Recommendations for board assembly of Infineon pressure sensor packages for automotive applications

About this document

Scope and purpose

This document provides additional information on the surface board mounting of Infineon devices with the package types of DSOSP, DSOF, and DFN.

Intended audience

This document addresses all users that are handling the pad and stencil design, the board mounting or the rework of the herein discussed Infineon devices.

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Acronyms and abbreviations

AOI	automated optical inspection
ASIC	application-specific integrated circuit
AXI	automated x-ray inspection
DFN	dual flat no-lead
DSOF	dual small outline flat lead
DSOSP	dual small outline sensor pressure
ESD	electrostatic discharge
LGA	land grid array
LTI	lead tip inspection
MEMS	micro-electro-mechanical system
MSL	moisture-sensitivity level
Ni/Au	nickel/gold
NSMD	non-solder mask defined
PG	plastic green
PCB	printed circuit board
SAB	side crash detection
SAC	tin silver copper (SnAgCu)
SMD	solder mask defined
SMD	surface-mount device
SMT	surface-mount technology
SPI	solder paste inspection
TPMS	tire pressure monitoring system

1 Package description

This document provides information about the surface mount technology (SMT) board assembly of automotive pressure sensor packages with open pressure port. Special attention is given to the pick-and-place during printed circuit board (PCB) assembly. The packages discussed here are of a leadframe based cavity type with a centrally arranged, wire bonded micro-electro-mechanical system (MEMS) chip.

This document does not discuss MEMS sensor packages with open signal port and land grid array (LGA) terminations. These package families are described in a separate document.

1.1 Gullwing lead package type

The dual small outline sensor pressure (DSOSP) package is designed as a part of tire pressure monitoring system (TPMS). The component has a lead frame based cavity package with gullwing leads. The package body features a pressure port opening where air can enter and stimulate the sensor chip. This pressure port is located at the top of the package. **Figure 1** shows an example image of this package type.

- PG-DSOSP packages

PG = plastic green
DSO = dual small outline
SP = sensor pressure

Figure 1 Example of DSOSP pressure sensor package with gullwing leads.

1.2 Flat lead package type

The dual small outline flat lead (DSOF) package is designed for pressure sensors such as in side crash detection applications (SAB). It features a MEMS sensor that is protected by an embedding gel to increase the overall product robustness. The flat terminations provide sufficient protrusion for optimal solder joint formation. Depending on the specific product the package can have different lid configurations in terms of singal port hole number and size. **Figure 2** shows an example image of this package type.

- PG-DSOF packages

PG = plastic green
DSO = dual small outline
F = flat lead

Figure 2 Example of DSOF pressure sensor package with flat leads.

1.3 No-lead package type

The dual flat no-lead (DFN) package is designed as a space-efficient solution for pressure sensors such as in SAB applications. It features a MEMS sensor below a lid with port holes. The chip is protected by an embedding gel to increase the overall product robustness. As a non-leaded package the solder joints are mainly formed underneath the component body. The terminations provide a lead tip inspection (LTI) capability by wettable termination tips. An automated optical inspection (AOI) of the solder joint connection is possible by checking the solder fillet that forms at the termination tips. **Figure 3** shows an example of this package type.

- PG-DFN packages

PG = plastic green
DFN = dual flat no-lead

Figure 3 No-lead DFN pressure sensor package with LTI features.

1.4 Package features and general handling guidelines

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 electrostatic discharge (ESD) precautions should be taken during transport, storage, handling, and processing to avoid performance degradation or loss of functionality.
- The pressure sensor components in DSOF and DFN packages should not be exposed to excessive x-ray radiation as this can deteriorate the device performance. As a general rule < 6 Gray, (2 gray for single shot, 6 gray for multiple shots, max. 3 times inspection)

For further information about ESD protective measures, please refer to the *General recommendations for board 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

It is generally recommended to avoid particle ingress through the sensor port hole during handling and board assembly. Whenever necessary the package should be protected from particle sources in an appropriate way. Furthermore, the following guidelines should be applied when handling DSOF and DFN packaged products:

- Care should be taken during handling to avoid damage to the gel and lid.
- The gel can be damaged due to access through the pressure port in the lid.
- The lid can be damaged by bending with excessive push/pull forces. Pull forces > 1 N should be avoided.

Maximum reflow conditions

The maximum temperatures from the product barcode label must not be exceeded during board assembly. Especially DSOSP packaged products are limited to a maximum reflow temperature of 250°C due to the construction of the package.

For further information about specific package handling, please contact your local Infineon sales, application, or quality engineer.

Internal construction

The here discussed Infineon pressure sensor packages are leadframe based with e.g. cavity type package. The centrally arranged, wire bonded chip may be protected by an embedding gel that increases the overall product robustness.

The chip in the DSOSP package is positioned on the bottom side of the reverse bent die paddle. The pressure port is accessible from the package top side A schematic of the DSOSP package can be seen in **Figure 4**.

The lid of the DSOF pressure sensor package is fixed within a socket exposing a distinct package rim. The lid can have different configurations in terms of pressure port number and size depending on the specific product. The flat lead terminations are formed from the leadframe and are bent inside the package mold body. A large portion of the wettable lead protrudes over the package edge. **Figure 5** shows a schematic of a DSOF pressure sensor package.

The lid of the DFN pressure sensor sits on top of the package rim. The no-lead terminations are directly formed underneath the package body with only a slight protrusion over the package outline. **Figure 6** shows a schematic of a DFN pressure sensor package.

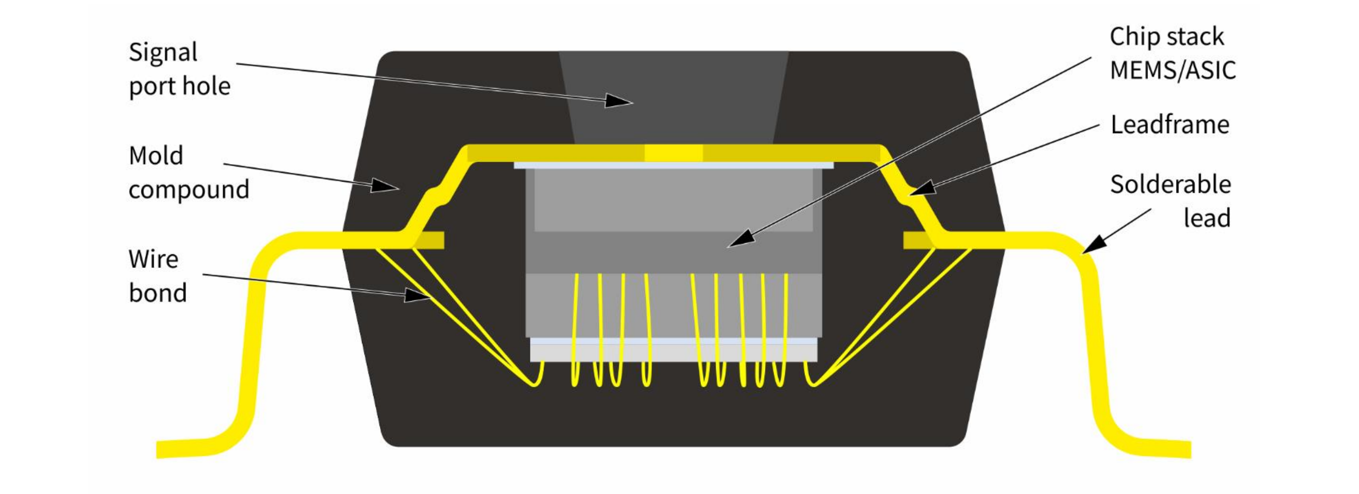

Figure 4 **Schematic showing the inner setup of a DSOSP pressures sensor package with gullwing lead terminations.**

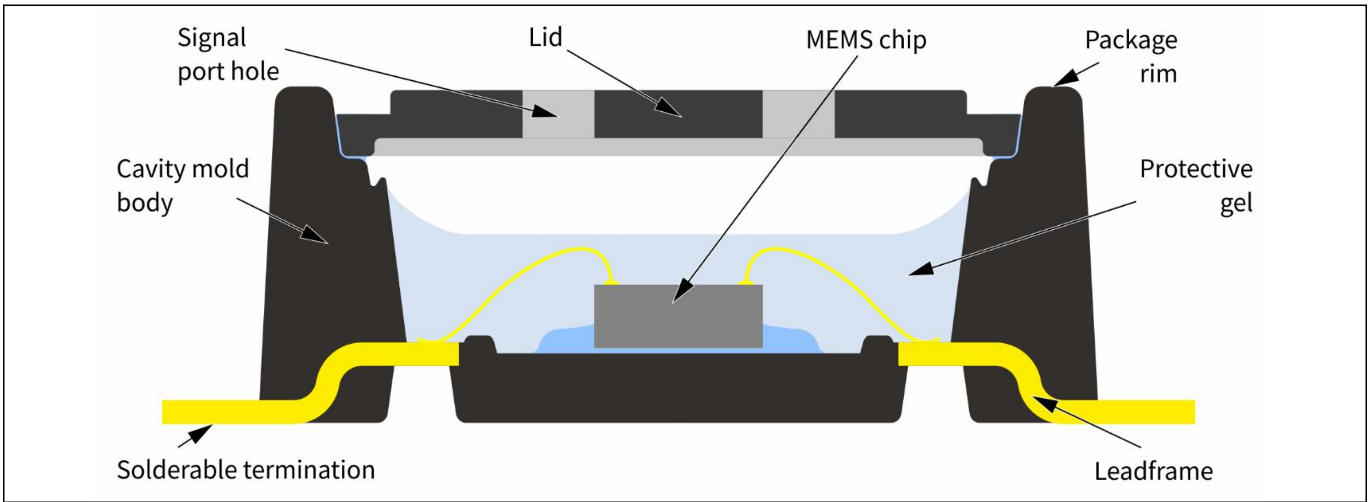

Figure 5 **Schematic showing the inner setup of a DSOF pressures sensor package with flat lead terminations.**

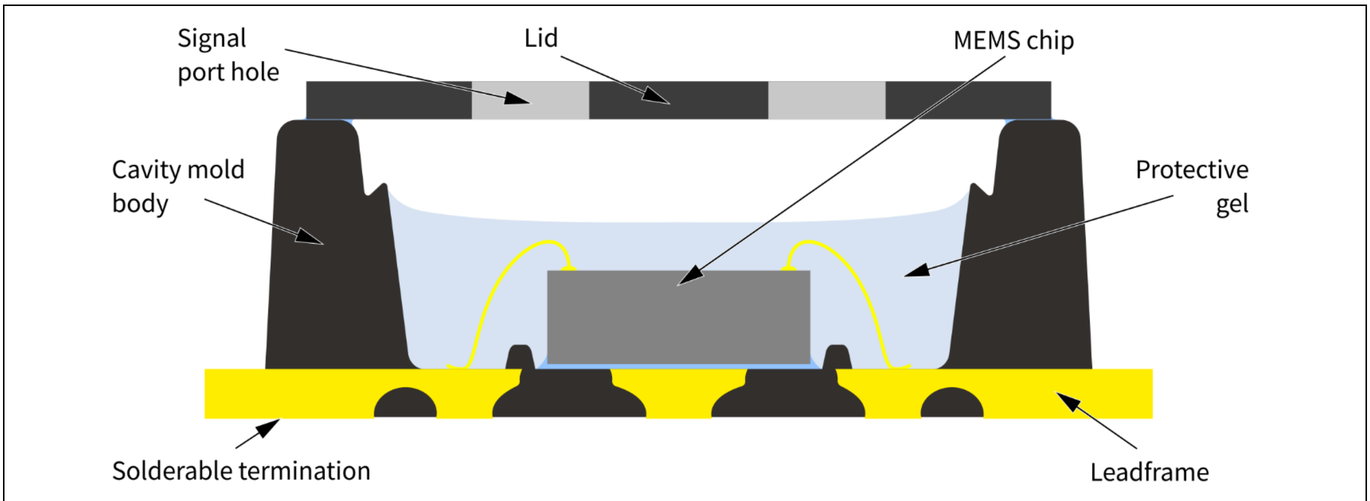

Figure 6 **Schematic showing the inner setup of a DFN pressures sensor package with no-lead terminations.**

Termination design

The DSOSP features gullwing leads that are considered one of the most reliable terminations for SMD. To form gullwing-shape terminations, the leads are bent to form a distinct “foot” and “heel” geometry. The feet are forming a seating plane that is then soldered to the PCB.

Figure 7 shows a comparison of the DSOF flat lead and the DFN no-lead termination. The flat lead protrudes to a large extend over the package body outline. The lead tip features a cut edge that is of bare copper and not wettable by design (also refer to the IPC-A-610 standard [6]). The largest portion of the wettable area of the no-lead termination is situated inside the package outline. Mold flash can cover some portion of the termination sidewall. The additional hollow groove LTI provides a reproducible wettable area for the purpose of optical inspection. **Figure 8** shows a cross section of a properly soldered DFN pressure sensor package. Within the hollow groove LTI the solder can wet up to the leadframe top side.

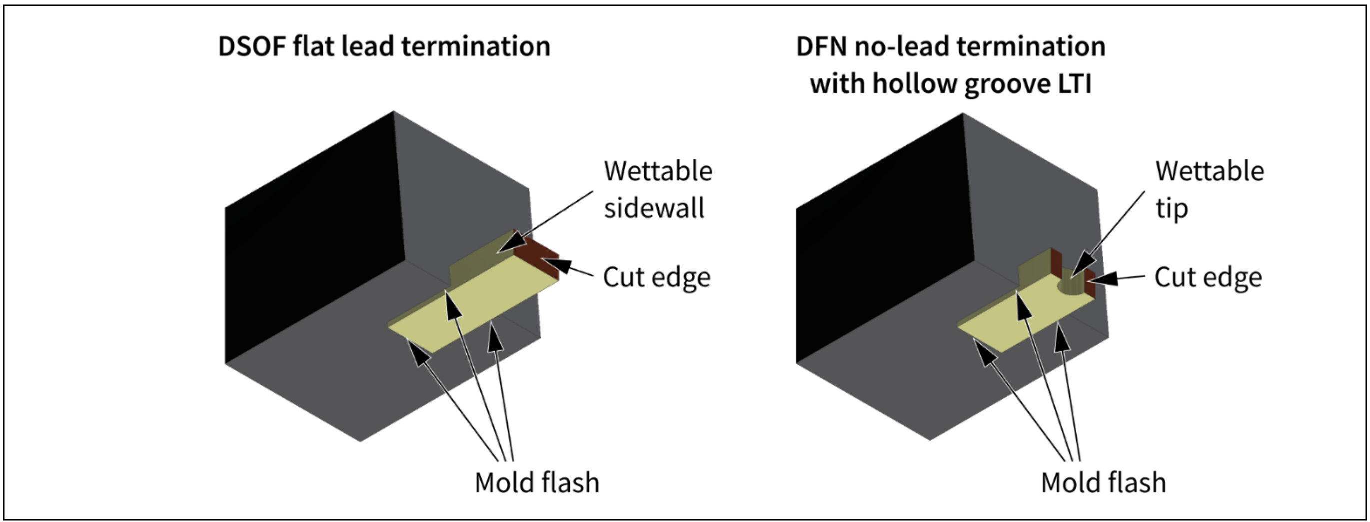

Figure 7 **Comparison of a DSOF flat lead termination (left) and DFN no-lead termination with hollow groove LTI (right). The images are not to scale.**

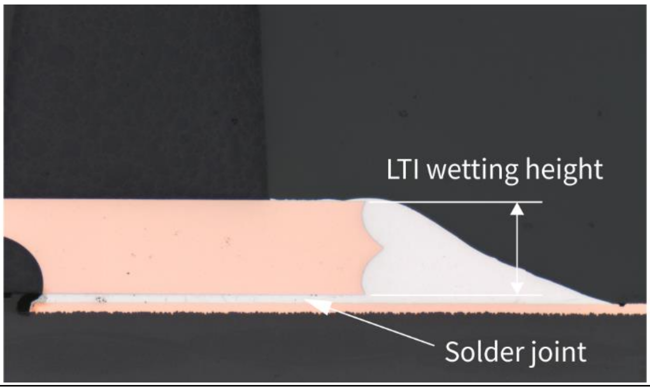

Figure 8 **Cross section of a DFN no-lead termination with hollow groove LTI. The wettable tip enables the formation of a solder fillet that can be insepected by AOI.**

For further information about LTI features, please refer to the *General recommendations for board assembly of Infineon packages* document that is available on the Infineon Technologies package web page [1]. Please also feel free to contact your local sales, application, or quality engineer.

Termination plating

The final finish of the ATV pressure sensor package terminations consist of a nickel/gold (Ni/Au) stackup. The sacrificial gold layer dissolves during reflow. The solder connection is then made to the Ni-layer with very stable results in solderability.

2 Printed circuit board

2.1 Routing

Printed circuit board design and construction are key factors for achieving solder joints with high reliability. Packages with exposed pads should not be placed opposite to each other on top and bottom side of a PCB if double-sided mounting is used. This will stiffen the assembly and cause solder joints to fatigue earlier than in a design in which the components are offset. Furthermore, the board stiffness itself has a significant influence on the reliability of the solder joint interconnect if the system is used in critical temperature-cycling conditions.

2.2 Pad design

The quality and reliability of interconnect solder joints to the board are affected by:

- Pad type (solder mask defined, SMD or non-solder mask defined, NSMD)
- Specific pad dimensions
- Pad finish (also called metallization or final finish)
- Via layout and technology

It is recommended to use non-solder mask defined PCB pads in which the solder mask opening is larger than the copper pad. The copper pad etching process is more capable and stable compared to the solder mask in terms of dimensional tolerances and registration accuracy. Especially smaller pads can be manufactured more accurately when defined by the copper outline. The mixture of different pad registration types in one PCB footprint is not recommended.

For PCB pads of gullwing lead packages such as the DSOSP it is beneficial to design a certain backward extension as shown in **Figure 9.** The extension is intended to support the formation of an optimal solder fillet shape at the lead heel. According to the IPC-A-610 the minimum solder wetting height shall reach an extended line projected from the lead tip top corner in parallel to the PCB pad plane. As a rule of thumb often the line parallel to the lead top plane is used to take into account the lower bend angle.

The PCB pad and therefore the solder paste print should have a distinct distance to the package mold in order to avoid an unclean solder process as it is induced by e.g. solder spatters.

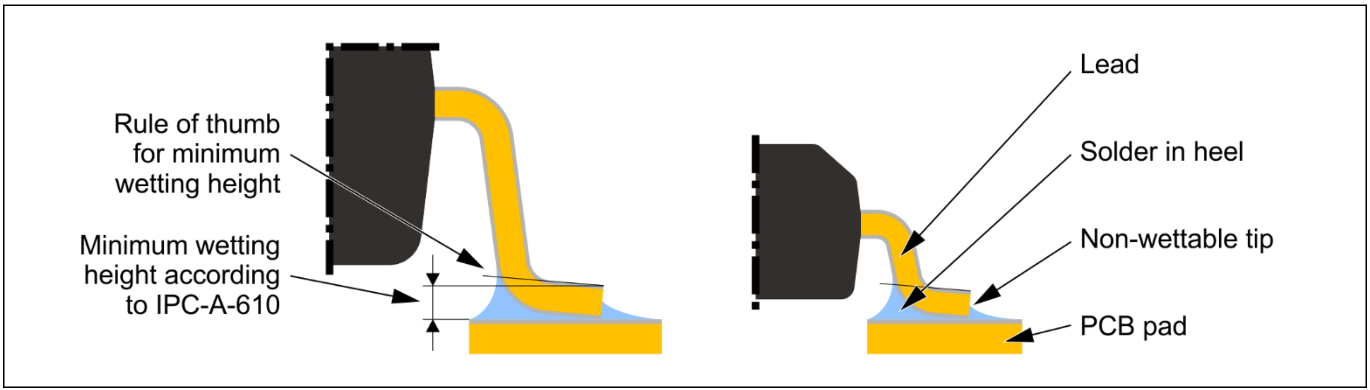

Figure 9 Schematic depictions of the backward PCB pad extension for optimal solder fillet formation in heel according to a rule of thumb and to the IPC-A-610 [6].

Printed circuit board

The PCB pad size for leadless packages such as the DFN should be slightly increased circumferentially compared to the footprint of the component. That allows for the formation of a frustum-shaped joint. The PCB pads for flat leads such as the DSOF are mainly extended to their sidewall, whereas those for the no-lead terminations with hollow groove LTI are narrower and extended to the tip.

Figure 10 shows an example of NSMD pads for a DFN pressure sensor package. The mold locks on the landing area of the package are accessible by the outside. These areas should be kept free from open metal structures on the PCB by defining "keep-out areas".

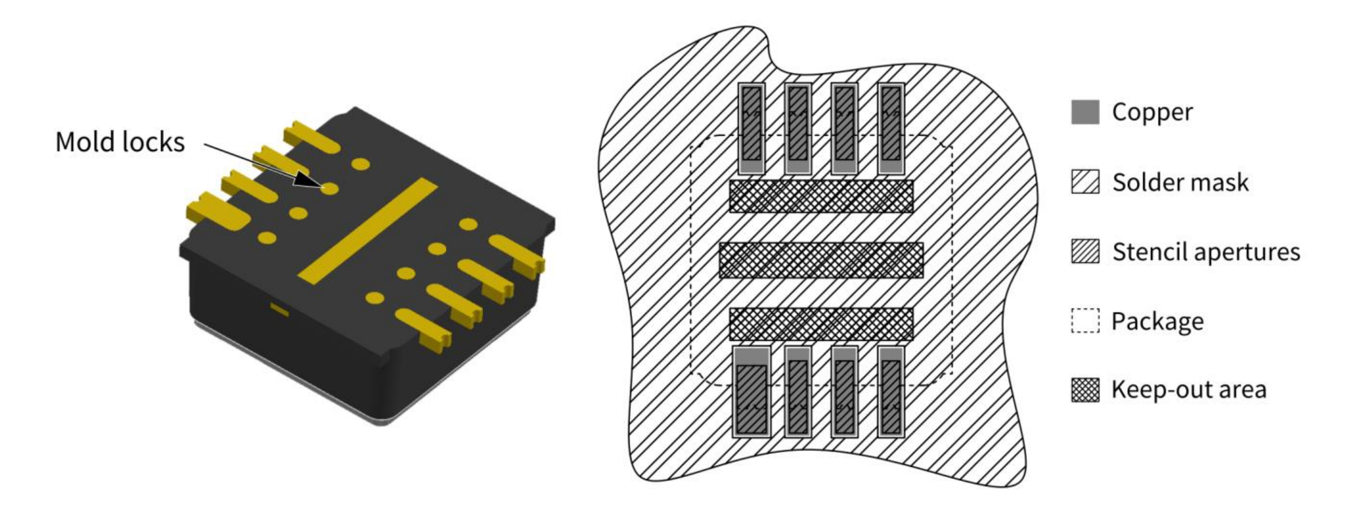

Figure 10 Example of a pad and stencil design based on the DFN package outline. The open metal from mold locks in the package landing area (left) are marked as a keep-out area on the PCB design (right).

For individual design optimizations or adaptations, the specific design rules of the board manufacturer should be considered. Besides the pad and stencil design, the type and quality of specific board finish has a considerable impact on the solder wetting behavior. In every case, application-specific tests and experiments are recommended.

Pad design for LTI features

The hollow groove LTI feature extends the wettable area of the DFN no-lead termination to its tip for the purpose of optical inspection. That allows for the formation of a solder joint fillet with reproducible height as it is shown in **Figure 11**. A stable concave fillet shape is especially important for AOI.

In order to ensure optimal results during the AOI, the pad extension protruding the termination tip should be of more than 400 µm. The solder paste volume should be accordingly increased by a sufficient amount to ensure a homogeneous and reproducible solder joint fillet formation.

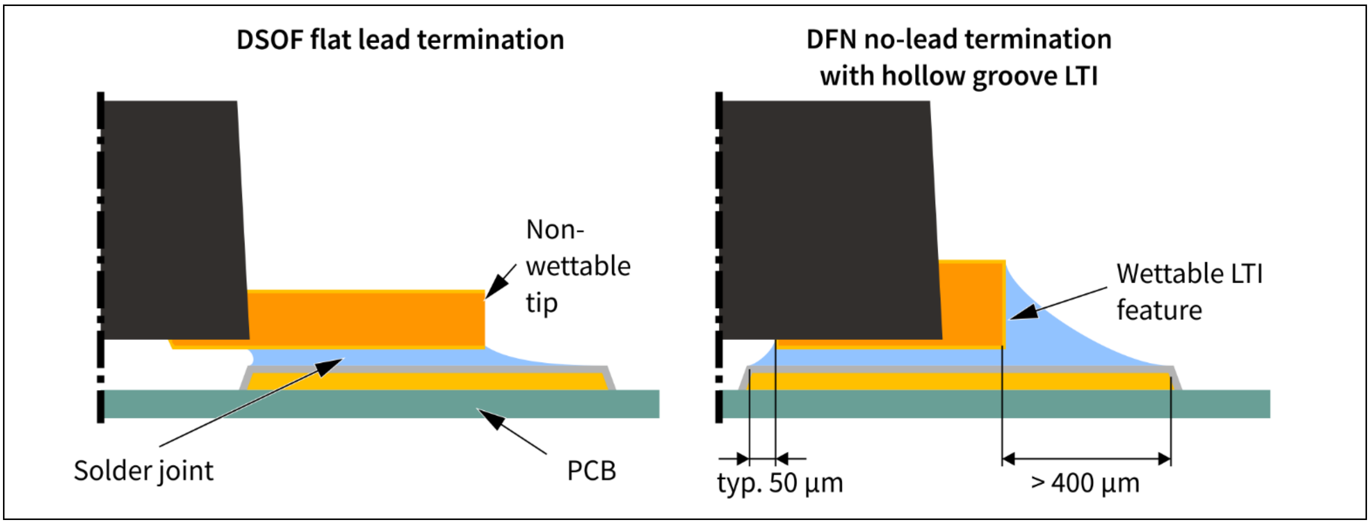

Figure 11 **Schematic depictions of the DSOF flat lead solder joint (left) and the DFN no-lead solder joint with hollow groove LTI (right). The PCB pads for flat leads are mainly extended to their sidewall, whereas those for the no-lead terminations with hollow groove LTI are narrower and extended to the tip. The images are not to scale.**

Details on package specific PCB pad recommendations can be found in the package data base that is available on the Infineon package web page [1]. Please choose a specific package when searching the data base, which will then show an example of the footprint layout for each package.

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

3 PCB assembly

3.1 Solder paste stencil

In SMT the solder paste is applied onto the PCB metal pads by stencil printing. The volume of the printed solder paste is determined by the stencil aperture and the stencil thickness. While an excessive solder paste volume will cause solder bridging, an insufficient solder paste volume can lead to reduced solder spreading between all contact surfaces. To ensure a uniform and sufficiently high solder paste transfer to the PCB, laser-cut (mostly made from stainless steel) or electroformed stencils (made from nickel) are preferred.

For DSOSP and DSOF pressure sensor packages a stencil thickness of 150 µm (approx. 6 mil) is recommended whereas for the smaller no-lead DFN pressure sensor package a stencil thickness of 130 µm (approx. 5 mil) should suffice.

For individual design adaptations to reach the optimum amount of solder the stencil thickness, the PCB pad finish, quality, solder masking, via layout, and the solder paste type should all be considered. In every case, application-specific experiments are recommended.

For further information about solder stencil design, please refer to the *General recommendations for board assembly of Infineon packages* document that is available on the Infineon package 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 sort 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 (with lower grain size of the solder alloy powder) 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 removing contaminants and oxides on the surface.

The solder paste solvents have to evaporate during reflow soldering, while residues of the flux will remain on the joint. The capacity of the flux additive for removing oxides is given by its activation level, which also affects the potential need for removing the flux residuals after the assembly. For leadless packages in which the solder joint is formed mainly on the package bottom side, a “no-clean” paste is recommended to avoid subsequent cleaning steps underneath the package. The small gaps make cleaning highly difficult if not impossible.

Vision systems may be used for inspection of solder paste depots after printing. They can either be integrated into the printer or as separate automated solder paste inspection (SPI) equipment. The lateral solder paste coverage as well as the volume can be measured. Adequate acceptance criteria have to be defined based on the manufacturing setup.

Generally, 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 and place the components. 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. The pressure sensor package with lids should not be suspended to pull forces > 1 N in order to avoid damaging the component. It is recommended that the used nozzle seals with all pressure ports of the lid. When picking the DSOF pressure sensor package the nozzle should seal with the package rim as shown in **Figure 12**.

Note: *The lid of DSOF and DFN pressure sensor packages can be damaged by bending with excessive push/pull forces. Pull forces > 1 N should be avoided.*

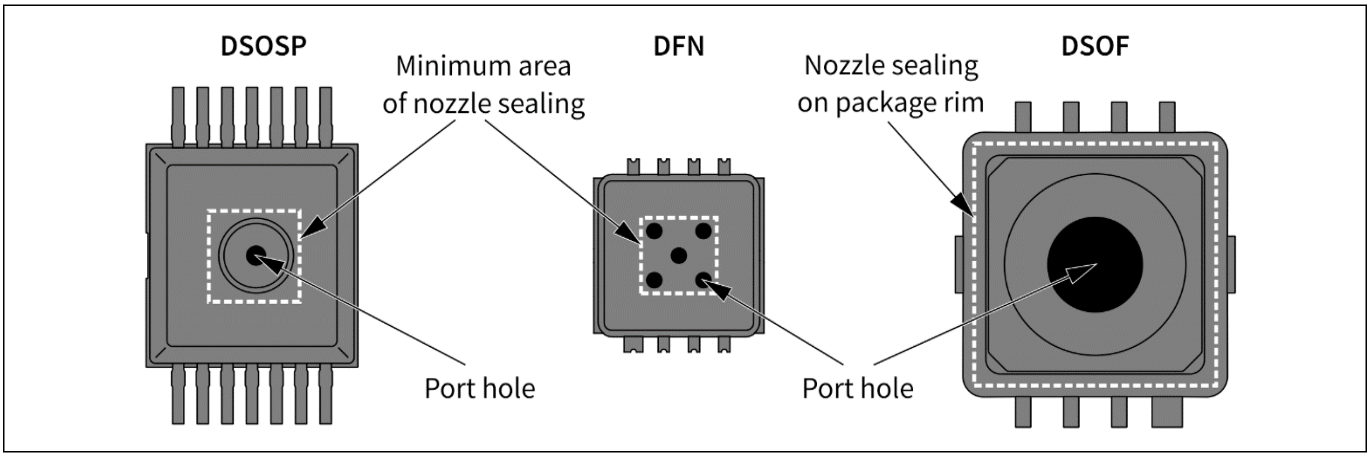

Figure 12 The vacuum nozzle of the pick-and-place tool should at minimum enclose the pressure ports of DSOSP and DFN packages (left). When picking the DSOF pressure sensor package the nozzle should seal with the package rim (right).

DSOF and DFN

The DSOF and DFN pressure sensor packages feature a protective gel that increases the overall product robustness. A dynamic vacuum test has shown that a vacuum pressure pulse of 10 kPa has no negative impact on the sensor functionality that are housed by DSOF and DFN packages. **Figure 13** shows the applied vacuum pressure pulse. It also shows the measurements of the sensor output accuracy before and after the pulse. The sensor output signal is displayed as deviation from the characteristic sensor function in mbar versus applied pressure.

Note: *Use a nozzle that encloseses all pressure port holes. The correct functionality of the device after a dynamic pressure pulse of 10 kPa has been verified specifically for products in DSOF packages.*

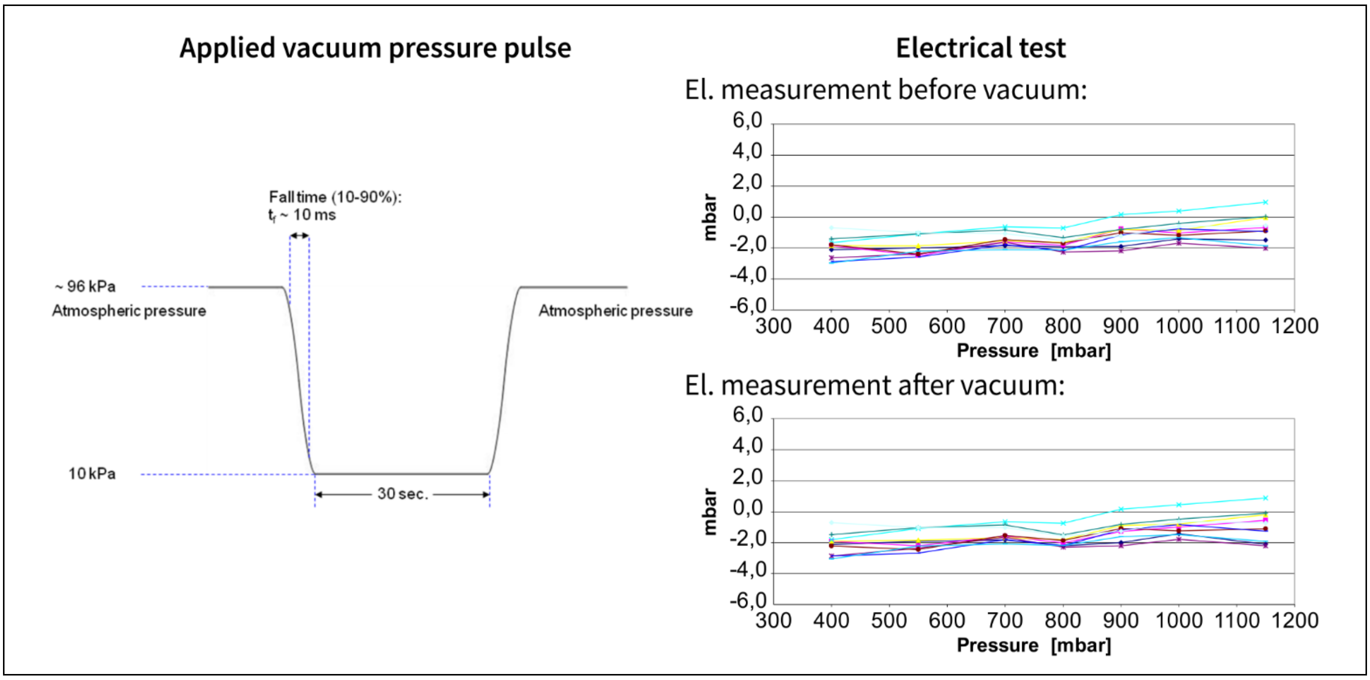

Figure 13 Dynamic vacuum test for the DSOF pressure sensors. A vacuum pressure pulse of 10 kPa (left) has no negative impact on the sensor functionality (right).

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

3.4 Reflow soldering

For PCB assembly of the Infineon pressure sensor packages, the widely used method of reflow soldering in a forced convection oven is recommended. Soldering in a nitrogen atmosphere can generally improve the solder joint quality but is not necessary to create a reliable joint. Vapor phase soldering can damage the internal structure of the pressure sensor components and shall therefore not be used for solder reflow.

Note: *Do not use vapour phase reflow process for pressure sensor packages, as the vapour can damage the component internals through the pressure port.*

The soldering profile should be in accordance with the recommendations of the solder paste manufacturer to achieve optimal solder joint quality. The position and the surrounding of the component on the PCB, as well as the PCB thickness, can influence the solder joint temperature significantly. It is recommended to optimize the reflow profile in such a way that excessive flux or solder spattering is avoided.

Minimum reflow conditions

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

Maximum reflow conditions and cycles

Components that are moisture-sensitivity level (MSL) classified by Infineon have been tested by three reflow runs in accordance with the J-STD-020 standard, including a double-sided reflow and one rework cycle. The maximum temperatures must not be exceeded during board assembly. Please refer to the product barcode label on the packing material that 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].

Note: DSOSP packaged products are limited to a maximum reflow temperature of 250°C due to the construction of the package. Please refer to the relevant datasheet.

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

4 Cleaning

After the soldering process, some flux residues may remain on the board, especially near the solder joints. Generally, cleaning beneath a component with bottom-only terminations such as the no-lead DFN pressure sensor package is difficult due to the small gap between the component body and the PCB. Therefore, a “no-clean” flux is recommended whose residues usually do not have to be removed after the soldering process.

In case a cleaning process is executed, it should be ensured that no contamination enters the pressure ports and that there is no mechanical damage to the gel (e.g. by applying a high pressure spray or air blow) of the relevant package types.

Note: *Any wet cleaning of the pressure sensor components is not recommended as the cleaning solvents can enter the pressure port hole.*

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

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

5 Inspection

5.1 Optical solder joint inspection

The solder joints of DSOSP packages can be inspected using AOI by applying the same concepts that are suitable for other gullwing leads. Similarly, the solder joints of DSOF pressure sensor packages can be optically inspected with sufficient lateral extension of the PCB pads to the flat lead sidewalls.

Compared to the leaded SMD packages such as of gullwing and flat type, the solder joints of the no-lead DFN pressure sensor packages are mainly formed underneath the component body with low chance of optical inspection. The hollow groove LTI provide wettable termination tips for the formation of a solder fillet that is suitable for AOI. **Figure 14** shows examples of the solder fillets that can be formed at the DFN pressure sensor package termination tips.

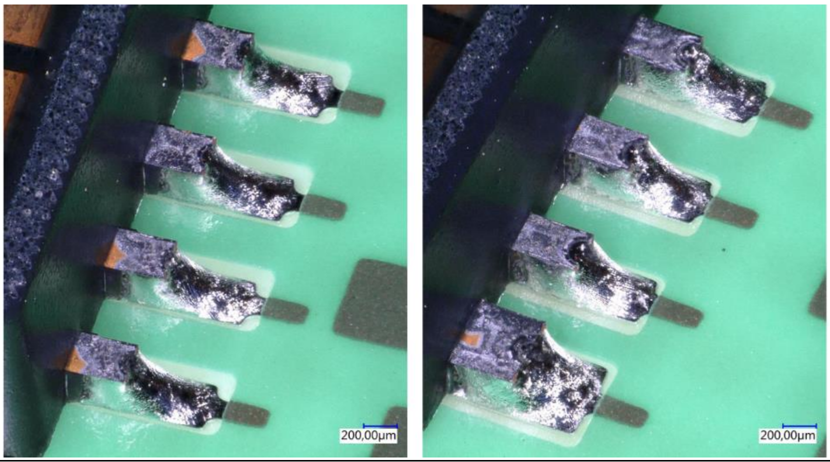

Figure 14 Examples of properly soldered DFN pressure sensor package terminations with hollow groove LTI inspected by optical microscopy.

5.2 X-ray solder joint inspection

Automated x-ray inspection (AXI) systems are appropriate for efficient inline control of components such as with pressure sensor packages. The here discussed devices should not be exposed to excessive x-ray radiation as this can deteriorate the performance of the MEMS.

Note: The pressure sensor components of DFN and DSOF family should not be exposed to excessive x-ray radiation as this can deteriorate the device performance. As a general rule < 6 Gray, (2 Gray for single shot, 6 Gray for multiple shots, max. 3 times inspection)

AXI systems are available as 2D and 3D solutions. They usually consist of an x-ray camera and the hardware and software needed for inspection, controlling, analyzing, and data transferring routines. These reliable systems enable the user to detect soldering defects such as poor soldering, bridging, voiding, and missing parts. However, other defects such as broken solder joints are not easily detectable by x-ray. **Figure 15** shows two x-ray images of properly soldered pressure sensor packages.

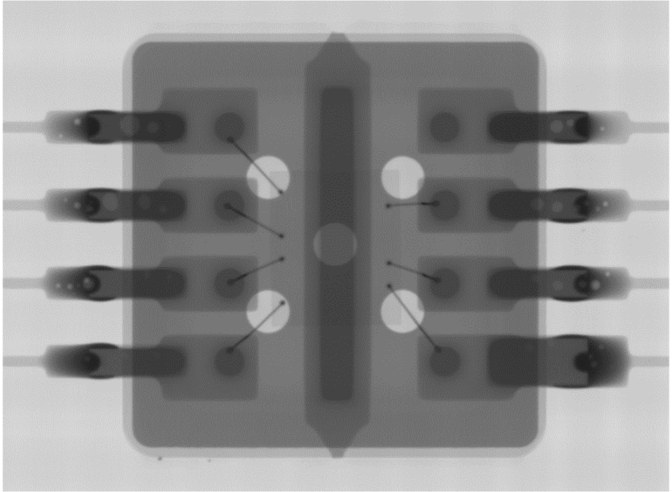

Figure 15 Example of properly soldered DFN pressure sensor package inspected by x-ray.

For the acceptability of electronic assemblies, please also refer to the IPC-A-610 standard [6].

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

6 Rework

The solder joints of Infineon DSOSP, DSOF, and DFN packages are generally reworkable.

Single solder joint repair of leadless terminations is difficult, and is therefore generally not recommended. Desoldered components shall not be reused but be replaced by new ones.

A rework process is commonly done on special rework equipment. There are various systems available that meet the requirements for reworking SMD packages. All handling guidelines discussed in this document have to be respected. Special focus should be on the following items:

- Due to the decreased automation level given by the general rework approach, even higher care compared to standard assembly must be taken. Tools that do not damage the component mechanically have to be chosen. Mechanical forces that do not necessarily cause visible external damage can still cause internal damage that reduces the component's reliability. A proper handling system with vacuum nozzles may be the gentlest process and is therefore recommended. The impact of rework tools has to be assessed properly. In general, more manual handling increases the effort for documentation, training, and monitoring of the rework process(es).
- During rework, special care must be taken concerning the proper moisture level of the component according to the J-STD-033. Drying the PCB and the component prior to rework might be necessary. A proper drying procedure for SMD packages is described in the international J-STD-033 standard [5]. Please also refer to the recommendations of your PCB manufacturer and take all specific needs of components, PCB, and other materials into account.
- Whatever heating system is used (hot air, infrared, hot plate, etc.), the applied temperature profile at the component must never exceed the maximum temperature according to the J-STD-020 standard. Depending on the specific heating profile used during rework, components adjacent to the mounting location might also experience a further "reflow run" in terms of the J-STD-020 standard [4]. Internal investigations have shown that the temperature profile must be recorded.

If a device is suspected to be defective and a failure analysis is planned, Infineon usually expects customers to desolder the component prior to return to Infineon. The component shall be returned in a proper condition according to the original package outlines.

In some special cases such as solder joint inspection Infineon may request that the PCB or part of the PCB with the component still attached should be sent to Infineon.

Note: *Before returning a device for failure analysis at Infineon, please clarify the return condition of the suspected component (i.e. onboard or desoldered) with the Infineon Application Engineer or Customer Quality Manager who supports your company.*

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

7 References

[1] Infineon: Packages. https://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.

[6] Association Connecting Electronics Industries: IPC-A-610. Acceptability of Electronic Assemblies.

Revision history

Page or reference	Major changes since the last revision
Entire document	DSOSP package added

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