Application Report
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AN-1412 Micro SMDxt Wafer Level Chip Scale Package

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ABSTRACT

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

- Package size equal to die size
- Smallest footprint per I/O count
- No need for underfill material
- Interconnect layout available in 0.4 mm or 0.5 mm pitch
- No interposer between the silicon IC and the printed circuit board

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1 Package Construction

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

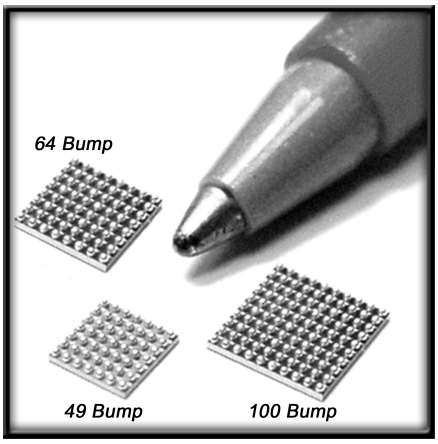

Figure 1. Micro SMDxt 49, 64 and 100 Bump

2 Micro SMDxt Package Data

Table 1. Package Arrays

Bump Count	Array Outline
36	6 x 6
42	6 x 7
49	7 x 7
56	7 x 8
64	8 x 8
80	8 x 10
81	9 x 9
100	10 x 10

Table 2. Bump Size Details

Bump Diameter (mm)	0.320	0.265
Pitch (mm)	0.5	0.4
Bump Count Range	36–100	
Package Thickness Nominal (mm)	0.65	
Bump Height Nominal (mm)	0.255	0.210
Bump Coplanarity within package (mm)	0.015	
Shipping Media	Tape & Reel	
Moisture Sensitivity Level	Level 1	

3 Surface Mount Assembly Considerations

Micro SMDxt 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 SMDxt 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

4 PCB Layout

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

- Non-solder mask defined (NSMD)
- Solder mask defined (SMD)

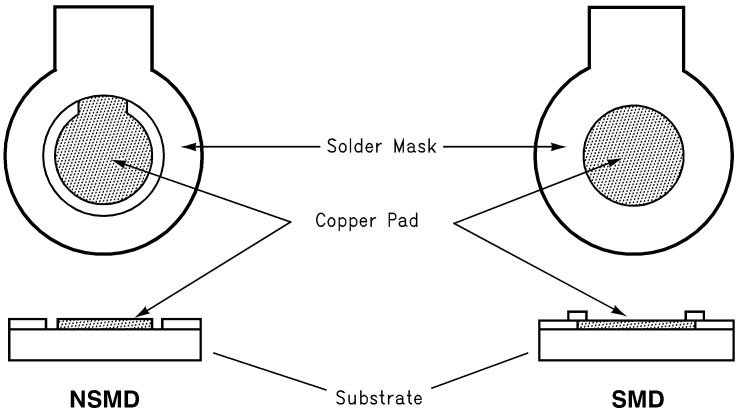

Figure 2. NSMD and SMD Pad Definition

- NSMD configuration is highly 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.
- 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.
- 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 3.

Table 3. Recommended PCB Pad Geometry

Pitch	0.5 mm		0.4 mm	
Solder Ball Size	0.32 mm Diameter		0.265 mm Diameter	
Pad Definition	Copper Pad	Solder Mask Opening	Copper Pad	Solder Mask Opening
NSMD	0.265 ± 0.02 mm	0.375 ± 0.025 mm	0.225 ± 0.02 mm	0.325 ± 0.02 mm
SMD	0.375 +0.0/−0.025 mm	0.275 ± 0.025 mm	0.325 ± 0.02 mm	0.225 ± 0.02 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. It is recommended that 'offset' vias be used when microvias are required for routing on the PCB.

Nickel-gold board finish on PCB pads is used for internal characterization.

- For Ni-Au (electroplated nickel, immersion gold) gold thickness must be less than 0.2 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.

5 Stencil Printing Process

- Use laser cutting followed by electro-polishing for stencil fabrication.
- The recommended stencil apertures are shown in Table 4.
- Use type 3 (25 to 45 micron particle size range) or finer solder paste for printing.

Table 4. Recommended Stencil Apertures

Pitch	**0.5 mm**	**0.4 mm**
Solder Ball Size	**0.32 mm Diameter**	**0.265 mm Diameter**
Recommended Stencil Aperture Size	0.275 x 0.275 mm to 0.3 x 0.3 mm square, 0.100 mm to 0.125 mm thick	0.25 X 0.25 mm square, 0.1 mm thick

6 Component Placement

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

- Vision system to locate package silhouette
- 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 better contrast for bump recognition.

Other features of micro SMDxt placement are as follows:

- It is preferable to use IC placement/fine pitch placement machines instead of chip-shooters for better accuracy.
- Although micro SMDxt 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 the printed solder paste to greater than 20% of paste block height.

7 Solder Paste Reflow and Cleaning

- Micro SMDxt is compatible with industry standard reflow process for lead-free solder composition.
- Micro SMDxt is qualified for up to four reflow operations (260°C peak) per J-STD-020.
- Use of Pb-free micro SMDxt with Sn/Pb eutectic solder paste is not recommended. Such an application can result in assemblies that will not meet desired reliability standards.

The micro SMDxt solder ball structure is engineered to maintain its shape with controlled (minimal) collapse compared to a standard solder ball. This allows significant improvement in solder joint reliability.

8 Rework

The key features for the micro SMDxt rework are listed below:

- Rework procedure used is similar to the one used for most BGA and CSP packages.
- Additional solder paste is required to be applied to either the PCB or to the component bumps prior to placement on PCB.
- Rework reflow process should duplicate original reflow profile used for assembly.
- Rework system should include localized convection heating element with profiling capability, a bottom side pre-heater and a part pick and place tool with image overlay.

9 Qualification

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

9.1 Solder Joint Reliability Qualification

9.1.1 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 and Figure 4

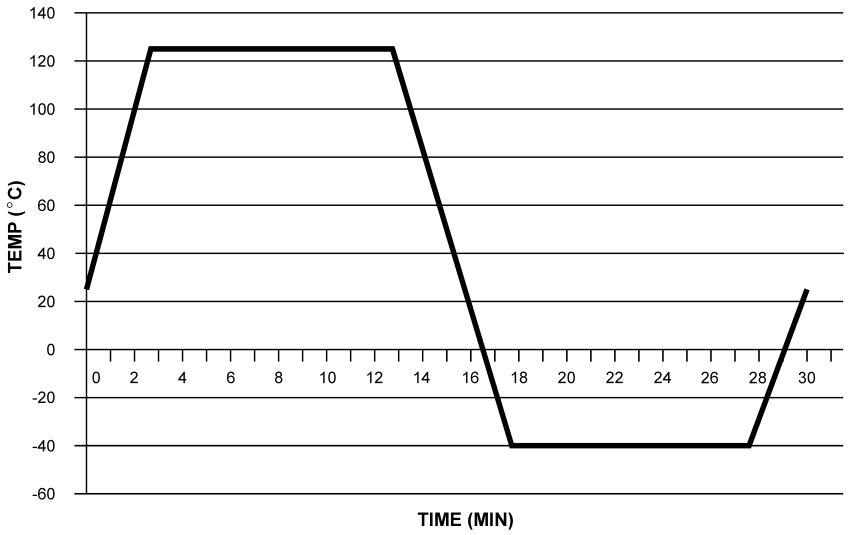

Figure 3. Thermal Cycling Profile Specified for the −40 to 125°C Profile With 5 Minute Ramp and 10 Minute Hold Times

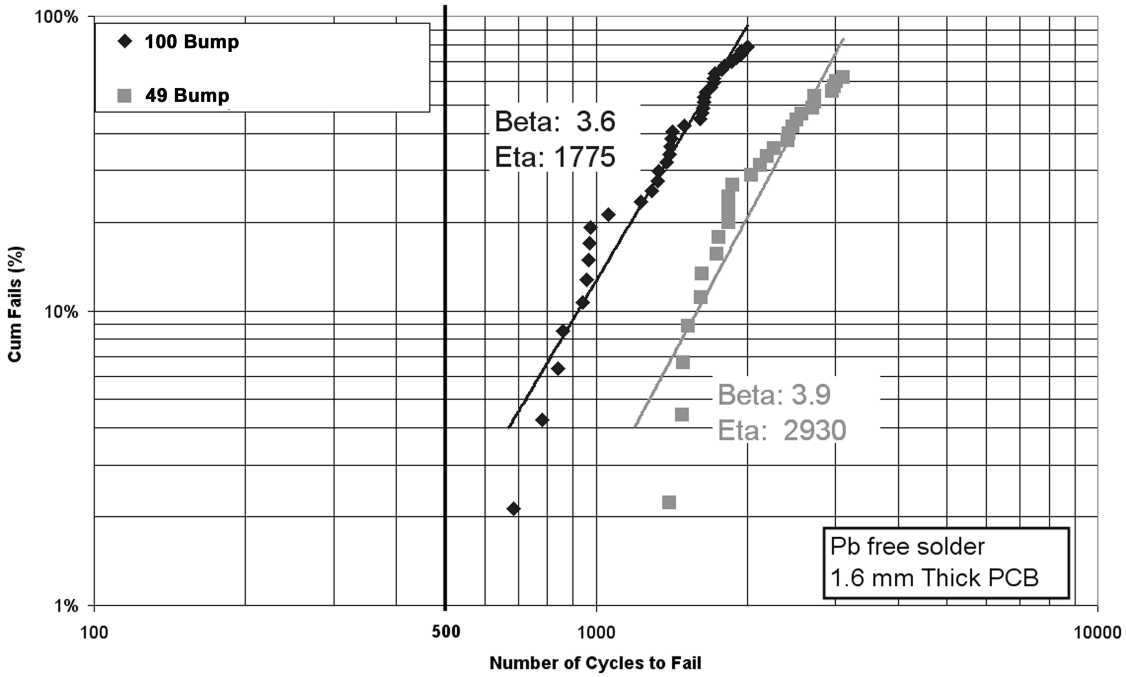

Figure 4. Weibull Plot for the 49 and 100 Bump micro SMDxt @ -40° to +125° C (14 min hold and 3 min ramp type thermal cycle)

9.1.2 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.

- 0.5 mm pitch micro SMDxt
  - 0.32 mm diameter solder bump: The package shear strength is greater than 250 g per solder joint.
- 0.4 mm pitch micro SMDxt
  - 0.265 mm diameter solder bump: The package shear strength is greater than 165 gm per solder joint.

Measured value of package shear may vary slightly depending on materials and methods used in surface mount assembly.

9.1.3 Drop Test

Drop test results are shown in Figure 5 and Figure 6. The results shown are for a 100 bump part tested in drop test per JEDEC's JESD22–B111 drop test specification. The drop test setup, board layout, fixtures and all drop criteria are per the JESD22–B111 specification. All drops are carried out 'face-down'. The peak deceleration is 1500 g for 0.5 ms (half-sine pulse). The fail criteria is 1k Ω resistance for 200 nano-seconds, recorded 4 times during 6 consecutive drops. The results show there is no significant difference between the PCB pad finish (OSP vs. ENIG) options tested.

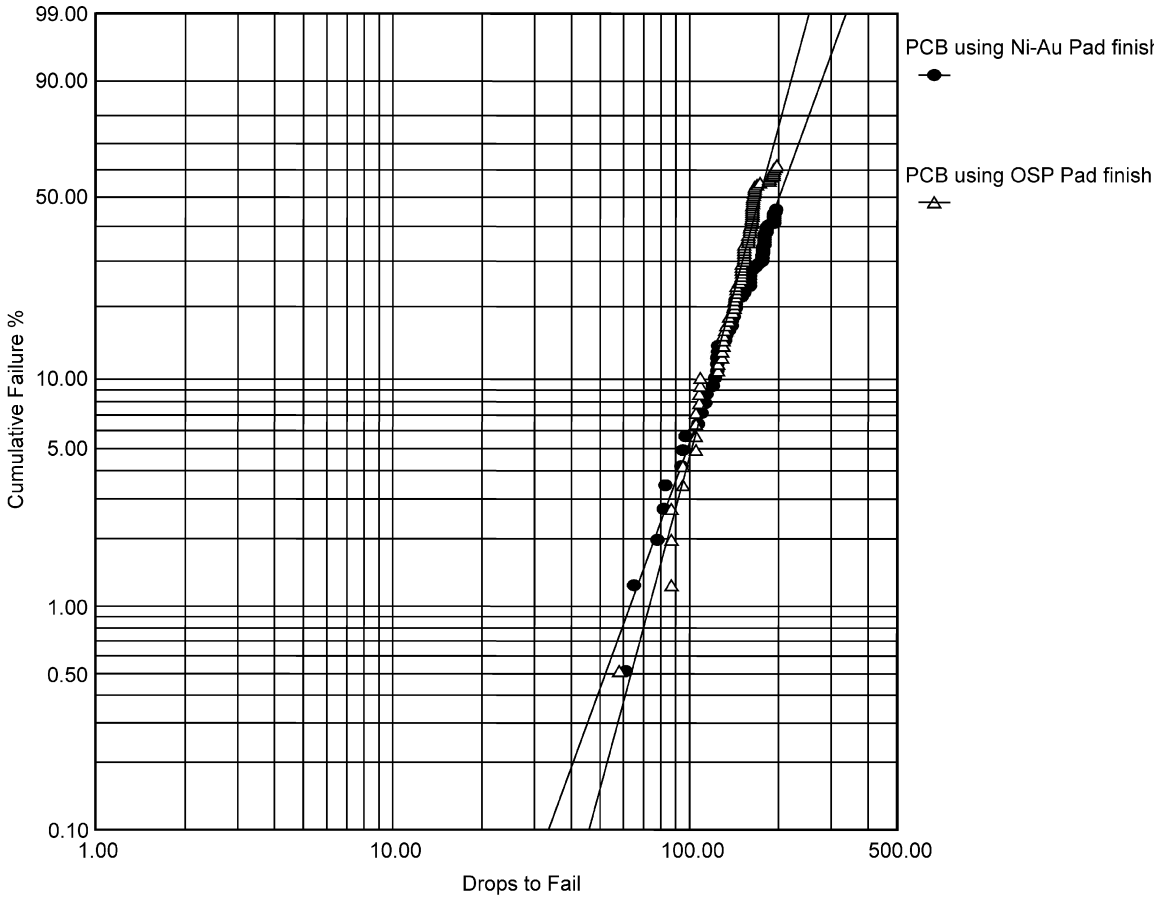

Figure 5. Weibull Plot for the 100 Bump micro SMDxt Showing Results of Drop Test per JESD22–B111

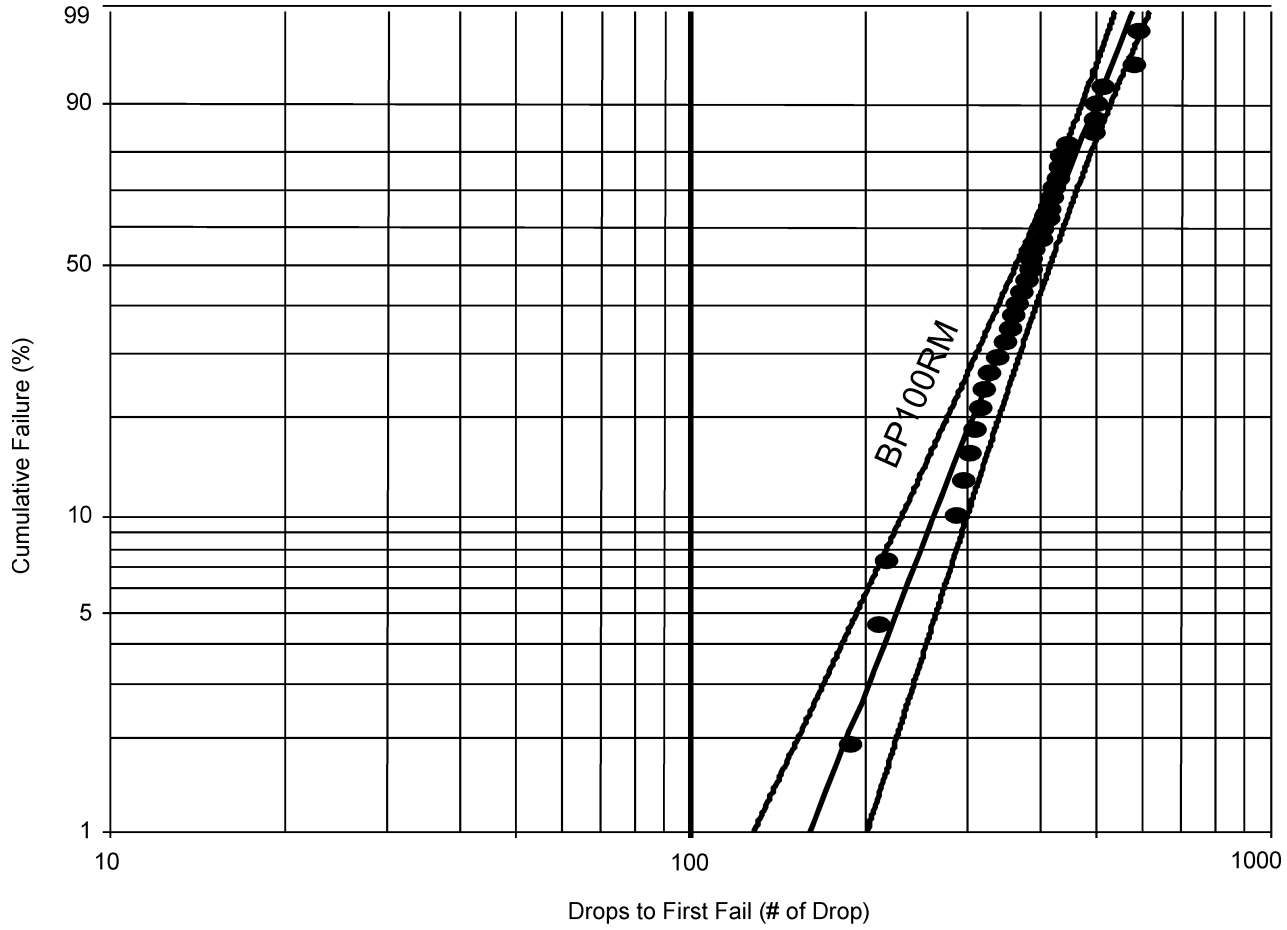

Figure 6. Weibull Plot for the 100 Bump micro SMDxt (0.4mm pitch) Showing Results of Drop Test per JESD22-B111

9.1.4 Flex Test

This is a repetitive flexing test where PCB is flexed at a preset frequency. Flex test results are shown in Table 5. An increase of 10% in resistance of network (daisy chain) is considered a failure. Figure 7 shows the setup used for the Flex test.

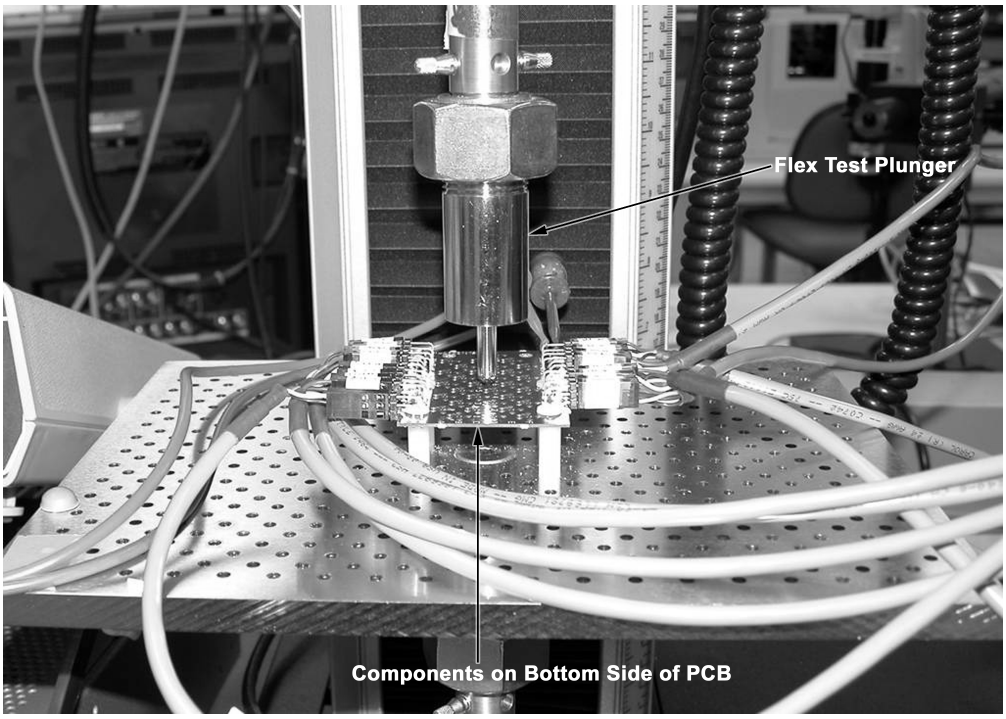

Figure 7. Test Setup for Flexural Testing

Table 5. Flex Test Results (1), (2), (3), (4), (5), (6), (7)

Package Name	Bump or Lead Size	PCB Pad Size	Cycles to First Fail (Average)
PCB Displacement: 1.00 mm			
Micro SMDxt 49 Bump (3.5 x 3.5 mm)	320 µm bump Dia	265 µm Dia	> 80000
Micro SMDxt 100 Bump (5.0 x 5.0 mm)	320 µm bump Dia	265 µm Dia	> 80000
LLP (5.0 x 5.0 mm)	200 X 400 µm Pad	200 X 600 µm	9360
PCB Displacement: 2.00 mm			
Micro SMDxt 49 Bump (3.5 x 3.5 mm)	320 µm bump Dia	265 µm Dia	5227
Micro SMDxt 100 Bump (5.0 x 5.0 mm)	320 µm bump Dia	265 µm Dia	3514
LLP (5.0 x 5.0 mm)	200 X 400um Pad	200 X 600 µm	333
PCB Displacement: 3.00 mm			
Micro SMDxt 49 Bump (3.5 x 3.5 mm)	320 µm bump Dia	265 µm Dia	2267
Micro SMDxt 100 Bump (5.0 x 5.0 mm)	320 µm bump Dia	265 µm Dia	1747
LLP (5.0 x 5.0 mm)	200 X 400 µm Pad	200 X 600 µm	31

(1) Flexing span: 50 mm
(2) PCB thickness: 0.79 mm (32 mil)
(3) Flexural frequency: 1 Hz
(4) First Fails: PCB location directly under plunger.
(5) PCB pad finish: ENIG (Electroless Ni, Immersion Gold)
(6) Test is not sensitive to PCB build-up type (RCC or ALIVH)
(7) 2 mm and 3 mm displacement are accelerated test deflection levels, not seen in a typical application.

9.1.5 Recommendations for Device Placement on PCB

It is recommended that in cases where PCB flexing is likely, the part should be placed as close to the mounting/rivet point as possible. It is also recommended that the device location be away from the area of maximum PCB flexing.

10 Thermal Characterization

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

11 Micro SMDxt Do's and Don'ts

0.5 mm Pitch micro SMDxt (0.3 mm diameter)		
	DO's	**DON'Ts**
PCB	245 µm < Pad Dia < 285 µm	Pad Dia < 245 µm or Pad Dia > 285 µm
	Prefer non-solder mask defined (NSMD) over solder mask defined (SMD). Solder mask opening ≤ 375 µm round.	Solder mask opening > 375 µm round
	Ni-Au surface finish (less than 0.2 µm Au thickness) or (Organic Solderability Preservative (OSP))	Greater than 0.2 µm Au thickness for Ni-Au surface finish.
		Hot Air Solder Leveled (HASL) board finish
Stencil	Square Aperture	Round Aperture
	275 µm x 275 µm square ≤ aperture ≤ 300 µm x 300 µm square	Aperture < 275 µm x 275 µm square Aperture > 300 µm x 300 µm square
	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 (particle size > 45 µm)
	Match solder paste alloy and assembly process with the component bumps alloy (for example, Pb-free paste and process to be used with Pb-free components).	Mix Lead-free micro SMDxt components with Sn/Pb eutectic solder paste or vice versa
0.4 mm Pitch micro SMDxt (0.265 mm diameter)		
	DO's	**DON'Ts**
PCB	205 µm < Pad Dia < 245 µm	Pad Dia < 205 µm or Pad Dia > 245 µm
	Prefer non-solder mask defined (NSMD) over solder mask defined (SMD). Solder mask opening ≤ 340 µm round.	Solder mask opening > 340 µm round
	Ni-Au surface finish (less than 0.2 µm Au thickness) or (Organic Solderability Preservative (OSP))	Greater than 0.2 µm Au thickness for Ni-Au surface finish
Stencil	250 µm x 250 µm square aperture	Hot Air Solder Leveled (HASL) board finish
	Laser cut + electro-polished or additive build-up	Less than 225 µm x 225 µm square aperture
	Thickness ≤ 100 µm	Thickness ≤ 100 µm
Solder Paste	Type 3 (25 to 45 µm particle size range)	Type 2 or Type 1 (Particle size > 45 µm)
	Match solder paste alloy and assembly process with the component bumps alloy (for example, Pb-free paste and process to be used with Pb-free components).	Mix lead-free micro SMDxt components with Sn/Pb eutectic solder paste or vice versa

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