder paste is not recommended.

Rework

The key features for the micro SMD rework are listed below.

1. Rework procedure used is identical to the one used for most BGA and CSP packages.
2. Rework reflow process should duplicate original reflow profile used for assembly.
3. Rework system should include localized convection heating element with profiling capability, a bottom side pre-heater and a part pick and placer with image overlay.
4. A rework demo video is available from National Semiconductor at http://www.national.com/appinfo/microsmd.

Qualification

The following sections describe solder joint reliability qualification and mechanical testing results for micro SMD when mounted on FR-4 PCB. Testing included use of daisy chain components. Product reliability data is included in respective product qualification reports.

SOLDER JOINT RELIABILITY QUALIFICATION

1. TEMPERATURE CYCLING: Testing performed per IPC-SM-785 Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments. The results of this testing after following the above mentioned assembly conditions described here are shown in *Figure 3*, *Figure 4* and *Table 3*.

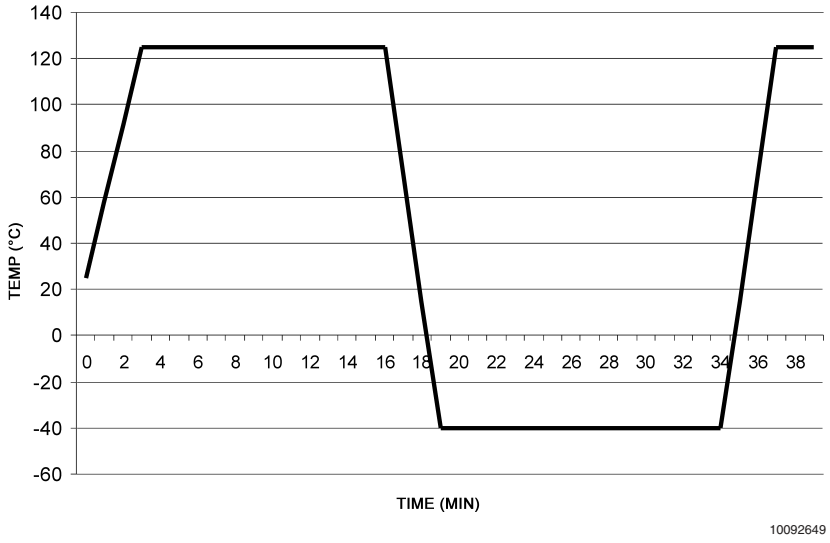

FIGURE 3. Thermal cycling profile specified for the –40 to 125˚C profile with 3 minute ramp and 14 minute hold times.

Qualification (Continued)

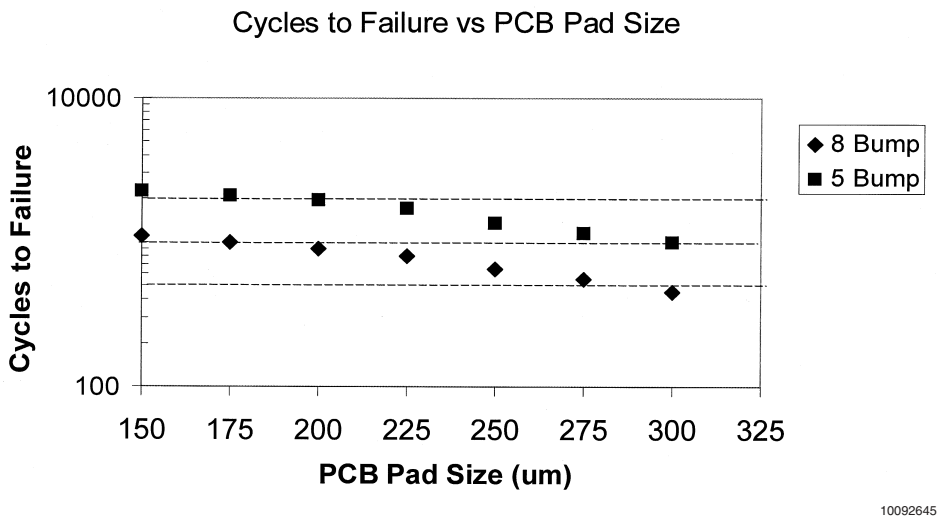

FIGURE 4. Impact of PCB Pad Size on Reliability for 0.17 mm Bump Package

TABLE 3. Temperature Cycling of Micro SMD Devices

Micro SMD Assembly	Stencil Type	Test Condition	0 cycles	284 cycles	764 cycles	1056 cycles	1152 cycles	
8 bump 0.17 mm bump diameter	0.100 mm thick 0.250 x 0.300 mm Oval aperture	–40 to 125˚C, 1 cycle/hr, 25 min dwell, 5 min transfer	0/32	0/32	0/32	4/32	5/32	
8 bump 0.17 mm bump diameter	0.125 mm thick 0.300 x 0.300 mm Square aperture		0/32	0/32	0/32	0/32	0/32	
Micro SMD Assembly	**Stencil Type**	**Test Condition**	**0 cycles**	**300 cycles**	**600 cycles**	**624 cycles**	**924 cycles**	**1224 cycles**
18 bump 0.3 mm bump diameter	0.125 mm thick 0.250 x 0.250 mm Square aperture	–40 to 125˚C, 1 cycle/hr, 15 min dwell, 15 min ramp	0/102	0/102	0/102	0/102	0/102	0/102
Micro SMD Assembly	**Stencil Type**	**Test Condition**	**0 cycles**	**500 cycles**	**600 cycles**	**700 cycles**	**800 cycles**	
36 bump 0.3 mm bump diameter	0.125 mm thick 0.250 x 0.250 mm Square aperture	–40 to 125˚C, 1 cycle/34 min, 14min dwell, 3min ramp	0/79	0/79	0/79	0/79	0/79	

Qualification (Continued)

2. PACKAGE SHEAR: As part of the manufacturing process, bump shear data is collected at package level to ensure attachment of solder ball to the package. The average package shear strength recorded was approximately 100 gm per solder joint for 0.17 mm diameter solder bump. For the 0.3 mm diameter solder bump, the package shear was greater than 200 gm per solder joint. Measured value of package shear may vary depending on materials and methods used in surface mount assembly.

3. PULL TEST: Assembled micro SMD 8 bump units were pulled vertically upward with a stud machined into the back of the component. Component was pulled till it was removed off the board. Average stud pull strength was recorded as 80 gm per solder joint for 0.17 mm diameter solder bump.

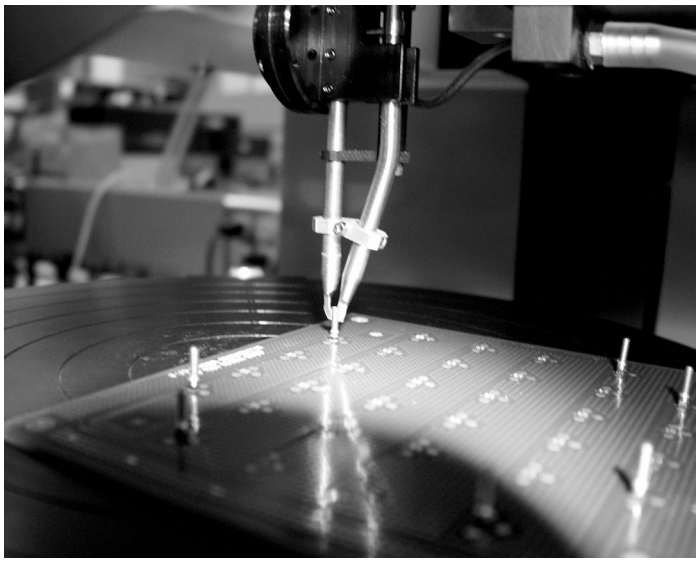

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FIGURE 5. Pull Test Carried Out on the SMD 8 Bump (0.17 mm Diameter Bump)

4. DROP TEST: Drop test results are shown in *Table 4* and *Table 5*. The tests were carried out on micro SMD 8 bump packages (0.17 mm diameter bump) and micro SMD 36 bump packages (0.3 mm diameter bump) mounted on 1.5 mm thick PCB. It included 7 drops on first edge, 7 on second edge, 8 drops on the corner and 8 drops on flat face, a total of 30 drops. An increase of 10% or more in daisy chain loop resistance was considered as a failure.

TABLE 4. Micro SMD Drop Test Results (0.17 mm Diameter Bump Package, 8 bump)

Test Results (Failures after 30 drops)				
Length		**1m**	**1.5m**	**2m**
Weight	**75 gm**	0/8	0/8	0/8
	150 gm	0/8	0/8	0/8

TABLE 5. Micro SMD Drop Test Results (0.3 mm Diameter Bump Package, 36 bump)

Test Results (Failures after 30 drops)			
Length		**1.5m**	**1.85m**
Weight	**75 gm**	0/32	0/32
	150 gm	0/32	0/32

5. THREE-POINT BEND TEST: The three-point bend test used a test board with a 100 mm span. Deflection was applied at the center at 9.45 mm/min. No solder joint failure was observed even with deflections as high as 25 mm.

Qualification (Continued)

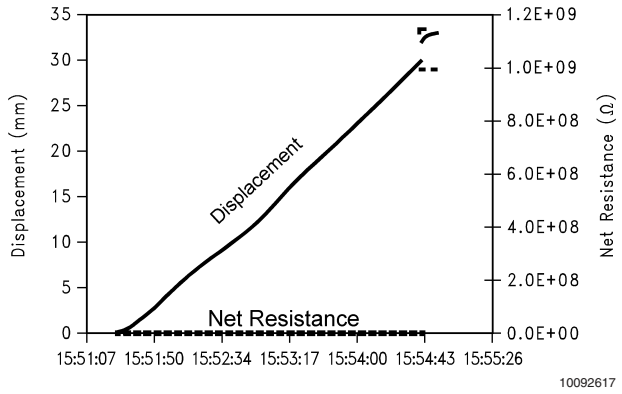

FIGURE 6. Board Deflection and Net Resistance (0.17 mm Diameter Bump Package)

Thermal Characterization

Thermal performance of micro SMD packages was assessed using low effective thermal conductivity test boards per EIA/JESD51-3. The performance of the SMD product depends on product die size and application (PCB layout and design), and the details of Theta JA values are available in product data sheets at http://www.national.com.

Micro SMD Do's and Don'ts

SMALL BUMP (0.17 mm)		
	DO's	**DON'Ts**
PCB	150 µm < Pad Dia < 200 µm	Pad Dia < 150 µm or Pad Dia > 200 µm
	Prefer non-solder mask defined (NSMD) over solder mask defined (SMD). Solder mask opening ≤ 350 µm round.	Solder mask opening > 375 µm round.
	Organic Solderability Preservative (OSP) or Ni-Au surface finish (Less than 0.5 µm Au thickness).	Greater than 0.5 µm Au thickness for Ni-Au surface finish.
		HASL (Hot Air Solder Leveled) board finish.
Stencil	300 µm x 300 µm square aperture	Less than 275 x 275 µm square aperture
		Greater than 300 µm x 300 µm square aperture
	Laser cut + electro-polished or Additive build-up	Chemical etch
	100 µm < Thickness < 125 µm	Thickness > 125 µm or < 100 µm
Solder Paste	Type 3 (25 to 45 µm particle size range)	Type 2 or Type 1
		Mix Lead-free micro SMD components with eutectic solder paste

Micro SMD Do's and Don'ts (Continued)

LARGE BUMP		
	DO's	**DON'Ts**
PCB	250 µm < Pad Dia < 275 µm	Pad Dia < 250 µm or Pad Dia > 275 µm
	Prefer non-solder mask defined (NSMD) over solder mask defined (SMD). Solder mask opening ≤ 375 µm round.	Solder mask opening > 375 µm round.
	Organic Solderability Preservative (OSP) or Ni-Au surface finish (Less than 0.5 µm Au thickness).	Greater than 0.5 µm Au thickness for Ni-Au surface finish.
		HASL (Hot Air Solder Leveled) board finish.
Stencil	250 µm x 250 µm square aperture	Less than 225 x 225 µm square aperture
		Greater than 275 µm x 275 µm square aperture
	Laser cut + electro-polished or Additive build-up	Chemical etch
	100 µm < Thickness < 125 µm	Thickness > 125 µm or Thickness < 100 µm
Solder Paste	Type 3 (25 to 45 µm particle size range)	Type 2 or Type 1
		Mix Lead-free micro SMD components with eutectic solder paste

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