

Semiconductor die products —

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

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National foreword

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English version

**Semiconductor die products –
Part 3: Recommendations for good practice in handling,
packing and storage
(IEC/TR 62258-3:2005)**

Halbleiter-Chip-Erzeugnisse –
Teil 3: Empfehlungen für die Praxis
bei Handhabung,
Verpackung und Lagerung
(IEC/TR 62258-3:2005)

This Technical Report was approved by CENELEC on 2006-12-12.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

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This Technical Report supersedes ES 59008-4-2:2000.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the Technical Report IEC/TR 62258-3:2005 was approved by CENELEC as a Technical Report without any modification.

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INTRODUCTION

Organizations that helped prepare this technical report included the ESPRIT GOOD-DIE project, DPC, and JEITA.

SEMICONDUCTOR DIE PRODUCTS –

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

1 Scope and object

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.

2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary*

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

IEC 61340-5-1:1998, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

IEC 61340-5-2:1999, *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*¹

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

¹ Under consideration.

3 Terms and definitions

For the purposes of this document, relevant terms which are defined in IEC 60050, together with additional terms and acronyms as given in IEC 62258-1, shall 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 – 28 °C
- b) Humidity 40 % nominal $^{+20}_{-10}$ %
- c) Particle count: ISO 14644-1, Class 8 or better

4.3 General handling precautions

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.

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 never be placed with the active side touching a hard surface. The die surface may also be damaged if it touches a soft surface that has embedded hard particles, such as silicon debris.

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 may be reduced through the use of grounded workstations, conductive wrist straps and/or shoe straps, conductive material totes, staticide 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 may 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 may cause scratches or chipping. These principles should be observed at all times, since if one die or wafer becomes contaminated, the contaminants may be transferred to other surfaces, process equipment and wafers.

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 clean may not adequately remove oils and residues.

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.

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 may 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. Polyester or nylon gloves may be worn under vinyl gloves. Rubber gloves packed with powder should not 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. 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 taken into the cleanroom.

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 may also damage or contaminate die products.

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 may 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

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 may create scratches or damage bumps on flip-chip die.

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 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.

5 Process handling issues

5.1 Wafer sawing

Wafer sawing is an essential process in the preparation of die products where supplied in unsawn wafer form. Normally, separation into individual components is carried out by cutting the wafer using a high-speed, high-precision, diamond-tipped saw blade. The wafer is affixed to a pressure-sensitive adhesive (PSA) tape mounted to a film frame. Film frames are manufactured from several materials and come in various sizes to accommodate equipment needs and wafer sizes.

Silicon wafers are brittle and special attention needs to be given to the sawing operation to ensure that the individual die are separated without causing damage. For example, particular consideration should be given to

- saw blade type,
- blade rotation speed,
- feed speed,
- flow rate of rinse and cutting water,
- adhesive film type,
- depth of cut,
- dual blade sawing to fully cut away process control modules/test structures in the saw lane, and
- back side and front side chipping.

It is recommended that a "bevel" cut be used for bare die and flip-chip products. This is to help eliminate front, side and back side edge chipping and cracks. The bevel process also eliminates metal flakes from the die edge caused when a nickel/diamond blade cuts through the aluminium test grids in the streets. Due to the potential defects caused by cracks and metal particulate, any deviation from this recommendation can affect the quality of the die. Figure 1 provides a pictorial view of the bevelled edge for both wire-bonded and flip-chip processing.

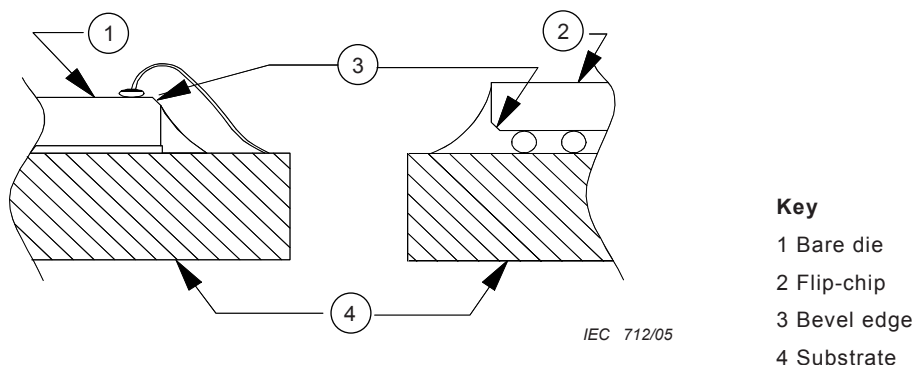


Figure 1 – Bevel cut for bare die and flip-chip products

It is not recommended that a finger or any tool is run under a mounted cut wafer to check the saw cut. This can cause edge chipping by adjacent die moving against each other.

Other wafer material, such as gallium arsenide (GaAs), composites such as silicon on sapphire (SoS) or bonded wafers, require special saw processes.

5.1.1 Guidelines for mounting wafers

Experience in the industry points to the importance of selecting the proper film material for use when mounting wafers. Defect reduction has been observed after wafer dicing when certain films are used. It is recommended that the film vendor be contacted to determine the optimum film for the application. Such things as a higher modulus film, higher tack level and UV films have all shown improved performance in reducing die chipping and fractures.

5.1.2 Use of water

Water is used in the sawing process as a lubricant, coolant and slurry rinse. Only ultra-pure water should be used to ensure that the die are not damaged by contaminants in the water. Ultra-pure water commonly produced by deionization is also highly resistive and static charges may build up during sawing. To reduce this static hazard, it is normal to introduce a small amount of pure carbon dioxide gas to the water by bubbling. However, excessive CO₂ may result in the water becoming acidic and corrosive, therefore the addition of CO₂ should be controlled.

Water additives may be used to improve the cutting process. Any additive used should be fully assessed to ensure die are not damaged by chemicals contained in the additive.

5.1.3 Washing and drying

Residue from the cutting process may remain on the surface of the wafer. It is normal to rinse or wash the cut wafer using ultra-pure water.

The process used to dry the wafer after washing should ensure that the surface is clean and dry.

5.2 Die sorting

Die products may be supplied in wafer form, either pre-sawn on adhesive film or unsawn, which will require sawing before use. In either case, individual die are removed from the adhesive film used in the sawing process to incorporate them into the end product.

Different types of equipment are available for this process and care should be taken to match the equipment to the wafer type and technology. Die especially sensitive to damage are those with unprotected surfaces such as unpassivated die or very thin or fragile die.

Die removed from the adhesive film may be placed into a die carrier for subsequent assembly. This process is known as die sorting and provides for segregation of electrically good die from bad die or separation into different grades of die. Carrier systems for individual die include chip trays, vacuum release trays and tape-and-reel.

5.2.1 Guidelines for handling frames containing sawn wafers

The wafer to be sorted will be mounted on the film frame after sawing. The frame should be well positioned on a holding fixture. The fixture should securely hold the frame during any indexing, loading, unloading or die removal.

5.2.2 Vacuum

Best results are obtained under good vacuum conditions at the pick-up tool and beneath the wafer-film. Manufacturers' recommendations on vacuum pressures should be followed.

5.2.3 Pick-up tools

See 4.4.4.1.

5.2.4 Die contact and removal

Contact force between the pick-up tool and the die should be minimized so that the die is properly engaged by the pick-up tool; the rate of ascent should initially be slow. Timing of the rise of the plunge-up needles and the pick-up tool need to be such that the die remains in contact with the pick-up tool until complete separation from the film has occurred. Rapid ascent may cause large die to separate from the tool before the die has separated from the membrane.

5.2.5 Removal from wafer film

The 'de facto' standard adhesive-backed film, used for mounting wafers to be sawn, changes adhesive strength after the tape is taken off the roll. This is due to the addition of a silicone spray, which serves as a release liner. Gradually, over a period of a few weeks, this additive is released to the atmosphere. This causes the adhesion level to increase after sawing by a factor of five or more and may make the die more difficult to remove during the die sorting process. To minimize this effect, the die sorting process should take place as soon as possible after sawing. Other forms of adhesive-backed film, such as UV tape, are available that do not exhibit this phenomenon.

5.2.6 Needle marks

During the die sorting process, it is common to use a needle or needle bed to remove die from the adhesive-backed film used at sawing. However, some wafers are not suitable for needle offload, such as thin or fragile wafers. For small die, the needle should have a small radius tip and smaller angle A (see Figure 2). The needle should puncture the film to allow the adhesive-backed film to peel off the die, without causing damage to the back of the die. For large die, the needle(s) should have a tip with a large radius and larger angle A. These needles should not puncture the film, but should elevate the die, allowing the film to peel off without leaving any adhesive residue on the back of the die.

Die have various back side surface finishes, some of which are more susceptible to damage by a needle than others.

The profile of the tip of the needle is important to ensure that damage does not occur in the die sorting process, the most important featuring being the radius of the tip as shown in Figure 2.