IEC 62435-5

Edition 1.0 2017-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electronic components – Long-term storage of electronic semiconductor devices – Part 5: Die and wafer devices

Composants électroniques – Stockage de longue durée des dispositifs électroniques à semiconducteurs – Partie 5: Dispositifs de puces et plaquettes

IEC 62435-5:2017-01(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

IEC 62435-5

Edition 1.0 2017-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electronic components – Long-term storage of electronic semiconductor devices – Part 5: Die and wafer devices

Composants électroniques – Stockage de longue durée des dispositifs électroniques à semiconducteurs – Partie 5: Dispositifs de puces et plaquettes

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.020

ISBN 978-2-8322-3837-0

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

FOREWORD ... 4
INTRODUCTION ... 6
1 Scope ... 8
2 Normative references ... 8
3 Terms, definitions and abbreviated terms ... 8
3.1 Terms and definitions ... 8
3.2 Abbreviations ... 9
4 Storage requirements ... 9
4.1 General ... 9
4.2 Assembly data ... 9
4.3 Prerequisite for storage ... 9
4.4 Damage to die products during long-term storage ... 9
4.5 Mechanical storage conditions ... 10
4.6 Long-term storage environment ... 10
4.7 Recommended inert atmosphere purity ... 11
4.8 Chemical contamination ... 11
4.9 Vacuum packing ... 11
4.9.1 General ... 11
4.9.2 Vacuum dry pack ... 11
4.10 Positive pressure systems for packing ... 11
4.11 Use of packing material having sacrificial properties ... 11
4.12 Use of bio-degradable material ... 12
4.13 Plasma cleaning ... 12
4.14 Electrical effects ... 12
4.15 Protection from radiation ... 12
4.16 Periodic qualification of stored die products ... 12
5 Long-term storage failure mechanisms ... 13
6 LTS concerns, method, verification and limitations ... 13
6.1 General ... 13
6.2 Wafers ... 13
6.3 Bare dice ... 14
7 Deterioration mechanisms specific to bare die and wafers ... 15
7.1 Wire bondability ... 15
7.2 Staining ... 15
7.3 Topside delamination ... 16
8 Specific handling concerns ... 16
8.1 Die on wafer film frames ... 16
8.2 Devices and dice embossed or punched tape storage ... 16
8.3 Handling damage ... 16
Annex A (informative) Audit checklist ... 17
Bibliography ... 20

Table 1 – LTS exposure concerns for wafers 14
Table 2 – LTS exposure concerns for bare dice 15
Table A.1 – Planning checklist 17

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ELECTRONIC COMPONENTS – LONG-TERM STORAGE OF ELECTRONIC SEMICONDUCTOR DEVICES –

Part 5: Die and wafer devices

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62435-5 has been prepared by IEC technical committee 47: Semiconductor devices.

The text of this standard is based on the following documents:

FDIS	Report on voting
47/2328/FDIS	47/2351/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62435 series, published under the general title *Electronic components – Long-term storage of electronic semiconductor devices*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This document applies to the long-duration storage of electronic components.

This is a document for long-term storage (LTS) of electronic devices drawing on the best long-term storage practices currently known. For the purposes of this document, LTS is defined as any device storage whose duration may be more than 12 months for product scheduled for long duration storage. While intended to address the storage of unpackaged semiconductors and packaged electronic devices, nothing in this document precludes the storage of other items under the storage levels defined herein.

Although it has always existed to some extent, obsolescence of electronic components and particularly of integrated circuits, has become increasingly intense over the last few years.

Indeed, with the existing technological boom, the commercial life of a component has become very short compared with the life of industrial equipment such as that encountered in the aeronautical field, the railway industry or the energy sector.

The many solutions enabling obsolescence to be resolved are now identified. However, selecting one of these solutions should be preceded by a case-by-case technical and economic feasibility study, depending on whether storage is envisaged for field service or production, for example:

- remedial storage as soon as components are no longer marketed;
- preventive storage anticipating declaration of obsolescence.

Taking into account the expected life of some installations, sometimes covering several decades, the qualification times, and the unavailability costs, which can also be very high, the solution to be adopted to resolve obsolescence should often be rapidly implemented. This is why the solution retained in most cases consists in systematically storing components which are in the process of becoming obsolescent.

The technical risks of this solution are, a priori, fairly low. However, it requires perfect mastery of the implemented process and especially of the storage environment, although this mastery becomes critical when it comes to long-term storage.

All handling, protection, storage and test operations are recommended to be performed according to the state of the art.

The application of the approach proposed in this standard in no way guarantees that the stored components are in perfect operating condition at the end of this storage. It only comprises a means of minimizing potential and probable degradation factors.

Some electronic device users have the need to store electronic devices for long periods of time. Lifetime buys are commonly made to support production runs of assemblies that well exceed the production timeframe of its individual parts. This puts the user in a situation requiring careful and adequate storage of such parts to maintain the as-received solderability and minimize any degradation effects to the part over time. Major degradation concerns are moisture, electrostatic fields, ultra-violet light, large variations in temperature, air-borne contaminants, and outgassing.

Warranties and sparing also present a challenge for the user or repair agency as some systems have been designated to be used for long periods of time, in some cases for up to 40 years or more. Some of the devices needed for repair of these systems will not be available from the original supplier for the lifetime of the system or the spare assembly may be built with the original production run but then require long-term storage. This document was developed to provide a standard for storing electronic devices for long periods of time.

For storage of devices that are moisture sensitive but that do not need to be stored for long periods of time, refer to IEC TR 62258-3.

Long-term storage assumes that the device is going to be placed in uninterrupted storage for a number of years. It is essential that it is useable after storage. Particular attention should be paid to storage media surrounding the devices together with the local environment.

These guidelines do not imply any warranty of product or guarantee of operation beyond the storage time given by the original device manufacturer.

The IEC 62435 series is intended to ensure that adequate reliability is achieved for devices in user applications after long-term storage. Users are encouraged to request data from suppliers to these specifications to demonstrate a successful storage life as requested by the user. These standards are not intended to address built-in failure mechanisms that would take place regardless of storage conditions.

These standards are intended to give practical guide to methods of long-term storage of electronic components where this is intentional or planned storage of product for a number of years. Storage regimes for work-in-progress production are managed according to company internal process requirements and are not detailed in this series of standards.

The IEC 62345 series includes a number of parts. Parts 1 to 4 apply to any long-term storage and contain general requirements and guidance, whereas Parts 5 to 9[1] are specific to the type of product being stored. It is intended that the product specific part should be read alongside the general requirements of Parts 1 to 4.

Electronic components requiring different storage conditions are covered separately starting with Part 5.

The structure of the IEC 62435 series as currently conceived is as follows:

Part 1 – General

Part 2 – Deterioration mechanisms

Part 3 – Data

Part 4 – Storage

Part 5 – Die and wafer devices

Part 6 – Packaged or finished devices

Part 7 – MEMS

Part 8 – Passive electronic devices

Part 9 – Special cases

1 Under preparation.

ELECTRONIC COMPONENTS – LONG-TERM STORAGE OF ELECTRONIC SEMICONDUCTOR DEVICES –

Part 5: Die and wafer devices

1 Scope

This part of IEC 62435, is applicable to long-term storage of die and wafer devices and establishes specific storage regimen and conditions for singulated bare die and partial or complete wafers of die including die with added structures such as redistribution layers and solder balls or bumps or other metallisation. This part also provides guidelines for special requirements and primary packaging that contain the die or wafers for handling purposes. Typically, this part is used in conjunction with IEC 62435-1 for long-term storage of devices whose duration can be more than 12 months for products scheduled for long duration storage.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62435-2, *Electronic components – long-term storage of electronic semiconductor devices – Part 2: Deterioration mechanisms*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
storage environment
specially controlled storage area, with particular control of temperature, humidity, atmosphere and any other conditions depending on the product requirements

3.1.2
long-term storage
LTS
planned storage of components to extend the life-cycle for a duration with the intention of supporting future use

3.1.3
desiccant
hygroscopic substance used to remove moisture from an atmosphere

3.2 Abbreviations

MEMS	microelectromechanical systems
rH	relative humidity
ESD	electro-static discharge
EMR	electromagnetic radiation
RF	radio frequency
MBB	moisture barrier bag
HIC	humidity indicator card
V_{T}	voltage threshold
QSS	surface state charge
I_{OFF}	current off
V_{OFF}	voltage off
VCI	volatile corrosion inhibitors
ILD	inter-layer dielectric

4 Storage requirements

4.1 General

This clause details requirements for storage of dies and wafers including specific environmental options. The required environment and control for any product shall be determined according to the exposure concern detailed in Tables 1 and 2.

For example, if oxygen is determined to be a possible concern for degradation of product over the expected length of storage, then a storage environment should be selected that best reduces the risk of long-term exposure to oxygen during storage.

This section details the different storage options commonly available.

4.2 Assembly data

Care should be taken that data or information required for subsequent processing of the product, such as wafer maps, is useable after storage.

4.3 Prerequisite for storage

Only a product with a known status, including quality and functionality, shall be stored. If in wafer form, the wafer should be inked or a wafer map should be stored in a way that can be used at the end of LTS. Be aware that wafer maps on electronic media may not be retrievable at the end of the storage period and backup methods should be periodically reviewed. It should be noted that ink may also be a potential source of contamination and may require evaluation for LTS.

Where initial 100 % test of the wafer cannot be performed, an alternative method shall be used to determine the overall quality and functionality of the product to be stored. This may include sample testing or qualification of an assembled sample of product representative of the wafers being stored.

4.4 Damage to die products during long-term storage

Defects caused by mechanical damage may affect different regions of the die or wafer and should be considered when designing long-term storage schemes.

4.5 Mechanical storage conditions

In order to ensure adequate mechanical protection for die and wafers, care shall be taken in the initial placement of products in storage containers and removal from these containers after storage. Damage can easily occur during loading and unloading.

During storage, sufficient protection shall be given to the product to guard against movement or vibration. Die or wafer orientation can be important, especially for MEMS or sensor products, to minimize damage due to shock or vibration. Containers and shelving may require anti-vibration or anti-resonance mounting. Packing material should be designed to offer some degree of protection against shock or vibration.

Die and wafers shall not be inspected unless required under a specific sample programme in order to minimize the amount of handling to which the die or wafers are subjected.

Material in contact with the wafer or die surface shall ensure that there is minimal abrasion and adhesion of foreign matter to surfaces.

4.6 Long-term storage environment

These conditions are more stringent than those for short-term storage since the storage environment is critical to successful long-term storage. Packing methods suggested here may not be suitable for shipping, especially by air transportation.

This storage atmosphere is designed to exclude oxygen and limit humidity which are known deterioration sources for unencapsulated semiconductor devices. Actual failure mechanisms shall be determined according to the device being stored with reference to IEC 62435-2.

Cabinets or containers for long-term storage of die or wafers shall use the following conditions:

a) purge gas: 99 % nitrogen or inert gas (see 4.7);
b) temperature: 17 °C to 25 °C;
c) cabinet humidity: rH minimum of 7 %, maximum of 25 %;
d) pressure: slightly above ambient atmospheric pressure.

The gas pressure should be sufficiently high to prevent the ingress of external contaminants.

To control the relative humidity, it is normal for die and wafer storage environments to use high-purity nitrogen, for example, derived from a liquid source.

Relative humidity should not fall below 7 % in order to prevent build-up of electrostatic fields and should not exceed 25 % in order to prevent condensation and moisture ingress. This is important after a storage cabinet has been opened; it is normal to fit a timed purge regulator to rapidly bring the relative humidity back down after a cabinet has been opened.

Packing materials incorporating static shielding, such as metal foils, may also be used. Static dissipative coatings shall not be used since these coatings may degrade during storage and contaminate the die or wafers.

Temperature or humidity during the storage period shall be recorded and logged.

Out-of-limit temperature and humidity conditions shall be dealt with by appropriate corrective action. It is unlikely that a few minor out-of-limit excursions will permanently degrade stored products. However, these out-of-limit conditions shall be taken into account when the product is taken out of storage for use.

4.7 Recommended inert atmosphere purity

When inert gas supply for the storage environment is selected, it shall satisfy the following:

- Better than 99,5 % purity containing
  - less than 0,5 % oxygen,
  - less than 0,01 % other gases,
  - less than 10^{-6} halides, and
  - less than 10^{-6} sulphurated gases.

4.8 Chemical contamination

Die and wafers shall be protected from ionic contamination of the active area or contamination by other chemicals, bearing in mind the mobility of contaminants through semiconductor materials and the possibility of induced intermetallic growths.

Special attention shall be given to the protection of contact areas, active areas and back side contacts. Wafers such as those that use III-V materials are particularly sensitive and may need special consideration.

Any degradable packing material used for die or wafer shipping shall be removed before placing the bare die or wafers in a suitable container for long-term storage. In particular, any packing items that could give rise to chemical or particulate contamination by long-term degradation shall be removed, for example all paper, cardboard, foam or pink film. This shall include any material that has been coated with a film to reduce static (ESD coated) since the film will outgas during storage.

4.9 Vacuum packing

4.9.1 General

Vacuum packing is commonly used for shipping bare die and wafers. However, this method may not be suitable for long-term storage due to the fact that a vacuum encourages ingress of contaminants through packing materials and will degrade over time. Addition of desiccants within the primary packing may cause minor particles to be present that could damage the product.

In general, foam should not be used inside the vacuum pack since foam may release absorbed contaminants when compressed. Nitrogen-filled, closed-cell foam does not have this problem and may be used.

4.9.2 Vacuum dry pack

An industry recognised form of vacuum packing is a vacuum dry pack where a moisture barrier bag is used to contain the primary packing unit of die and wafers, complete with desiccant and HIC card. Light evacuation of the bag is preferred over full evacuation.

Refer to IEC 60749-20-1 for more information.

4.10 Positive pressure systems for packing

Packing methods that use positive pressure are inherently better than vacuum-sealed bags. However, this requires good inlet filtering and is commonly implemented by initial vacuum followed by back-fill with nitrogen to help keep major contaminants out.

4.11 Use of packing material having sacrificial properties

Packing materials are sometimes used that have sacrificial properties, for example the packing material may contain reactive copper which is designed to corrode in preference to