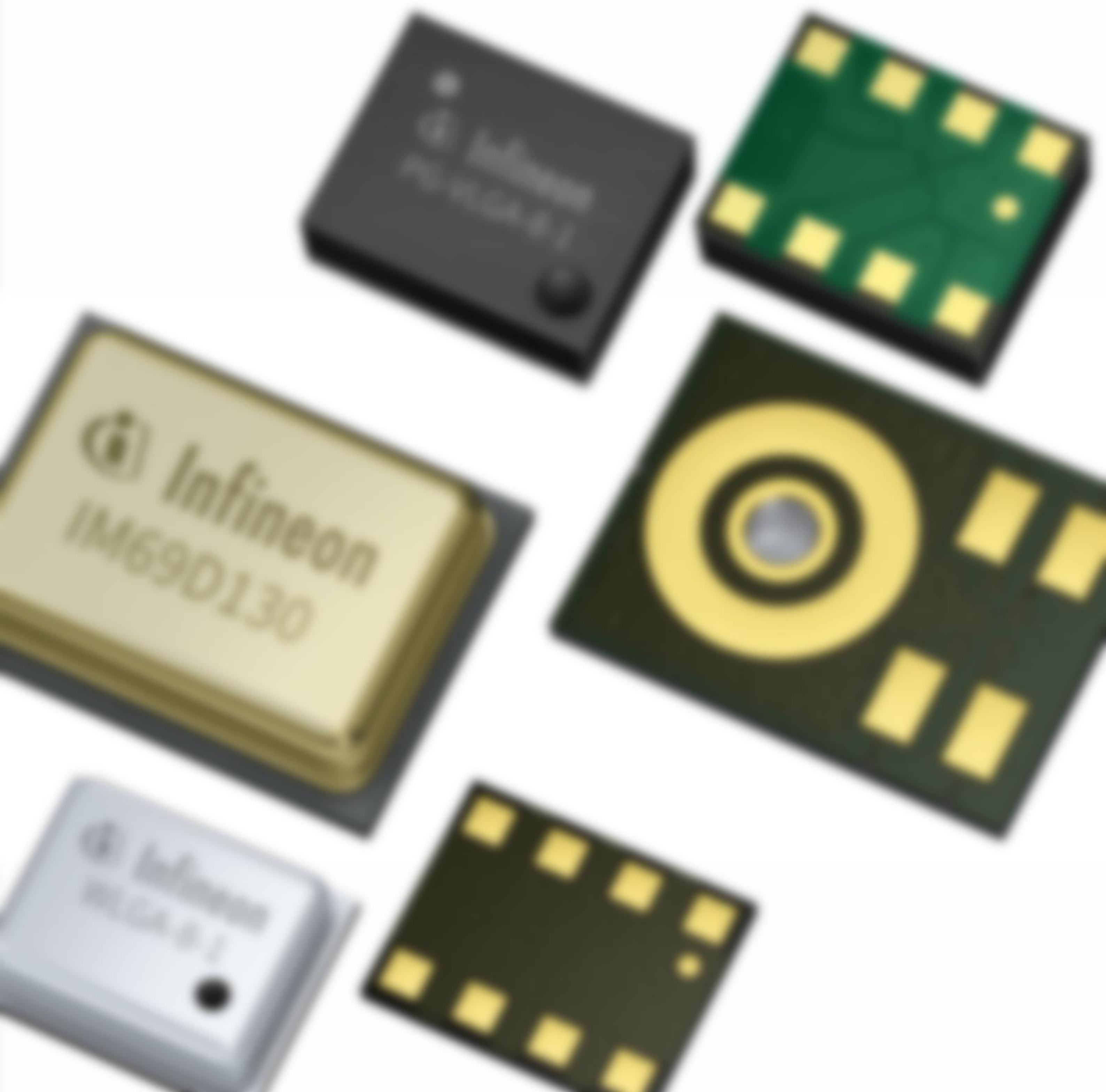
Recommendations for Board Assembly of Infineon MEMS Packages with open Sensor Ports and Bottom-Only Terminations



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Acronyms and Abbreviations

ASIC	Application-Specific Integrated Circuit
ESD	Electrostatic Discharge
LLGA	Low-Profile Land Grid Array package
MEMS	Micro-Electro-Mechanical Systems
MSL	Moisture-Sensitivity Level
NSMD	Non-Solder-Mask-Defined pad
PG	Plastic Green
PCB	Printed Circuit Board
SMD	Solder-Mask-Defined pad
SAC	Tin-Silver-Copper alloy solder
VLGA	Very thin profile Land Grid Array
WLGA	Very, Very thin profile Land Grid Array

1 Package Description

This application note provides information about the board assembly of Micro-Electro-Mechanical System (MEMS) sensor packages with open sensor ports in the package body and with bottom-only termination. Special attention is given to avoiding damage via open sensor ports during handling and Printed Circuit Board (PCB) assembly.

1.1 Package Type with Top Port Hole

Packages with their port hole on top can feature a plastic mold top such as the Very Thin profile Land Grid Array (VLGA) components or can feature a metal top such as the Very, Very Thin profile Land Grid Array (WLGA) components. **Figure 1** shows examples of this package family.

- PG-VLGA packages
- PG-WLGA packages

PG = Plastic Green
V = Very thin profile
W = Very, Very thin profile
LGA = Land Grid Array

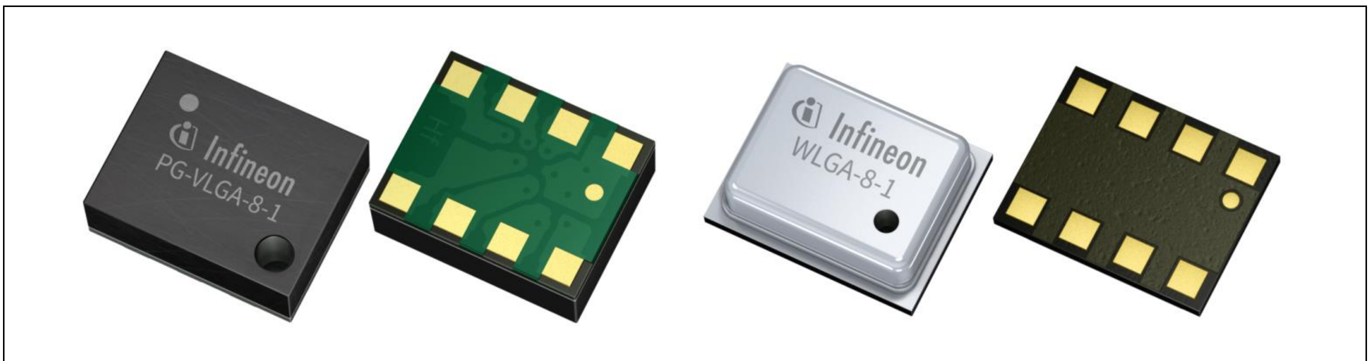

Figure 1 Examples of a VLGA and a WLGA MEMS package with a sensor port in the package body top.

1.2 Package Type with Bottom Port Hole

Low-Profile Land Grid Array (LLGA) components include variants with the open sensor port situated in the landing area of the package. **Figure 2** shows examples of this package family.

- PG-LLGA packages

PG = Plastic Green
L = Low-Profile
LGA = Land Grid Array

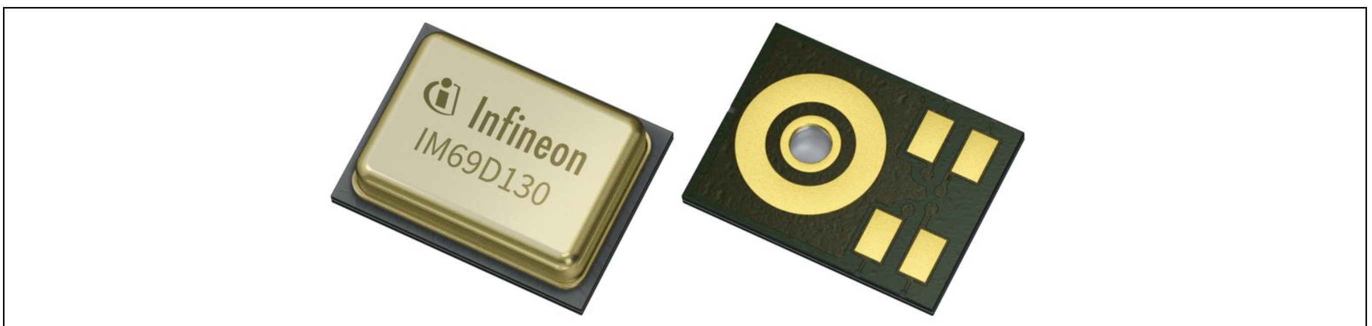

Figure 2 Example of a LLGA MEMS packages with sensor port in the landing area.

1.3 Package Features and General Handling Guidelines

Infineon Technologies MEMS packages can contain an acoustic sensor or a pressure sensor. The signal is directed through a port hole in either the package top (VLGA) or bottom (LLGA). **Figure 3** and **Figure 4** show schematics of the two different package configurations. Packages can be built up featuring metal covers or mold compound. Besides the MEMS chip, an Application Specific Integrated Circuit (ASIC) and patented or proprietary Electrostatic Discharge (ESD) protection circuitry is included in the Infineon Technologies MEMS components.

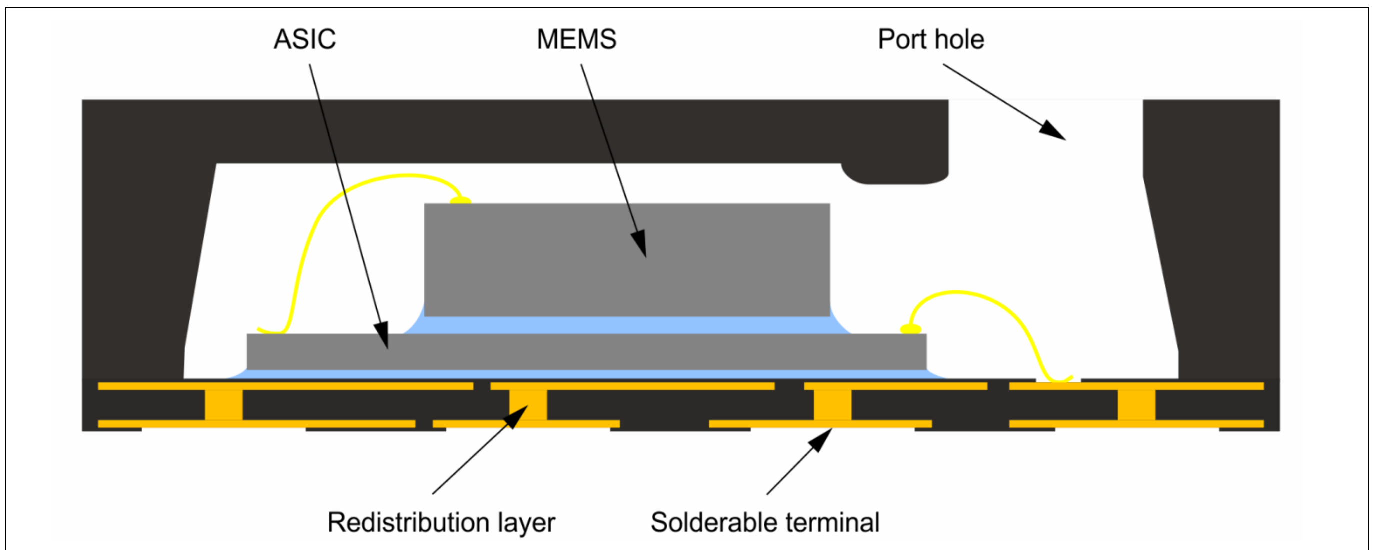

Figure 3 **Schematic showing the inner setup of a MEMS package with port hole in the package body top side.**

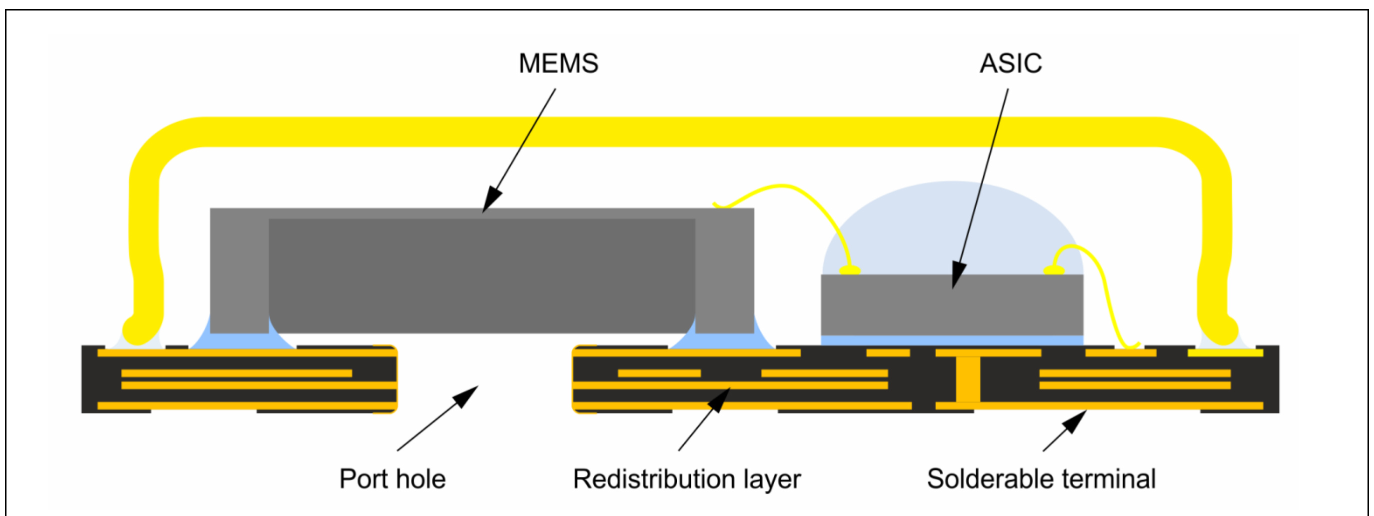

Figure 4 **Schematic showing the inner setup of a MEMS package with port hole in the package landing area.**

Package Description

Infineon Technologies MEMS packages can be handled using standard industry pick-and-place equipment and processes. However, since the sensors can have sensitive membranes, care should be taken to avoid damage to the MEMS structure by following the guidelines outlined below.

ESD and Radiation Precautions

- Notwithstanding the potential presence of protection circuitry, damage may occur on devices subjected to high-energy electrostatic discharge. Since charged devices and circuit boards can discharge without detection, proper ESD precautions should be taken during transport, storage, handling, and processing to avoid performance degradation or loss of functionality.
- The devices should not be exposed to X-ray radiation higher than 1 Gray, as this can deteriorate the performance of the MEMS.

For further information about ESD protective measures, please refer to the *General Recommendations for Assembly of Infineon Packages* document that is available on the Infineon Technologies web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

Package Handling Precautions

- Do not use excessive force to place the component on the PCB. The use of standard industry pick-and-place tools is recommended in order to limit the mechanical force exerted on the package.
- Do not pick the component with vacuum tools which make contact with the signal hole.

Precautions against Sensor Damage

- The signal port hole should not be exposed to vacuum; this can destroy or damage the MEMS reducing its performance.
- Do not blow air into the package signal port hole. If an air-blowing cleaning process is used, the signal port hole must be sealed to prevent particle ingress.
- The MEMS membrane is sensitive to particle contamination that can enter through the signal port hole of the package. In order to avoid deteriorated MEMS performance due to particle contamination, it is recommended to seal the port hole during the PCB assembly. PCB assembly in a clean-room environment (class 100k or better) can also be beneficial.
- If the MEMS component will be operating in a harsh environment (e.g. dust, salt), the port hole should be covered by common approaches (e.g. with polymer mesh). Protective tape should be placed on the signal port hole of the system level PCB directly after the component mounting, to prevent particle ingress during PCB sawing and system assembly.

Special Precautions for Packages with their Sensor Port in the Solderable Landing Area

- Sensor packages with the sensor port situated in their solderable landing area are especially prone to port contaminations e.g. by evaporating flux chemicals.
- The reflow profile should be optimized to avoid excessive flux or solder spattering.
- Special attention should be given to the PCB, footprint, and stencil design.

2 Printed Circuit Board Design

The Non-Solder-Mask-Defined (NSMD) design is recommended based on board assembly tests. Solder-Mask-Defined (SMD) pad designs can be beneficial for packages with large ground pads in order to allow for the connection of large conductor areas below the solder mask. However, depending on the specific pad width, the solder mask can have a negative impact on the print. Generally, mixing both solder mask designs in one footprint is not recommended. **Figure 5** shows two examples with NSMD pads depending on the specific package footprint.

The final open pad size on the PCB should be slightly increased compared to the pads on the component circumferentially so that the solder can form a lightly frustum-shaped joint. For individual design optimizations or adaptations, the specific design rules of the board manufacturer should be considered. Besides the footprint and stencil design, the type and quality of specific board finish has a notable impact on the solder wetting behavior. In every case, application-specific tests and experiments are recommended.

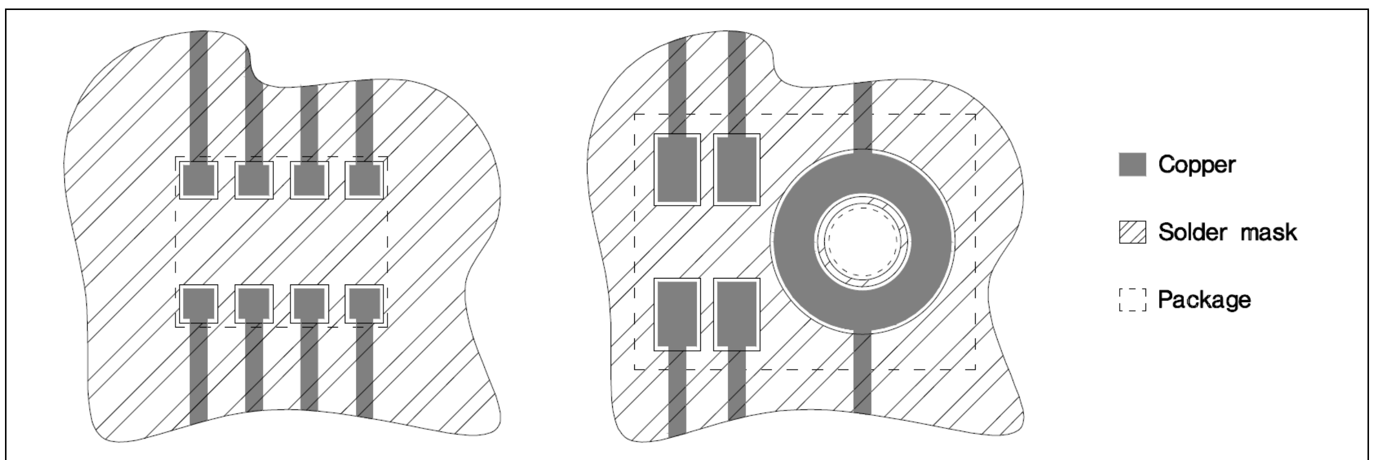

Figure 5 Examples of two non-solder mask defined pad designs.

MEMS components whose sensor port is situated in the landing area of the package will require a signal port hole through the PCB. The diameter of the PCB hole should be larger than the signal port hole diameter of the component to ensure optimal performance. In the specific case of PG-LLGA-4-1 and PG-LLGA-5-1 MEMS microphone packages, a PCB sound port hole diameter of 0.8 mm is recommended.

Further details and specific footprint recommendations can be found in Infineon Technologies package data that is available on the Infineon Technologies web page [1]. Please choose a specific package when you are searching the data base, which will then show you an example of the stencil aperture layout for each package.

For further information about PCB pad design, please refer to the *General Recommendations for Assembly of Infineon Packages* document that is available on the Infineon Technologies web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

3 PCB assembly

The MEMS membrane is sensitive to particle contamination that can enter through the signal port hole of the package. In order to avoid deteriorated MEMS performance due to particle contamination, it can be beneficial to perform the PCB assembly in a clean room environment (class 100k or better). Sealing the port hole during the PCB assembly (e.g. by polymer mesh) is also recommended. In case the latter solution is chosen, the protective tape should be placed on the signal port hole of the system level PCB after the reflow step, to prevent particle ingress during PCB sawing and system assembly.

3.1 Solder Paste Stencil

The board assembly of packages with asymmetric footprints can lead to slight component tilt. An obvious tilt may have a negative impact on the signal which is transferred to the sensor in a package with a bottom sensor port hole. In order to reduce this tilt, a uniform distribution of solder per wettable area is recommended. Therefore, the stencil transfer can be stabilized by using rounded stencil aperture outlines and by using similar aperture dimensions for each footprint structure.

Figure 6 shows an example of stencil optimization by harmonizing the apertures both for the print on pads as well as on a ring. The similar length and width of the apertures ensure a similar stencil transfer while the radii stabilize it. The component tilt can be reduced by using comparable solder volume per wettable surface for the pads and the ring.

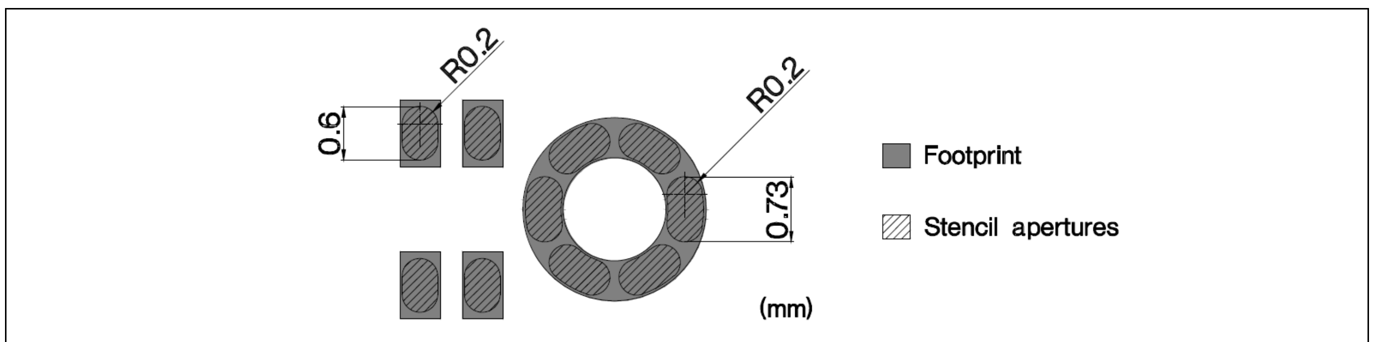

Figure 6 Example of stencil optimization by harmonizing the apertures for the print on pads as well as on a ring.

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For further information about stencil design, please refer to the *General Recommendations for Assembly of Infineon Packages* document that is available on the Infineon Technologies web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

3.2 Solder Paste

Pb-free solder pastes typically contain some type of SnAgCu alloy (SAC solder with typically 1-4% Ag and <1% Cu). The most common alloy is SAC305 (3.0 % Ag and 0.5 % Cu). The average alloy particle size must be suitable for printing the solder stencil aperture dimensions. The usage of paste type 4 or of higher type is recommended for the assembly of the packages discussed in this document.

The solder alloy particles are dispersed in a blend of liquid flux and chemical additives (approx. 50% by volume or 10% by weight) forming a creamy paste. The flux and chemical solvents have various functions such as adjusting the viscosity of the paste for stencil printing or cleaning the surface to remove organic

contaminations and oxides. The solvents have to evaporate during reflow soldering while residues of the flux will remain on the joint. The capacity for removing oxides by the flux additive is given by its activation level which also conditions the potential need for removing the flux residuals after the assembly. For MEMS packages with open signal ports, the use of a so called "no-clean" paste is highly recommended to avoid subsequent cleaning steps.

Note: A "no-clean" paste is recommended for the assembly of the MEMS Microphone to avoid subsequent cleaning steps.

Solder paste is sensitive to age, temperature, and humidity. Please follow the handling recommendations of the paste manufacturer.

3.3 Component Placement

The use of standard industry pick-and-place equipment is recommended in order to limit the mechanical force applied to the package as well as to allow for accurate placement. Such machinery typically uses vacuum tools to pick the components. It is imperative that the tool nozzle does not make contact with the signal port of the component since this can destroy or damage the MEMS reducing its performance.

Note: Do not use excessive force to place the component on the PCB.

Note: Do not pick the component with vacuum tools which make contact with the signal hole.

The placement accuracy of common standard industry pick-and-place equipment is provided by special vision systems allowing for a placement tolerance of less than ±50 µm. The self-centering effect by the liquid solder surface tension during reflow will then level the position of the component to its center depending on PCB tolerances.

For further information about factors influencing component placement please, refer to the *General Recommendations for Assembly of Infineon Packages* document that is available on the Infineon Technologies web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

3.4 Reflow Soldering

Reflow soldering in a forced convection oven is recommended for PCB assembly of the MEMS sensors.

The soldering profile should be in accordance with the recommendations of the solder paste manufacturer to reach an optimal solder joint-quality. Sensor packages with the sensor port situated in their solderable landing areas are especially prone to port contamination (e.g. by evaporating flux). Therefore, it is recommended to optimize the reflow profile to avoid excessive flux or solder spattering.

The lower temperatures and durations of an optimal reflow profile shall stay above those of the solderability qualification. The solderability of the terminals of Infineon Technologies components is tested according to the standards IEC 60068-2-58 and J-STD-002 [2][3].

The maximum temperatures and durations shall not exceed the Moisture-Sensitivity Level (MSL) classifications. Components which are MSL classified by Infineon Technologies have been tested by three reflow runs in accordance with the J-STD-020 standard considering a double sided reflow and one rework cycle. Please refer to the product barcode label on the packing material which states this maximum reflow temperature according to the J-STD-020 [4] standard as well as the MSL according to the J-STD-033 standard [5].

For further information about reflow soldering, please refer to the *General Recommendations for Assembly of Infineon Packages* document that is available on the Infineon Technologies web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

4 Cleaning

The MEMS membrane is sensitive to mechanical impact, and to particle or fluid contamination that can enter through the signal port hole of the package. Generally, the port must be protected during any cleaning step. The introduction of cleaning steps into the mounting process can also be prevented; e.g. by using a no-clean solder paste during board assembly. Furthermore, a protective tape should be placed on the signal port hole of the system level PCB directly after the component mounting, to prevent particle ingress during PCB singulation (e.g. PCB panel sawing) system assembly.

Note: The MEMS membrane can be damaged if subjected to cleaning processes.

In case washing the assembled PCB and/or conducting any other cleaning or surface treatment is inevitable, it must be ensured that no contaminants do enter the MEMS sensor signal port hole. After the soldering process, some flux residues can be found around the solder joints or spreading over the whole PCB. Generally, a "no-clean" paste is recommended for the assembly of the MEMS packages with open sensor port since the residues usually do not have to be removed after the soldering process.

Ultrasonic cleaning procedures shall not be applied to the MEMS membrane due to high risk of negative mechanical impact on the inner structures.

Do not blow air into the package signal port hole. If an air-blowing cleaning process is used, the signal port hole must be sealed to prevent pressure and particle ingress.

For further information about the special cleaning precautions for Infineon Technologies MEMS packages with open sensor ports, please contact your local sales, application, or quality engineer.

5 Inspection

The specific footprint design of the LLGA packages featuring a closed ring requires special attention when it comes to solder joint integrity. An open solder ring poses the risk of a deteriorated acoustic path. The PCB footprint and the stencil design as well as the type and quality of the specific board finish have a notable impact on the solder joint integrity. Since the terminals are based on a bottom-only approach, X-ray inspection of the solder joint would be the natural choice. **Figure 7** and **Figure 8** show two examples of properly soldered MEMS microphone packages.

Microphone devices should not be exposed to X-ray radiation higher than 1 Gray, as this can deteriorate their performance.

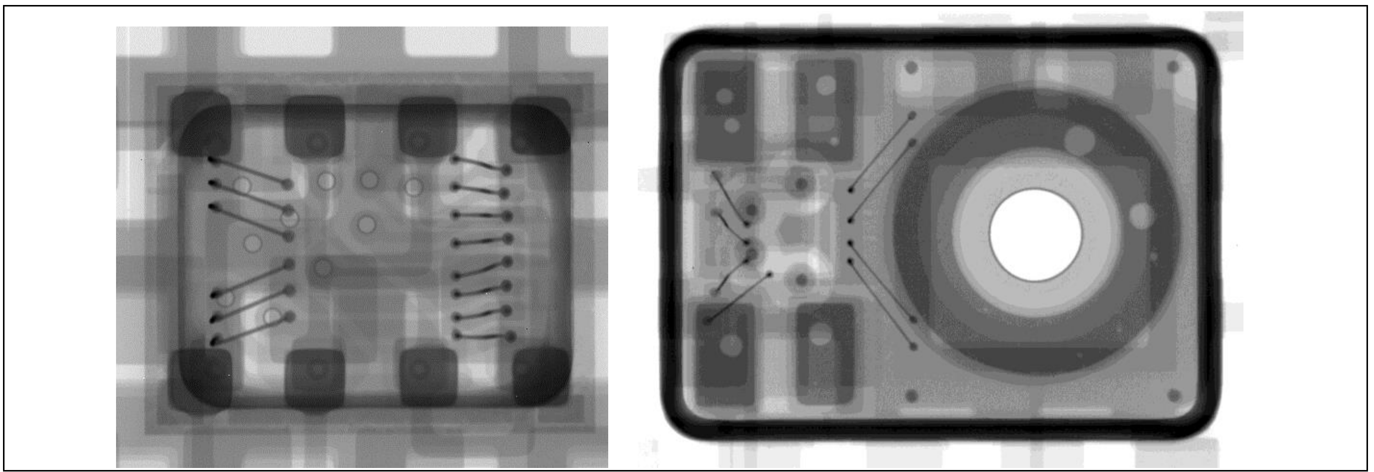

Figure 7 Examples of properly soldered MEMS packages inspected by X-Ray.

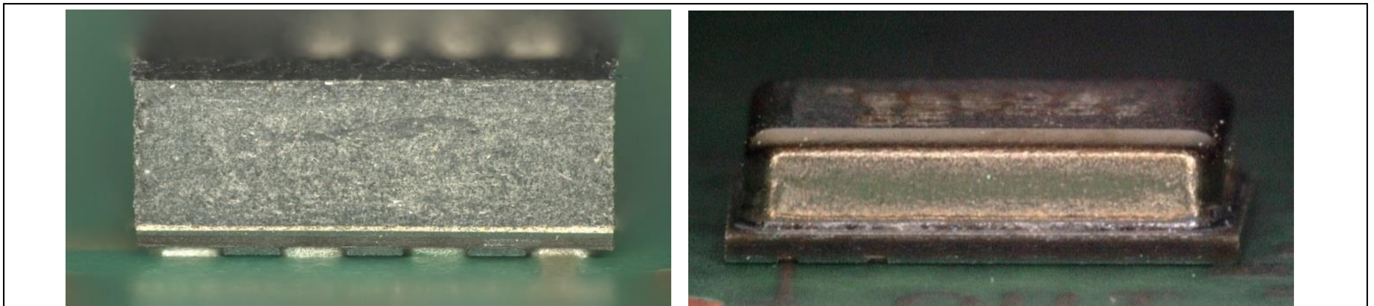

Figure 8 Examples of properly soldered MEMS packages inspected by optical microscope.

For further information about the on-board inspection of Infineon Technologies MEMS packages with open sensor ports please contact your local sales, application, or quality engineer.

6 Rework

Single solder-joint repair of bottom-only terminated packages is highly difficult, if not impossible, and is therefore generally not recommended. Furthermore, the reuse of desoldered components is not recommended. The desoldered components should be replaced by new ones.

A rework process is commonly done on special rework equipment. There are various systems available which meet the requirements for reworking SMD packages. All handling guidelines previously discussed in this document have to be considered. Due to the decreased automation level given by the general rework approach, even higher care must be taken compared to standard assembly. Use tools that do not damage the component mechanically. Please note that excessive mechanical forces not necessarily do cause visible external damage, but can cause internal damage which reduces the component's reliability.

Generally, in all steps of the rework process, the special sensitivity of the MEMS device through the package sensor port must be considered. This especially applies to the mechanical handling of the component and the increased risk of sensor port contamination. During rework, special care must also be taken concerning the proper moisture level of the component according to the J-STD-033 [5]. Whatever heating system is used (hot air, infrared, hot plate, etc.), it has to be ensured that the applied temperature profile at the component never exceeds the maximum temperature according to the J-STD-020 [4]. Depending on the specific heating concept during rework, components adjacent to the mounting location might also experience a further “reflow run” in terms of the J-STD-020 standard.

In case a component is suspected to be defective and a failure analysis is planned, the component should not be removed from the PCB. The entire PCB with components should be sent to Infineon Technologies. This guarantees that no further defects are introduced to the component, which may hinder the failure analysis or even make it impossible.

Note: For failure analysis at Infineon Technologies the entire PCB must be shipped in order to avoid damage during a component removal from the board.

For further information about component rework on PCB, please refer to the *General Recommendations for Assembly of Infineon Packages* document that is available on the Infineon Technologies web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

References

[1] Infineon Technologies: Packages. www.infineon.com\packages.

[2] International Electrotechnical Commission: IEC 60068-2-58. Environmental testing - Part 2-58: Tests - Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD).

[3] Electronic Components Industry Association, Assembly and Joining Processes and JEDEC Solid State Technology Association Committee: EIA/IPC/JEDEC J-STD-002. Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires.

[4] JEDEC Solid State Technology Association: IPC/JEDEC J-STD-020. Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices.

[5] JEDEC Solid State Technology Association: IPC/JEDEC J-STD-033. Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices.

Revision History

Major changes since the last revision

Page or Reference	Description of change
Section 1	Update of packages

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Document reference

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