Microfil Wafer Level Underfilled Chip Scale Package

National Semiconductor
Application Note 1279
November 2003

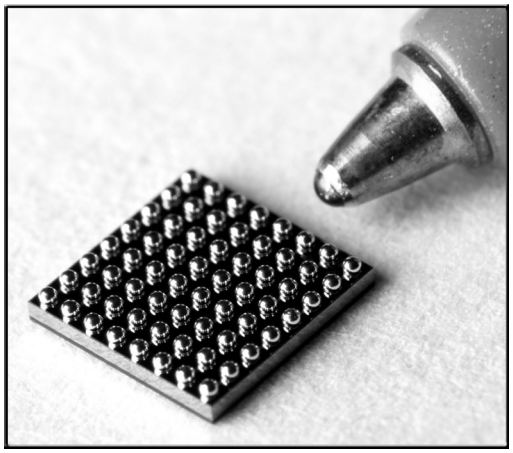
Table of Contents

Introduction 2
Package Construction 2
Microfil Package Data 2
Surface Mount Assembly Considerations 2
PCB Layout 2
Stencil Printing Process 3
Component Placement 3
Solder Paste Reflow And Cleaning 4
Rework 4
Qualification 4
SOLDER JOINT RELIABILITY QUALIFICATION 4
Thermal Characterization 5
Microfil Do's and Don'ts 5

Introduction

Microfil™ is a underfilled micro SMD, a version of wafer level CSP (WLCSP) with the following features:

1. Underfill is pre-applied at the wafer level.
2. Assembled similar to any standard WLCSP package in SMT assembly, for eg. like micro SMD.
3. No time-consuming underfill step required after SMT assembly.
4. Underfill fillet formation occurs simultaneously with reflow during SMT assembly.
5. Smallest footprint on PCB per I/O count.
6. Higher I/O counts (up to 64) than all typical WLCSP.
7. These packages can be reworked.



20069046

FIGURE 1. Microfil 64 Bump

Package Construction

Figure 1 shows a typical Microfil product. It has solder bumps located on the active side of silicon IC. It also has a pre-applied layer of epoxy which covers part of the bumps. The Microfil is manufactured similar to existing micro SMD devices with the additional step of underfill application after the solder bump deposition operation. These devices are shipped in standard tape and reel packaging. The package is assembled on PCB using standard surface mount assembly techniques (SMT).

Other Characteristics

- Bump size: 0.3 mm diameter
- I/O Count Range: 36 to 64
- Pitch (mm): 0.5
- Package Thickness Max. (mm): 0.675
- Bump Height (mm): 0.21 - 0.26
- Bump Coplanarity within package (mm): < 0.03
- Shipping Media: Tape & Reel

Microfil Package Data

Examples of Package Arrays Available

Bump Count	Array Outline
36	6 x 6 (area)
48	6 x 8 (area)
64	8 x 8 (area)

Surface Mount Assembly Considerations

Microfil surface mount assembly operations include,

- Printing solder paste on PCB.
- Component placement using standard pick and place equipment.
- Solder reflow.

Advantages of Microfil 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.

PCB Layout

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

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

PCB Layout (Continued)

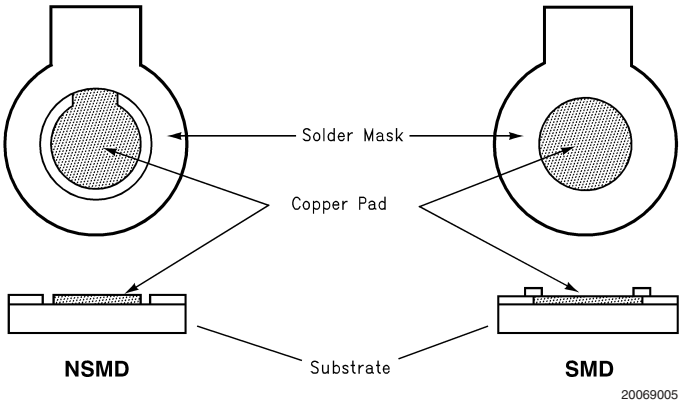


FIGURE 2. NSMD and SMD Pad Definition

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 pad 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. Recommended PCB Pad Geometry*.

TABLE 1. Recommended PCB Pad Geometry

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

Organic solderability preservative coating (OSP) as well as Ni-Gold board finish was 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 cannot be used with these devices.

Stencil Printing Process

- Use laser cutting followed by electro-polishing for stencil fabrication.
- The recommended stencil apertures are shown in *Table 2. Recommended Stencil Apertures*.
- Use Type 3 (25 to 45 micron particle size range) or finer solder paste for printing.

TABLE 2. Recommended Stencil Apertures

	0.3 mm Diameter Solder Bump
Recommended Stencil Aperture Size	0.25 mm round, 0.125 mm thick

Component Placement

Standard pick-and-place machines can be used for placing the Microfil packages. 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 (slower and more expensive).

Other features of Microfil placement are,

1. It is preferable to use IC placement/fine pitch placement machines over chip-shooters for better accuracy.
2. Microfil solder bumps self-align when placed at an offset due to the self-centering nature of solder bumps.

Component Placement (Continued)

3. Though Microfil 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

- Microfil is compatible with industry standard reflow process.
- Microfil is qualified for up to three reflow operations (235˚C peak) per J-STD-020.

Rework

The key features for the Microfil 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. Care should be taken to remove all underfill (turns into cleanable material during rework) from the site on PCB.

Qualification

The following sections describe solder joint reliability qualification results. During mechanical testing it was noted that the Microfil performed significantly better than equivalent non-underfilled WLCSP packages.

Testing included use of daisy chain as well as functional device units mounted on FR-4 boards. Product/functional device reliability data is included in respective product qualification reports.

SOLDER JOINT RELIABILITY QUALIFICATION

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 are shown in *Figure 3* and *Table 3. Temperature Cycling of Microfil Devices*.

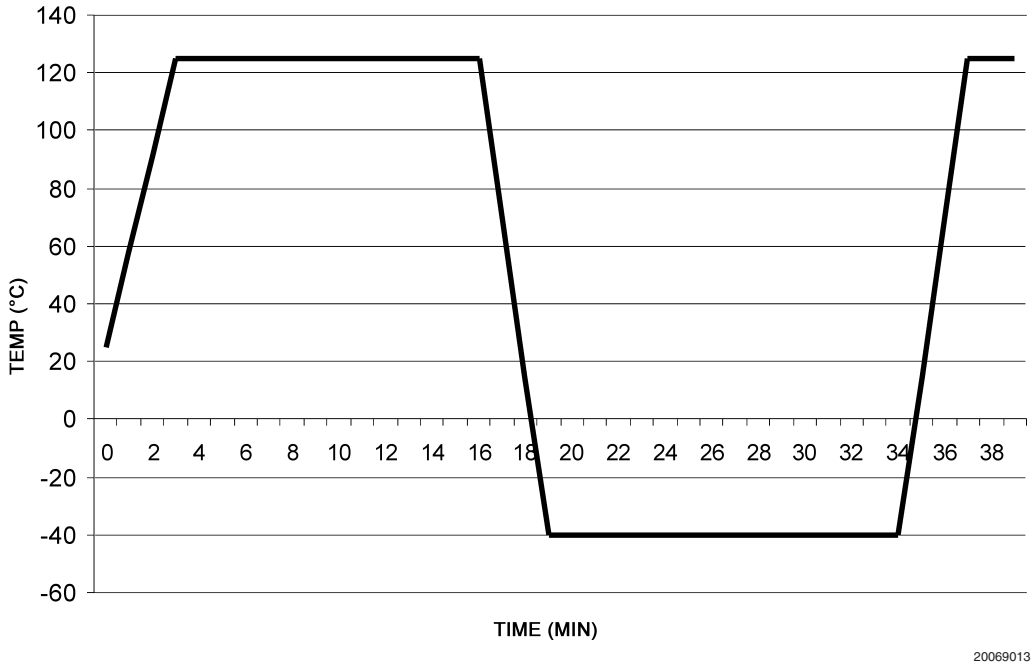


FIGURE 3. Thermal cycling profile specified for the –40 to 125˚C profile with 3 minute ramp and 14 minute hold times

TABLE 3. Temperature Cycling of Microfil Devices

Microfil Assembly	Stencil Type	Test Condition	0 cycles	500 cycles	750 cycles	1000 cycles	1250 cycles
36 Bump	0.125mm thick, 0.250x0.250 mm Sq. Aperture	–40 to 125˚C, 34min cycle, 14min dwell, 3 min ramp; Pass: 500cyc	0/78	0/78	0/78	7/78	12/78
Microfil Assembly	**Stencil Type**	**Test Condition**	**0 cycles**	**500 cycles**	**580 cycles**	**710 cycles** (Note 1)	**1065 cycles** (Note 1)

Qualification (Continued)

TABLE 3. Temperature Cycling of Microfil Devices (Continued)

Microfil Assembly	Stencil Type	Test Condition	0 cycles	500 cycles	750 cycles	1000 cycles	1250 cycles
64 Bump	0.125mm thick, 0.250x0.250 mm Sq. Aperture	–40 to 125˚C, 34min cycle, 14min dwell, 3 min ramp; Pass: 500cyc	0/48	0/48	1/48	2/48	24/48
Micro SMD (Control)	**Stencil Type**	**Test Condition**	**0 cycles**	**500 cycles**	**600 cycles**	**700 cycles**	**800 cycles**
36 Bump	0.125mm thick, 0.250x0.250 mm Sq. Aperture	–40 to 125˚C, 34min cycle, 14min dwell, 3 min ramp; Pass: 500cyc	0/80	0/80	43/80	63/80	73/80

Note 1: Time-points between 710 and 1065 not included to avoid extraneous detail.

PACKAGE SHEAR: As part of the manufacturing and qualification process, package assembly bump shear data is collected to ensure attachment of solder joints to the package and to the PCB.

In the case of assembled Microfil package, available package shear equipment was unable to shear the assembled package off the PCB. Maximum force of 15kg shear applied could not remove a 64 bump package off the PCB.

For typical WLCSP (non-underfilled) with bump diameter of 0.3mm, the average pacakge shear strength recorded was greater than 200 gm per solder joint.

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

Thermal Characterization

Thermal performance of Microfil packages was assessed (with simulation and thermal modeling) using low effective thermal conductivity test boards per EIA/JESD51-3. The performance of the product depends on product die size and application (PCB layout and design). In general the thermal performance was comparable to equivalent WLCSP without underfill applied. Details of Theta JA values are available in product data sheets at http://www.national.com .

Microfil Do's and Don'ts

0.3 mm BUMP DIAMETER		
	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 200 x 200 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 Pb-free MSMD components with eutectic solder paste

Notes

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no ''Banned Substances'' as defined in CSP-9-111S2.

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560