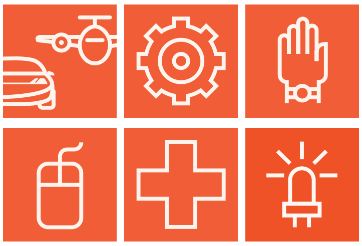
Fundamentals of LED handling

Application Note

Published by ams-OSRAM AG
Tobelbader Strasse 30,
8141 Premstaetten Austria
Phone +43 3136 500-0
ams-osram.com

Fundamentals of LED handling

Application Note No. AN004



Valid for:
General Guideline

Abstract

LEDs are exposed to various mechanical stresses during processing and in application. However, each mechanical stress has direct effects on the functionality and lifetime of the LED. Excessive stress may lead to a LED failure. Whether defects occur or how robust an LED is in regard to certain stresses is product-specific.

In order to operate the LED within its mechanical stability capabilities it is important to avoid mechanical stress factors and to ensure a proper handling. This application note gives general handling and storage recommendations, an overview on basic LED design differences and explains how mechanical stress can be avoided. In this regard, this document provides a general overview and addresses typical error sources. Reference is made to special application notes that go into more depth on the subject.

Information:
AN005_Preventing LED failures caused by corrosive materials
AN020_ESD Protection while handling LEDs
AN037_Recommended pick and place tools of LEDs
AN021_Further details on lead free reflow soldering of LEDs

Table of contents

1 Mechanical stress on LEDs

Mechanical stress on LEDs should always be avoided. Stress can occur directly during handling and processing of the LED, but also during further processing of the PCBs' and applications. For example a process step using ultrasonic welding can damage the LED and should therefore be avoided, as the mechanical vibrations of the ultrasonic waves can damage the sensitive structure of the LED. During processing, mechanical stress on the surface should be minimized as much as possible.

ams-OSRAM AG provides a number of application notes to support the correct handling of the LEDs. This present Application Note gives an overview of the correct handling, while specific topics (e.g. to avoid ESD damage) are explained in more detail in special Application Notes.

A selection of these special Application Notes is presented in chapter "Further and more detailed handling information".

1.1 Handling of LEDs

LEDs should not be removed from the tape as bulk material. They should only be processed directly from the reel by using automated placement machines. Care should be taken that an appropriate pick-and-place-tool is used and that the process parameters are conform to the package characteristics. For more information on an appropriate pick-and-place-tool please refer to the product related application note or to the application note "Recommended pick and place tools of LEDs".

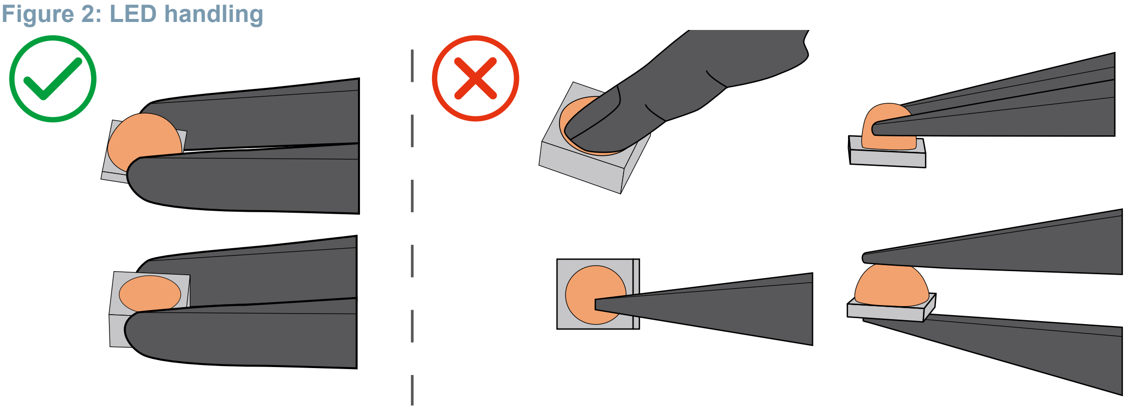
Depending on the LED construction, manual handling and assembly is possible, automatic placement is strongly recommended. Please refer to the notes in the respective product application note.

For manual assembly and placement — in the production of prototypes, for example — the use of vacuum tweezers or ESD plastic precision tweezers are recommended for most LEDs (Figure 1).

Figure 1: Examples of tweezers for manual handling

In general, all types of sharp objects (e.g. tweezer, fingernails, etc.) should be avoided, in order to prevent stress to or penetration of the encapsulation, since this can lead to impairment of the component. LEDs should only be handled at the housing (see Figure 2). The LED light emitting area should not be touched or punctured as this can damage the sensitive component structure.

Figure 2: LED handling

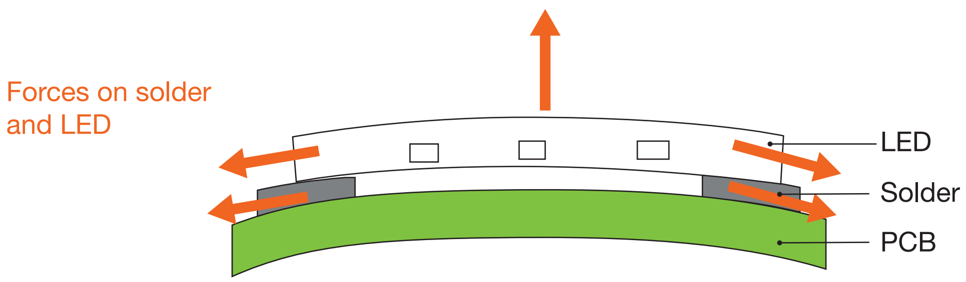


1.2 PCB separation

For reasons of efficiency, several boards are often assembled in a panel. After the assembly process, the LED boards will be separated. This is usually done with punching tools or by a breaking process. During this separation process, mechanical forces which lead to a bending of the circuit board are applied. Depending on the used PCB material, size, etc., this mechanical stress varies.

Bending or pushing PCBs increases mechanical stress, especially at the solder joints. Any bending stress could have a direct effect on the LED (see Figure 3). It can lead to cracks in the LED packaging and/or the solder joint, or possibly resulting in any component failure.

Figure 3: Forces acting on soldering and LED



Especially when using flex boards (FPC) or thin rigid PCBs, special care must be taken during manual handling processes to ensure that the boards are not bent or twisted. A suitable separation process keeps the mechanical stress on the LED as low as possible.

To exclude this possible source of error, it must also be noted that the circuit board is also not bended in the later processing steps or in the application itself.

1.3 Warpage, delamination or overheating during assembly

Another type of mechanical stress can take place during the soldering process. Here, failure modes such as warpage, delamination or overheating can arise due to the thermal influence.

Although this mechanical stress only acts for a short time and the component usually returns to its original position, damage to the internal structure can occur. The risk is higher for specific products. Therefore, the recommended soldering profile should be followed, both in terms of the peak temperatures and the ramp up and ramp down times. Before further processing, the assemblies should cool down to room temperature. For more details on this, please refer to the application note "Further details on lead free reflow soldering of LEDs".

1.4 Storage of assembled devices

A suitable storage system should be implemented in order to ensure that assembled LED boards and panels are not stacked on top of each other (Figure 4). Special features of the design, such as LEDs with lens, must be taken into account.To avoid the risk of damage to the assembled LEDs, make sure that they are not exposed to compression forces of any kind. Furthermore, LEDs and other components on the PCB-Assembly must not be touched directly.

Figure 4: Correct storage

2 LED design related aspects

The design and construction of LEDs depends on the light extraction properties and application requirements. To avoid mechanical damage, it is important to check for each LED type whether additional handling instructions must be observed due to the individual design. The key design features can be found in the respective LED data sheet, see Figure 5.

Figure 5: Example LED design features in data sheet

Features:

- Package: SMD ceramic package with silicone lens
- Chip technology: Thinfilm
- Typ. Radiation: 60°
- Color: λ_{dom} = 617 nm (• amber)
- Optical efficacy: 60 lm/W
- Corrosion Robustness Class: 3B
- Qualifications: The product qualification test plan is based on the guidelines of AEC-Q101-REV-C, Stress Test Qualification for Automotive Grade Discrete Semiconductors.
- ESD: 2 kV acc. to ANSI/ESDA/JEDEC JS-001 (HBM, Class 2)

A few design related properties are presented in the following.

2.1 Silicone resin LEDs

LED-packages based on silicone resin typically allow a higher junction temperature than based on epoxy resins. In addition, they exhibit high moisture and cycling reliability and are well suited for use in the automobile industry.

When assembling boards in SMT production mechanical pressure on the surface of the resin must be prevented. This is assured by choosing a appropriate pick-and-place-nozzle. A nozzle recommendation for the respective products can be found in the Application Note "Recommended pick-and-place tools for LEDs".

The silicone materials used by ams-OSRAM AG are especially qualified for use within semiconductor devices and is suitable for automotive applications. In particular, the materials used have an extremely low level of volatile content.

They also provides good chemical resistance, but it is somewhat permeable for gases and small molecules. For this reason, the possibility of LED failures due to corrosion should be considered especially at this point. Please refer to the application note "Preventing LED failures caused by corrosive materials".

2.2 Epoxy resin LEDs

Epoxy encapsulations provide good mechanical stability and high resistance to gases. In addition, the adhesion to the surface is good. For these LEDs, reflow soldering in a nitrogen atmosphere is recommended. This prevents possible negative effects of the soldering process on the optical properties.

2.3 LEDs with ceramic package

ams-OSRAM AG also offers LEDs with a ceramic substrate or a ceramic package for a multitude of applications. The electrical contacts are located on the backside of the package. Please also refer to the application note “Application hints for high-current LEDs” and “Ceramic LEDs - Details on handling and processing” for information.

3 Cleaning

Any direct mechanical or chemical cleaning of the LED should be avoided. As a matter of principle, LEDs must be cleaned in an powerless state if wet cleaning is used. In any case, all materials and methods should be tested beforehand in order to determine whether the component will be damaged in the process. Detailed information can also be found in the individual data sheet of each LED.

Typically, LEDs — such as other microelectronic components — are produced under controlled, dust-free and clean conditions in so-called clean rooms. During LED production a clean room classification of 10,000 for the backend processes must be maintained. With respect to purity, this means that in 1 ft³, no more than 10,000 particles larger than 0.5 µm in size, or in relation to 1 m³, no more than 352,000 particles are permitted. Since packaging of the LEDs is also governed by the corresponding conditions (vacuum-packed, ESD-secure, and moisture-resistant), for the most part, the LEDs can be considered to be 100 % clean at the time of delivery.

Contamination can therefore only be assumed to occur after unpacking, during ongoing processing, uncovered temporary storage of products or possibly from use. In general, it can be determined that LEDs with a normal standard epoxy encapsulation are less susceptible to contamination than those with a silicone encapsulation. The reason is that the surface of the silicone exhibits a slight residual stickiness after curing, allowing dust and contaminants to more easily remain attached to the surface. This characteristic should always be taken into consideration when cleaning.

Depending on the type and extent of the contamination, a combination of dry and wet cleaning may be required. Special LED type-specific notes for cleaning can also be found in the corresponding data sheets. The most important cleaning methods are described in the following.

3.1 Dry cleaning

For dusty or slightly contaminated LEDs, simple dry cleaning is usually sufficient.

Ideally, cleaning by means of compressed air (e.g. central supply or spray can) is recommended here. The LEDs and/or the board are blasted with clean air. If compressed air from a central supply is used, care should be taken that the air is purified. If this is not the case, the opposite effect may be achieved, e.g. additional contaminants such as oils may be sprayed onto the components or the board. In order to ensure that the compressed air does not contain any oil residues, the use of a spray can is suggested. A maximum pressure of 4 bar at a distance of 20 cm to the component is recommended.

Care should be taken when dry cleaning LEDs with silicone encapsulation. Since the silicone is softer and therefore more sensitive to pressure, dust is more likely to adhere to the slightly sticky surface. The probability that dry cleaning will not achieve the desired effect is relatively high.

3.2 Wet cleaning

Please note, that for some of the LEDs from ams-OSRAM AG a wet cleaning process is not applicable e.g. due to not hermetically sealed packages. Please refer to the respective data sheets for further information. Generally, due to health and environmental issues as well as the worldwide regulations, cleansing solutions with CFCs (chlorofluoro-carbons) should not be used.

Cleaning with a cleansing solution is most often required if the LEDs are dirtier or with more strongly adhering contamination such as residue from the soldering process (flux material, etc.). For LEDs with a silicone encapsulation, ams-OSRAM AG suggests using Isopropyl alcohol for cleaning. In case other solvents are used, it must be assured that these solvents do not dissolve the package or resin. We recommend rinsing the LEDs after soldering for 5-10 seconds, maximum 15 seconds. If flux-cleaning is necessary it should be performed immediately after the soldering process.

Of the numerous cleansing solutions available, isopropyl alcohol (IPA) can be used for the cleaning of all LEDs which allow for wet cleaning in general.However after the reflow soldering process, some flux residues may remain on the board, especially near the solder joints. Due to the small gap between the LED package and the PCB cleaning beneath a QFN or BoT (bottom-only terminals) is difficult. Therefore, ams-OSRAM AG recommend to use a solder paste with a “no-clean” flux, whose residues usually do not have to be removed after the soldering process.

If special cleansing solutions and methods (spray or vapor cleaning) are used, their appropriateness must be tested beforehand, especially as to whether or not they will damage the LED or cause long term reliability issues. Please contact the solder paste or flux manufacturer for recommended cleaning solutions.

3.3 Ultrasonic cleaning

Cleaning of LEDs in an ultrasonic bath is generally not recommended. Ultrasonic vibrations can be transferred very well to solids and liquids, where the ultrasound then creates cavitation. The vibrations move the contamination on the surface along with it. These waves can cause the LED to vibrate and thus cause damage. It is also possible that cleaning fluid can penetrate the component due to the mechanical forces acting.

The effect of ultrasound on the component is essentially dependent on the power of the ultrasonic bath, the temperature, the treatment time and the cleansing solution used. Possible effects or long-term consequences therefore cannot be foreseen or calculated.

4 ESD Basics

Electrostatic discharge causes a short, high electrical current pulse, which is caused by a large potential difference in an electrically insulating material. LEDs can be severely damaged by an electrostatic discharge.

One of the most frequent causes of electrostatic discharge is an electrical charge generated by friction, which can occur e.g. during transport, handling or processing. The external evidence of a load discharge will often take the form of a visible spark or fracture taking less than a microsecond. With sensitive semiconductor products, even discharges of a few volts are sufficient to result in destruction or damage, whereas a person will not feel a discharge until it reaches several thousand volts (approx. 3000 V) or more. The fractures created inside the semiconductor will then result in the failure of the component, either immediately or delayed. When processing LEDs, it is therefore necessary to ensure an ESD safe environment with appropriate ESD protection in place, in accordance with the ESD guidelines for components at risk and to provide appropriate protection against electrostatic discharge in the application.

For further and more detailed information, it is advisable to consult and use the appropriate standards, as well as the literature and the publications of the approved associations and committees (e.g. ANSI, JEDEC, ESDA). Furthermore the Application Note "ESD protection while handling LEDs" should be considered.

5 Electrical overstress (EOS)

If the LED operating current exceeds the maximum current specified in the data sheet, this is called electrical overstress, short EOS. The effect on the LED depends on the duration and the current intensity. However, every time the maximum current is exceeded, the LED can be damaged. Sometimes this leads to an immediate failure, but it can also lead to a failure after several hours of operation. Therefore EOS events should be avoided. For more information the Application Note "The basic principles of Electrical Overstress (EOS)" should be considered.

6 Storage

Unused components should generally be stored in the appropriate packaging until processing. Individual components should not be handled as bulk material and should remain in the tape. Further processing and assembly directly from the tape is recommended.

If LEDs are exposed to high humidity or to the relative humidity (RH) of the environment over a longer period of time, the components absorb moisture. This increases the probability that the LED will fail during the further processing steps.

Possible failure patterns due to moisture in the component are:

- Delaminations between the chip and the plastic encapsulation material
- Cracks in the package ("popcorn effect")
- Open contacts

Therefore, the control of moisture levels in the package body is critical to reducing the risk of moisture-induced failures. A procedure to define the sensitivity of a component against moisture is set out in JEDEC-STD-020E. In this standard, moisture sensitive components are classified in eight different groups, each differing in their permissible storage time in a defined climate (characterized by temperature and relative humidity at normal pressure).

6.1 Normative references

SMT components are at risk of moisture migration into the component while stored. During processing this can result to an increase in pressure inside the component. In order to prevent this potential damage, there are various methods and procedures which are described in the following standards for handling, packaging, transport and operation of moisture-sensitive components:

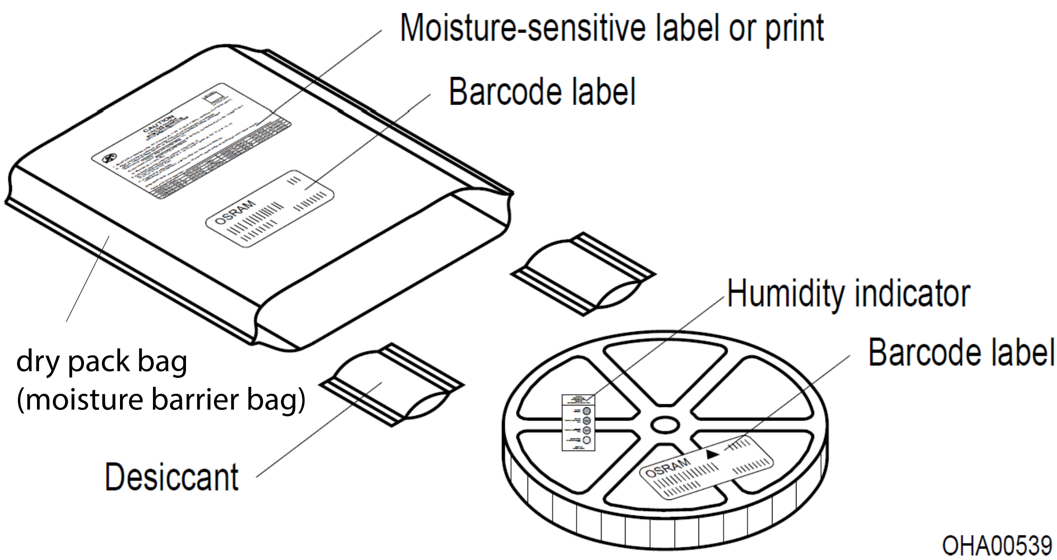
- JEDEC-STD-020E: Moisture/Reflow Sensitivity Classification for Plastic Integrated Circuit Surface Mount Devices
- JEDEC-STD-033B: Standard for Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices
- EIA — 583: Packaging Material Standards for Moisture Sensitive Items
- EIA/JEP 113-B: Symbol and Labels for Moisture-Sensitive Devices
- EIA/JEP 124: Guidelines for the Packing, Handling and Repacking of Moisture-Sensitive Components
- MIL-B-81705 C: Barrier Materials
- MIL-D-3464: Desiccants
- ICE62435
- ZVEI “Guidelines for the Long-Term Storage of Components, Subassemblies and Devices”
- JEP160A: Long-Term Storage for Electronic Solid-State Wafers, Dice, and Devices

6.2 Storage of delivered parts

Moisture-sensitive components are shipped in vacuum-sealed moisture barrier bags packed with a desiccant material and a humidity indicator card. Upon receipt, the bags should be inspected for damage to ensure that the bag integrity has been maintained. Inspection should verify no holes, gouges, tears, or punctures of any kind that may expose the contents of the bag.

The dry pack bag (moisture barrier bag) is of a three layer laminated design and is MIL-STD 81705C, type 1, class 1 compliant. ESD (Electro Static Discharge) protection is provided by the middle layer of aluminum metalized polyester. Figure 6 shows exemplary how products are packed in a dry bag. Every bag contains a moisture sensitive label, a desiccant and a humidity indicator.

Figure 6: Moisture-sensitive product is packed in a dry bag containing desiccant and a humidity card



Before using dry packed components, it is essential that the humidity indicator be checked immediately after bag opening. Should it indicate a RH of less than 10 % (the color of the 10 % dot has not changed from blue to pink), the components contained are ready for use.

If the humidity indicator in the dry pack shows a RH of more than 10 %, then please follow the instructions as described in Application Note "Dry pack information".

If a 24-month shelf life is exceeded, the devices will need to be dry baked again if the RH in the bag has exceeded 10 percent RH. This RH change can be seen on the humidity indicator card.

In addition please check the dry pack for damage on opening or storage under too severe climatic condition.

Once the dry pack bag is opened, the desired quantity of units should be removed and the bag resealed within two hours. If the bag is left open longer than 30 minutes the desiccant should be replaced with dry desiccant. The closed desiccant pouches may be dried by baking them at 120 °C — 125 °C for 16 hours if the material of the bag is heat resistant.

For more details especially on desiccant, humidity indicator, labels and how to rebake devices, please refer to the detailed Application Note "Dry pack information".

6.3 Storage of unpacked devices

Unpacked devices may be assembled under environmental conditions not exceeding 30 °C and humidity levels of 60 % RH. Devices must be soldered on a printed circuit board (PCB) assemblies within specified floor life hours, described in Table 1.

Table 1: Moisture sensitive level

Moisture Sensitive Level	Floor life
1	no limit
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	6 hours

The floor life of in-process materials may be extended by the use of controlled environments. Packages may be stores outside the Moisture Barrier Bag independent of moisture/reflow sensitivity considerations, if the ambient relative humidity is ≤ 10 % RH. The use of desiccator cabinets with dry N_2 or dry air is suggested for such storage. Please refer also to ZVEI “Guidelines for the Long-Term Storage of Components, Subassemblies and Devices”.

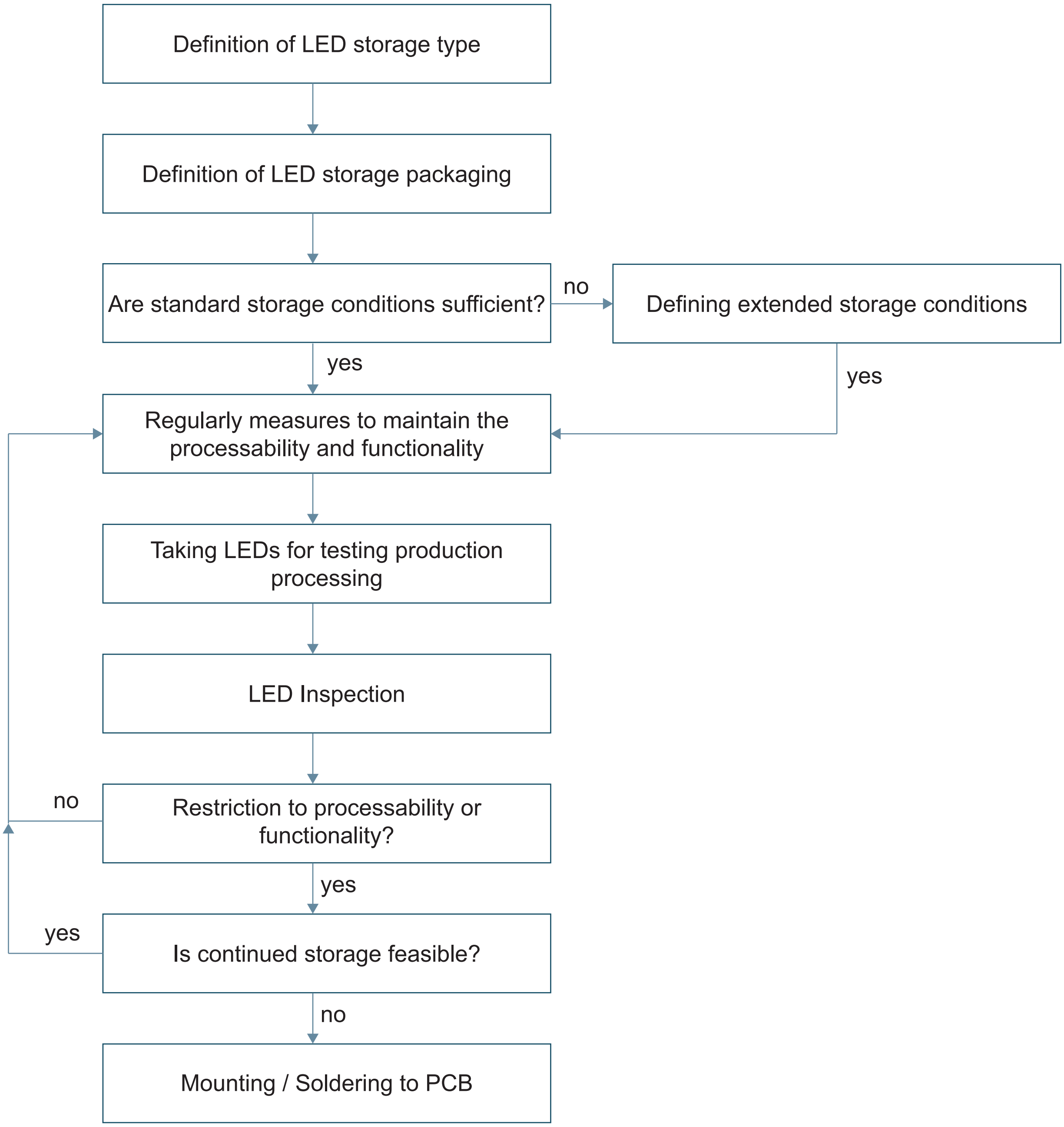
6.3.1 Storing moisture-proof packs prior to opening

Devices packaged in moisture-proof packaging should be stored in ambient conditions not exceeding temperatures of 40 °C or humidity levels of 90 % RH. Storage life at these conditions should not exceed 24 months.

6.4 Long term storage

Current leadframe technologies as well as packaging technologies allow to extend the storage of LEDs. ZVEI provides an outline of best practices and recommendations for long-term storage of semiconductor products. The procedure is illustrated in Figure 7.

Figure 7: ZVEI procedure



The storage of LED components can be extended if the components delivered in the dry bag (Moisture Barrier Bag MBB) are additionally packed in a corrosion protection bag for long-term storage (Intercept protection bag). This can extend the storage time for up to 15 years. For this storage, the JEDEC 033D standard regarding vacuum and residual moisture should be observed.

For this purpose, the original parts must be packed in an Intercept protective bag with an active desiccant. This is then vacuumed (without nitrogen) by using an automatic vacuum sealer with the appropriate "intercept" settings and sealed with a weld seam. Care must be taken to use an appropriate vacuum to avoid damages to the reel or components. To find the correct vacuum, please refer to the specifications and examples in the JEDEC 033D. This packaging process must be completed within 5 minutes, otherwise the desiccant will draw too much moisture. The protective bag must then be checked for tightness. To do this, the weld seam and the protective bag (MBB) are checked for faulty spots or holes. By pulling the bag apart at the weld seam, it can be checked whether it is tightly sealed. It should be noted that only one packaging unit may be processed in this way. If the protective bag is defectively welded, it must be replaced including the dessicant.

For long-term storage, monitoring should be carried out with regular checks. This is because the electro-optical parameters do not change initially, but the processability and solderability may deteriorate. Even a good MSL level does not automatically mean good solderability. Therefore, soldering tests are recommended for monitoring to prevent the risk of the popcorn effect or poorer wettability due to moisture.

For regular monitoring, the 0h condition should be recorded. This conditions should be checked at least every 3 years (if no production run was done in between) under mass production conditions (on application board, with solder material and reflow soldering profile).

For further professional advice concerning long term storage of LEDs according to IEC 62402 please fill free to contact CMCAUK (Brindley Court, Gresley Rd, / Worcester WR4 9FD, UK / Phone: +44 1905 458307 / https://www.cmcauk.co.uk) or HTV (Robert-Bosch-Straße 28 / D-64625 Bensheim / Phone: +49 6251 848000 / https://www.htv-gmbh.de). Both will also offer adequate trainings for long term storage of electronic equipment, boards, parts etc.

7 Further and more detailed handling information

To support the correct handling of the LEDs, ams-OSRAM AG offers further detailed topic-related application notes. A selection of them is listed below:

- Handling of silicon resin LEDs
- Dry pack information
- ESD Protection while handling LEDs
- Ceramic LEDs_Details on handling and processing
- Preventing LED failures caused by corrosive materials
- Cleaning of LEDs
- The basic principles of Electrical Overstress (EOS)
- Further details on lead free reflow soldering of LEDs

Please also visit our homepage and find all new and further application notes.

8 Summary

Avoiding mechanical stress, both directly during the processing of the LED, as well as in the following process steps and in the application, enables trouble-free operation. The most important points for avoiding mechanical stress are summarized below:

- Pay attention to a correct handling of the LED as recommended for the respective LED type
- Avoid ESD
- Avoid EOS
- Use automated placement machines with an appropriate pick and place tool
- Do not use ultrasonic welding
- Pay attention to correct storage
  - For the individual LED
  - For the assembled LED
  - For assembled boards
- Avoid ultrasonic cleaning
- Make sure that the PCB is not bent during separation or in subsequent process steps
- Check the data sheet if wet cleaning is possible

ABOUT ams OSRAM Group (SIX: AMS)

The ams OSRAM Group (SIX: AMS) is a global leader in optical solutions. By adding intelligence to light and passion to innovation, we enrich people's lives. This is what we mean by Sensing is Life. With over 110 years of combined history, our core is defined by imagination, deep engineering expertise and the ability to provide global industrial capacity in sensor and light technologies. Our around 24,000 employees worldwide focus on innovation across sensing, illumination and visualization to make journeys safer, medical diagnosis more accurate and daily moments in communication a richer experience. Headquartered in Premstaetten/Graz (Austria) with a co-headquarters in Munich (Germany), the group achieved over EUR 5 billion revenues in 2021. Find out more about us on https://ams-osram.com

For further information on our products please see the Product Selector and scan this QR Code.

Published by ams-OSRAM AG
Tobelbader Strasse 30, 8141 Premstaetten, Austria

Published by ams-OSRAM AG
Tobelbader Strasse 30,
8141 Premstaetten Austria
Phone +43 3136 500-0
ams-osram.com