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Edition 2.0 2010-08

TECHNICAL REPORT

RAPPORT TECHNIQUE

Semiconductor die products –
Part 3: Recommendations for good practice in handling, packing and storage

Produits à puces de semi-conducteurs –
Partie 3: Bonnes pratiques recommandées pour la manipulation, le conditionnement et le stockage

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SEMICONDUCTOR DIE PRODUCTS –

Part 3: Recommendations for good practice in handling, packing and storage

FOREWORD

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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 62258-3, which is a technical report, has been prepared by IEC technical committee 47: Semiconductor devices.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
47/2024A/DTR	47/2058/RVC

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

This second edition cancels and replaces the first edition published in 2005. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition.

1. Special requirements have been added throughout the document for optical die, where applicable. For example see 4.3 paragraph 4 and 10.1.3 paragraph 3.
2. The following new subclauses have been added:
   - 4.4.6 ESD Guidelines
   - 5.1 Wafer thinning
3. Subclause 5.2 (Singulation or die separation) has been renamed from the previous Subclause 5.1 (Wafer sawing) and has been expanded to included other methods of singulation or sawing, including:
   - 5.2.2 Wafer scribing
   - 5.2.3 Laser cutting
   - 5.2.4 Dice before grind (DBG)
4. Subclause 5.3.7 (previous edition Subclause 5.2.7) has been changed to include optical and microwave die.
5. In Subclause 6.3, the Subclause 6.3.2 (Specialised wafer tubs) has been added to include wafer tubs specially handle and ship wafers that have not been singulated.
6. Two new subclauses have been to Clause 6:
   - 6.9 Handling and packing of thinned die or wafers
   - 6.10 Packing materials and their reuse
7. A new subclause has been added to Subclause 9.6:
   - 9.6.3 Use of packing material having sacrificial properties
8. Annex A (Planning checklist) has been updated throughout
9. In Annex B (Material specifications) a new subclause has been added:
   - B.5 Adhesive gel tray material specifications

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

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

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

INTRODUCTION

This technical report is based on the work carried out in the ESPRIT 4th Framework project GOOD-DIE which resulted in publication of the ES59008 series of European specifications. Organisations that helped prepare this document included the European IST ENCASIT project, JEITA, JEDEC and ZVEI.

The structure of this International Standard as currently conceived is as follows

Part 1: Requirements for procurement and use

Part 2: Exchange data formats

Part 3: Recommendations for good practice in handling, packing and storage (Technical Report)

Part 4: Questionnaire for die users and suppliers (Technical Report).

Part 5: Requirements for information concerning electrical simulation

Part 6: Requirements for information concerning thermal simulation

Part 7: XML schema for data exchange (Technical Report)

Part 8: EXPRESS model schema for data exchange (Technical Report).

Further parts may be added as required.

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SEMICONDUCTOR DIE PRODUCTS –

Part 3: Recommendations for good practice in handling, packing and storage

1 Scope

This technical report has been developed to facilitate the production, supply and use of semiconductor die products, including:

– wafers,
– singulated bare die,
– die and wafers with attached connection structures, and
– minimally or partially encapsulated die and wafers.

This report contains suggested good practice for the handling, packing and storage of die products.

Success in manufacture of electronic assemblies containing die products is enhanced by attention to handling, storage and environmental conditions. This report provides guidelines taken from industry experience and is especially useful to those integrating die products into assemblies for the first time. It is also intended as an aid to setting up and auditing facilities that handle or use bare die products, from wafer fabrication to final assembly.

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2 Normative references

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The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references the lasted edition of the referenced document (including any amendments) applies.

IEC 60050, *International Electrotechnical Vocabulary*

IEC 60286-3, *Packaging of components for automatic handling – Part 3: Packaging of surface mount components on continuous tapes*

IEC 61340-5-1, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

IEC 61340-5-2, *Electrostatics – Part 5-2: Protection of electronic devices from electrostatic phenomena – User guide*

IEC 62258-1, *Semiconductor die products – Part 1: Requirements for procurement and use*

ISO 14644-1, *Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness*

3 Terms and definitions

For the purpose of this document, the terms and definitions defined in IEC 60050, IEC 62258-1 apply.

4 Handling – Good practice

4.1 General

Contact with the exposed active surface of die products should be avoided. When contact is absolutely necessary, only properly designed tools and materials should be used.

The working environment, including tools, materials and containers for handling and transport of die products should provide for ESD protection (refer to IEC 61340-5-1 and IEC 61340-5-2).

It should also be realised that die products are sensitive to certain chemicals.

4.2 Working environmental controls

The following are the typical recommended working environmental conditions for most semiconductor technologies. Characterisation of the particular technology used should be conducted to determine any specific environmental needs. This working environment should not be used for storage of semiconductor die.

a) Temperature: 17 °C to 28 °C

b) Relative Humidity: 40 % nominal $^{+\ 20\ \%}_{-\ 10\ \%}$

c) Particle count: ISO 14644-1, Class 8 or better

4.3 General handling precautions

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The selection of appropriate tools is critical to successful handling of bare die and wafers. There is a range of specialized tools available for correct handling of die and wafers. If any tooling or equipment is found to damage die products, its use should be suspended immediately.

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Die products should never be allowed to come into contact with each other, or to be stacked on top of each other without the use of suitable separators.

Die products should not be placed with the active side touching a hard surface. The die surface can also be damaged if it touches a soft surface that has embedded hard particles, such as silicon debris.

Extra care is required when handling optical die, such as lasers, where edges of the die may be critical optical facets which should not contact with tools or surfaces.

When handling wafers it is recommended that physical contact should be made only with the outer periphery and/or the back side of the wafer.

4.4 Cleanroom good practice

Containers of bare die or wafers should only be opened in a work area with a controlled environment, known as a cleanroom. This applies to any process that exposes the die or wafer surface to the environment, for example quality checks, die sorting or assembly of products containing bare die.

Personnel working in these areas need to be adequately trained to ensure that die products are not physically damaged nor contaminated when handled in the cleanroom.

4.4.1 General

ESD damage can be reduced through the use of grounded workstations, conductive wrist straps and/or shoe straps, conductive containers, ESD treatment chemicals, conductive floor

waxes, tiles, mats, ionizers, conductive packing foams, and shielded bags. These items can also improve the efficiency of the environmental controls employed.

Bare die or wafers in process should remain in a clean environment at all times. If wafers are to be transported between cleanrooms, a suitable wafer carrier should be used and the container should remain closed during transportation. The container should be externally cleaned on re-entering the cleanroom.

It is recommended that die or wafers should not be handled manually. Handling die or wafers with bare hands should be avoided since this will cause contamination from skin oil, skin flakes, and a variety of other contaminants from human and other sources. Even when using gloves, handling can cause contamination by transfer of plasticizer from the glove. However, it is acceptable to handle wafers with a gloved hand as long as the wafer is held on the edge and the active surface is not touched at all.

All surfaces coming in contact with die products throughout the process should be clean and, when practicable, non-metallic. Any hard material in contact with the die products can cause scratches or chipping.

Care should be taken to avoid contaminating surfaces used for product handling. Working surfaces should not be used to hold non-clean items, such as equipment covers, internal parts or personal belongings. Wiping a surface may not adequately remove oils and residues. These principles should be observed at all times, since if one die or wafer becomes contaminated, the contaminants can be transferred to other surfaces, process equipment and wafers.

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4.4.2 Attire

4.4.2.1 Hats, hoods, nets, masks and shoes

Head and facial hair should be completely enclosed at all times using appropriate hoods or nets to avoid contamination from skin particles or hair.

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It is recommended that masks are worn at all times while in the production area with exposed wafers or die to prevent contamination by spittle. Masks should cover the mouth, and ideally, the nose and should be replaced daily or more often if they become contaminated.

Special ESD-safe cleanroom shoes should be worn within the cleanroom. These shoes should be kept inside the cleanroom or changing area and only be taken outside the area for cleaning or repair. Alternatively, overshoes can be used which should be discarded immediately after use in suitable waste containers. Some overshoes are suitable for re-use after washing, however, they are not intended to be re-used without being cleaned.

4.4.2.2 Smocks and gowns

Special smocks and gowns should be worn within the cleanroom, to cover normal clothing. They should be selected according to the cleanroom classification and should be made of material that is both anti-static and lint-free.

4.4.2.3 Gloves

Gloves serve as the final barrier in preventing release of skin flakes, skin oils, and other hand-carried contaminants. Disposable vinyl gloves that are approved for cleanrooms are appropriate for general use.

Cotton gloves or other gloves that shed lint or powder should not be worn in handling die products, even under vinyl gloves, since vinyl can tear and release particulates from the inner glove. Polyester or nylon gloves may be worn under vinyl gloves. Rubber gloves packed with powder should not to be used.

Gloves should be replaced each time the cleanroom is entered, or more often if they become contaminated in any way, for example by ink or from touching the face. Gloves that have rips or tears should be replaced immediately.

When gowning, gloves should always be put on last, after other items. Gloves should be worn over cuffs on sleeves and should be held at the wrists only at all times.

No contact should be made with face, hair, or other potential sources of contamination by gloved hands; such contamination can be transferred to other items, including die products, process equipment and handling equipment.

4.4.2.4 Finger cots

Finger cots are often used instead of gloves in lower class clean rooms for some back-end operations. These offer less protection from contamination, but are more convenient for some operations, for example wafer quality control inspection. It is recommended that finger cots be worn on all fingers to prevent inadvertent contamination from an uncovered finger. Finger cots should be kept and used in the cleanroom area and not kept in the cleanroom gowning area.

Finger cots should not be re-used and should be replaced if torn or damaged. Fresh finger cots should be used after re-entering the cleanroom.

4.4.3 Conduct

Food and drink should not be allowed in the cleanroom.

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Hands should be washed before gowning and entering the work area, especially after handling foods.

Cosmetics should not be worn in the cleanroom as the chemicals they contain could damage or contaminate die products. Excessive use of creams and lotions should also be avoided since chemical additives can also damage or contaminate die products.

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The following are some of the practices and items that should be prohibited in the controlled environment:

a) smoking or the use of any tobacco product;
b) acts of personal hygiene or grooming;
c) hair brushes or combs;
d) chewing-gum, sweets or candy;
e) plants or cut flowers;
f) pencils or erasers;
g) paper or card products not designed for cleanroom use.

4.4.4 Tools

The use of automated equipment and vacuum tools is preferred at all times for handling die and wafers. Any tool used should not generate ESD hazards.

Tools should only be used for their designed purpose in handling die products and should not be used as screwdrivers, pry bars, letter openers, etc.

4.4.4.1 Pick-up tools and collets

A wafer extraction tool should be used to assist in guiding the wafer out of a cassette in order to avoid scratching or damaging the wafer.

Vacuum wand-tips and die pick-up collets should be cleaned regularly using appropriate materials such as isopropyl alcohol and polyester cleanroom wipes. Extreme care should be taken in handling and cleaning die pick-up tools that touch the active surface of the die.

Wafer vacuum pick-up tools should be used to grasp the back (unpatterned) side of the wafers only.

The largest pick-up tool compatible with the die size should be used in order to deliver the maximum vacuum to the surface of the die. For very small die, increasing the bore size of the pick-up tool may be necessary, most tool suppliers have this capability. Damaged tooling, irregular edges on the tooling, and so forth can also adversely affect die pick-up, since this would prevent the tool from making a good seal with the die. A soft tip on the tool is recommended as this will assist in die pick-up and reduce any damage to the die surface. At no time should a "hard-faced" tool be used for die removal, unless it is designed for "edge contact" of the die only. Tools of this type are typically referred to as collets. Heated collets should not be used to remove die from the membrane due to the temperature limits of PVC. Note that some die have junctions extending to the edge of the die, especially discrete power devices, so that any chipping of the edges of these die can cause leakage or shorts.

If any die are dropped in the assembly work area, they should be inspected by microscope for mechanical damage and contamination prior to returning them to the die bank. It should be ensured that individually-handled die are correctly oriented in a die carrier before they are reintroduced to assembly equipment. Any individual die that fall to the floor of a production line should be scrapped.

4.4.4.2 Tweezers

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Manual handling of individual die with tweezers should be prohibited, but it is recognized that for low-volume use, tweezers may have to be used for operations where conditions do not permit the use of other types of pick-up tools. Where tweezers are used to handle bare die, care should be taken not to chip the edge of the die. They should not come in contact with the active surface since this can create scratches or damage bumps on flip-chip die.

https://ecommerce.sist.si/catalog/standards/sist/62c1c509-1a19-4735-a5ae-e9f39cd070b5/iec-tr-62258-3-2010

Tweezers for handling wafers are of a special design and should be made of plastic or be coated with PTFE and have an off-set to limit the distance they extend onto the wafer. These tweezers should be used to grasp the wafer at the flat of the outside edge and should not be allowed to extend into its centre. The larger tip should contact only the back side of the wafer.

Tweezers should be cleaned regularly using suitable cleaning materials such as methanol or isopropyl alcohol and a polyester clean-room wipe. They should remain at the work area at assigned locations and should not be stored with personal belongings or hung on garments.

Tweezers with a damaged coating should not be used.

4.4.5 Protocol

A protocol should be established in each cleanroom area which shows how personnel and materials are to move from one class-level environment to another without compromising each environment, product, carriers, or protective clothing. This protocol should include the following:

a) physical path to follow for personnel travelling from one area to another;

b) required protective clothing, care, and dressing sequence during gowning or removing;

c) approved flow of materials through the area including identification and required protective packaging;

d) restrictions of materials that are allowed in each area;

e) requirements for managing process equipment in the area, including bringing in new equipment or repairing equipment;

f) maintenance and cleaning of the cleanroom environment.

4.4.6 ESD Guidelines

Die products, either prior to assembly or in a partially assembled state, are very sensitive to ESD damage.

Complete wafers of die products are not immune from ESD damage and are particularly prone to damage due to electrical discharge from equipment and tools used to handle the wafers.

Advanced and small geometry die tend to have reduced on-chip ESD protection circuitry and are ultra-sensitive to ESD.

4.4.6.1 Ionizers

The use of Ionizers is generally the most effective way of reducing potential ESD from handling equipment. Ionizers should be cleaned and balanced on a regular basis including a performance test. Self-balancing ionizers should also be tested periodically to ensure they are functioning correctly. A poorly balanced ionizer could be worse than not having one at all.

5 Process handling issues

5.1 Wafer thinning

Wafers, as cut from crystals of semiconductor materials, are normally thicker than required for final products. Wafers are often thinned after patterning, normally by grinding the backside of the wafer. The trend for advanced products using thin semiconductor die may require additional processing such as plasma etch or chemical-mechanical polish (CMP).

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(https://ecommerce.sist.si)

After mechanical grinding, a stress or damage region can remain which is several microns thick. This stress layer weakens the crystal structure and is normally removed to increase the strength of very thin wafers. This region is normally removed by fine polishing or etching using plasma etch or CMP.

https://ecommerce.sist.si/catalog/standards/sist/...-2010

In order to remove material from the backside of the wafer, it may be mounted face down onto an adhesive film, known as back-grind tape, mounted on a film frame or ring. This tape normally has higher adhesive strength than used for wafer sawing to ensure that the wafer is held rigidly during processing. Ultra-violet (UV) sensitive or heat release tape can be used which has a high adhesion strength during back-grind. This adhesive strength is reduced by the action of UV radiation or heat to enable easy release of the wafer after back-grind.

An alternative method for mounting wafers is to mount them in wax. This can be used for bumped wafers where insufficient adhesion would be obtained using back-grind tape. After grinding, the wax is heated to remove the wafer which then has to be carefully cleaned to avoid leaving any residue on the wafer.

Very thin wafers, i.e. <100um, are very flexible and can easily be damaged if not supported. Additional special handling may be required.

Wafers may need to be supported by or mounted on a temporary rigid carrier during the thinning process to produce very thin wafers. The carrier can also be used during subsequent processing such as singulation, adding a redistribution layer or bonding to another wafer.

5.2 Singulation or die separation

The term singulation used throughout this document includes any method for separation of wafers into individual die devices. Singulation includes wafer sawing, scribing, dicing and dice