Assembly of Chip-Scale Packages

For Sensirion SHTxx Humidity and Temperature Sensors

Preface

Due to their small size, Sensirion chip-scale packages (CSP) provide the benefit of using a minimum of space in applications while still being compatible with standard SMD assembly processes. However, the assembly of packages with small-pitch solder balls poses somewhat higher requirements on handling and assembly processes. This document gives customers guidance in all aspects of handling and assembly of Sensirion CSP devices.

Introduction

This document gives guidance for the assembly of Sensirion chip-scale packages. Sensirion CSP are bare-die components, lacking any kind of substrate, leadframe or molded package (as used e.g. for BGA or QFN packages), thereby offering the best possible form factor.

Chip-scale packages provide the advantage of minimal size and thus enable applications with very limited space budgets. Due to their small size, they may pose a higher challenge in terms of handling and the assembly process than larger SMD packages.

Substrate

Substrate Material

For applications with large range in operating temperature and/or extreme thermal cycling conditions, high temperature substrates with lower CTE (Coefficient of Thermal Expansion) are preferable over standard substrate materials (e.g. standard FR4), in order to reduce thermo-mechanical stress on the interconnects between substrate and CSP.

Recommended surface finish for land pads:

- Electroless Nickel, Immersion Gold (ENIG)
- Organic Solderability Preservative (OSP)

Land Pad Design

Please refer to IPC-7351B (Generic Requirements for Surface Mount Design and Land Pattern Standard) for land pattern design.

NSMD (non-solder-mask-defined) pads are recommended for Sensirion CSP devices. Design recommendations:

- round pads, the diameter of the pad shall be 70% to 80% of the ball diameter in order to ensure maximum stand-off height.
- connecting trace width max 60% of land pad diameter
- maximum one signal trace per land pad
- foot-print with symmetrical layout (for improved self-alignment)

Recommended land pattern designs for specific products can be found in the product data sheets.

Solder Mask

- recommended between all pads
- solder mask clearance to pad (NSMD) 50µm to 75µm

Assembly Process

To facilitate a capable assembly process, the substrate shall be clean and solder pads shall not be (excessively) oxidized (any remaining oxidation must be removed through activation of the flux).

Stencil Design

Stencils for solder paste printing should be designed according to IPC-7525 Stencil Design Guidelines.

Design recommendations:

- Laser cut stencils with electro-polish, or electroformed stencils
- Trapezoidal apertures (larger on bottom side, for improved paste release)
- Stencil thickness of 75µm to 100µm
- Square aperture openings with rounded corners (for improved paste release)

Solder paste recommendations:

- Type 4, **no-clean** solder paste
- SAC alloy (tin/silver/copper, named for the elemental symbols Sn/Ag/Cu).

It is strongly recommended to use **no-clean type solder paste/flux** for the assembly of Sensirion CSP devices. Cleaning liquids trapped in the gap between the CSP and the substrate may lead to reliability problems. More importantly, cleaning solvents/agents may affect the

integrity of the humidity sensor element, possibly affecting the performance of the humidity sensor.

Automated Solder Paste Inspection (SPI) is recommended to effectively monitor process performance, enabling an optimal soldering performance.

Pick&Place Process

To prevent surface damages and transfer of particles into the sensor opening, it is important to use clean vacuum nozzles.

Nozzle height and force need to be well controlled to prevent mechanical damage to the CSP device. There must be no impact force on the CSP during pick-up or placement. Furthermore, the dwell force after placement must be controlled to ensure that all balls are sufficiently engulfed in the solder paste.

The capability for self-alignment of the CSP during the reflow process strongly depends on the quality of the complete process. With a capable soldering process, a standard SMT pick & place equipment with effective placement accuracy of 50µm at 3σ (or better) should be sufficiently accurate for the assembly of Sensirion CSP devices.

Vision systems with solder ball recognition generally achieve better alignment than systems only recognizing and aligning to the package outline.

Reflow Soldering

For soldering Sensirion CSP devices, standard reflow soldering ovens may be used. Sensirion CSP devices are compatible with soldering profiles according to IPC/JEDEC J-STD-020 with peak temperatures at 260°C during up to 30sec for Pb-free assembly in IR/Convection reflow ovens (see Figure 1).

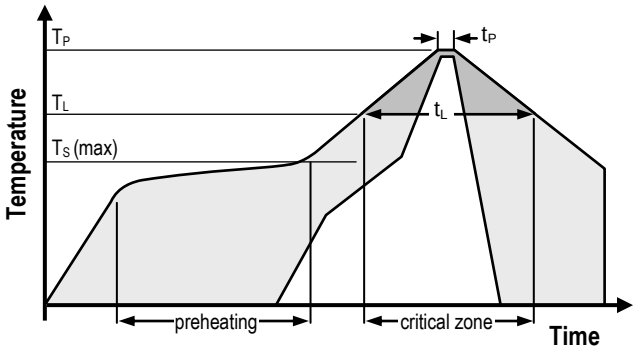

Figure 1 Soldering profile according to JEDEC standard. T_P <= 260°C and t_P < 30sec for Pb-free assembly. T_L < 220°C and t_L < 150sec. Ramp-up/down speeds shall be < 5°C/sec.

The IPC/JEDEC J-STD-020 standard only defines the maximum temperature profile. The actual temperature profile must be adjusted to provide a good soldering result on the actual assembly. The effective temperature is dependent on thermal load of the assembly on the reflow oven. Profile recommendations by the manufacturer of the solder paste/flux should also be considered.

Sensirion CSP devices are qualified to withstand up to 3 solder cycles for Pb-free assembly in IR/convection reflow ovens according IPC/JEDEC J-STD-020.

To allow good solder wetting and formation of solder bumps, Nitrogen (N_2) purge during reflow soldering is strongly recommended (target oxygen levels <1000 ppm).

A good reflow soldering process will allow the original solder balls on the CSP to 'collapse' and even, spherical solder bumps to be formed, completely engulfing the land pad, creating strong solder joints, leading to neither opens nor shorts.

Only the solder bumps shall be in contact with the board. A sufficient positive clearance must remain between any area/edge/corner of the CSP and the board (which includes the solder mask). In case of insufficient clearance between the CSP body and the board, any bending/warping stress on the board may be transferred directly onto the CSP body with may induce die chipping or cracks.

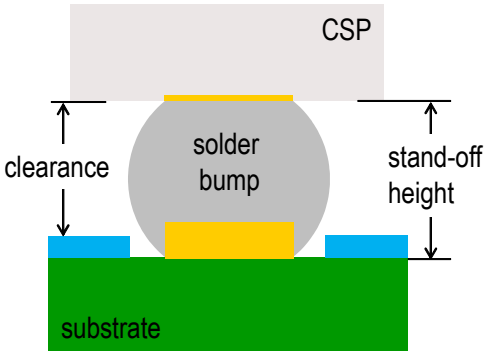

Figure 2 Collapsed solder bump after reflow.

Immediately after the exposure to high temperatures the humidity sensor may read a negative humidity offset (typ. -1 to -2 %RH after reflow soldering). This offset slowly disappears again when the sensor is exposed to ambient conditions (typ. within 1-2 days). If relative humidity testing is performed immediately after reflow soldering, this offset should be considered when defining the test limits.

Rework

As the rework process may affect the integrity of the humidity sensor, rework or especially re-use of Sensirion CSP devices is strictly not recommended. In case rework is inevitable, the following procedure is recommended:

1. Heat up the board from the back-side of the substrate to a temperature well below $T_{liquidus}$ (e.g. 150°C) preferably.
2. Locally heat up the package from the back-side of the substrate to a temperature at which the solder melts.

Grab the package and shear or twist it away from the board.

Note: Once removed from a board, the re-use of humidity sensors is not recommended. A removed sensor shall be replaced by a new one.

3. Clean up the land pads on the substrate.
4. Deposit solder paste on the land pads and carefully align a new component onto the land pads (visual alignment system recommended).
5. Solder the part in compliance with the Pb-free solder profile according J-STD-020.

Underfill

Sensirion CSP are fully qualified without underfill. This implies that from a product reliability point of view, underfill is not required.

It is up to the customer to judge whether underfill is needed from a system/application reliability point of view and select an appropriate underfill material.

If the customer decides to use underfill, it is recommended to apply and cure the underfill material under well ventilated conditions to prevent polluting the sensor.

Any underfill material or bleed (or any other material) entering into the sensor cavity may permanently damage the sensor. As a process control criterion, it is recommended not to allow any material to be dispensed or to flow onto the top surface of the sensor package.

To prevent chipping or die crack to the sensor, any mechanical impact of the dispense tool must be prevented. Jet dispensing is recommended and preferred over needle dispensing process, as it reduces mechanical risks to the sensor and allows to better control small dispense volumes.

General

It is strongly recommended to fully evaluate and qualify all materials and process choices prior to starting production.

Revision History

Date	Version	Page(s)	Changes
16. January 2015	1	all	Initial release

Headquarters and Subsidiaries

SENSIRION AG
Laubisruetistr. 50
CH-8712 Staefa ZH
Switzerland

phone: +41 44 306 40 00
fax: +41 44 306 40 30
info@sensirion.com
www.sensirion.com

Sensirion AG (Germany)
phone: +41 44 927 11 66
info@sensirion.com
www.sensirion.com

Sensirion Inc., USA
phone: +1 805 409 4900
info_us@sensirion.com
www.sensirion.com

Sensirion Japan Co. Ltd.
phone: +81 3 3444 4940
info@sensirion.co.jp
www.sensirion.co.jp

Sensirion Korea Co. Ltd.
phone: +82 31 345 0031 3
info@sensirion.co.kr
www.sensirion.co.kr

Sensirion China Co. Ltd.
phone: +86 755 8252 1501
info@sensirion.com.cn
www.sensirion.com.cn

To find your local representative, please visit www.sensirion.com/contact