TECHNICAL REPORT

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First edition
2005-06

Semiconductor die products –

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DIE PRODUCTS –

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

FOREWORD

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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
47/1794/DTR	47/1806/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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 62258, as currently conceived, consists of the following parts, under the general title *Semiconductor die products* [1]

Part 1: Requirements for procurement and use

Part 2: Exchange data formats

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

Part 4: Questionnaire for die users and suppliers

Part 5: Requirements for information concerning electrical simulations

Part 6: Requirements for information concerning thermal simulations

Further parts may be added as required.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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- withdrawn;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.

A bilingual version of this publication may be issued at a later date.

[1] At the time of writing, IEC 62258-3 is the only part in existence. Other parts are under consideration.

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 lasted 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* [2]

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

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[2] 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 is 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 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. 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

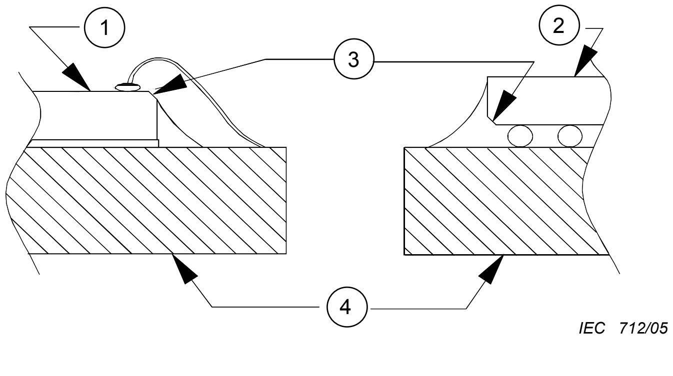
5.1 Wafer sawing

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.



Key
1 Bare die
2 Flip-chip
3 Bevel edge
4 Substrate

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 CO_2 may result in the water becoming acidic and corrosive, therefore the addition of CO_2 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.

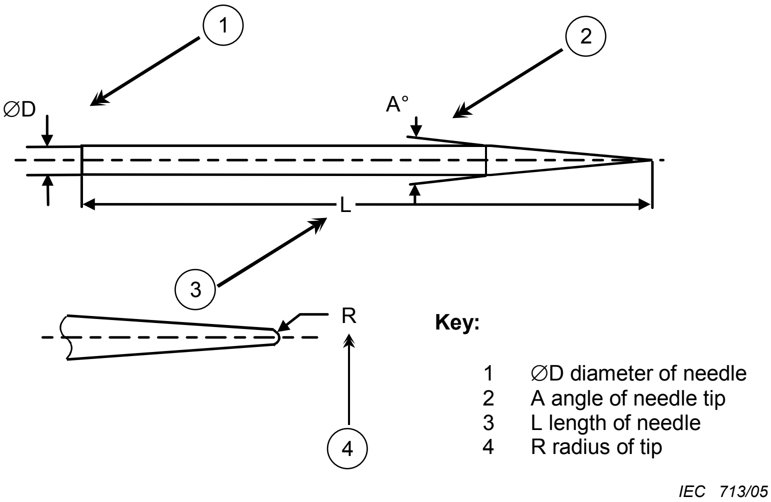
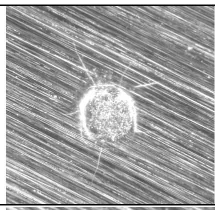
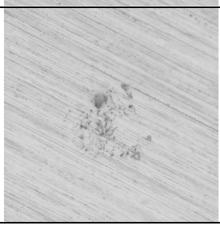
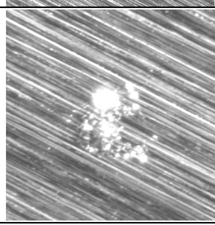


Figure 2 – Die eject needle

Examples of marks caused by die eject needles on the back surface of a back-lapped die are shown in Table 1.

Table 1 – Example die eject marks

Description	Normal lighting	Dark-field lighting	Accept/reject	Cause/remedy
Backlapped wafer – normal surface appearance. No needle mark or film adhesive residue			Accept	Correct die eject set-up – no visible needle mark or film adhesive residue
Excessive needle mark showing micro-cracks			Reject unless there is no evidence of microcracks	Heavy needle mark caused by too much 'over-travel' or wrong choice of needle. Reduce over-travel or change needle
Excessive needle mark, scratches and micro-cracks			Reject	Too much over-travel and incorrect machine set-up resulting in needle bounce. Adjust machine set-up, die eject speed and needle over-travel
Excessive needle mark with scrape and residue			Reject	Die eject not perpendicular to die surface caused by incorrect machine set-up or broken needle. Check machine die eject/replace needle

5.2.7 Unpassivated die and MEMS

Some types of die are unpassivated and require special handling to avoid damage to the top active surface. Use of a normal vacuum pick-up tip can scratch the active surface. A soft rubber tip or collet that grips the edge of the die may be used.

MEMS and sensors may have mechanical features in the centre of the active surface that are susceptible to damage if a normal pick-up tip is used. In this case, a collet that grips the edge of the die should be used.

MEMS and sensors may also have mechanical features that extend through the die. In this case, normal die ejection using a needle should not be used as this may damage the mechanical features on the underside of the die.

6 Die and wafer transport and storage media

Various shipping and storage media are available for transport or storage of die and wafers. Wafer cassettes may be used for transportation and storage within a single facility. Wafer shipping carriers and containers may be used when transferring product between facilities. Shipping and storage boxes may be used to handle sawn wafers on frames (adhesive-backed film held rigid by a frame). Chip trays, vacuum release trays or reels of adhesive-backed carrier tape or pocketed tape may be used to transport singulated die.

Exposure to the work-area air should be kept to a minimum. Wafers and die should be kept in suitable closed wafer storage containers, or reels of die on tape kept in sealed bags. Containers of die or wafers should not be opened outside the cleanroom since the product may be contaminated by particles or moisture in the air. Product shipped via air transportation should be sealed in hermetic bags or containers.

Die and wafer containers should not be touched with ungloved hands, even outside the cleanroom, since ionic contamination may be transferred from the container to the product when subsequently opened in the cleanroom.

Die and wafer storage containers and cassettes should be cleaned regularly, especially whenever visible contamination is present.

Die and wafers should remain in their carriers at all times and should only be removed when they are in process.

Wherever possible, wafer handling tools should be used to manipulate wafers in cassettes. If wafers have to be manipulated by hand, only the edge of the wafers should be touched by a gloved hand. Refer to Clause 5 for information on handling.

6.1 Wafer carriers and cassettes

At various points during their production, semiconductor wafers are transported between different equipment and facilities, such as:

– raw wafer processing and shipping;
– wafer processing including patterning, metallization and passivation;
– back-end processing including test, thinning and bumping;
– finished wafer shipping and handling.

Any of these stages can take place in facilities remote from each other. It is also common to have some stages sub-contracted out to another company.

It is important to differentiate between transportation or process carriers and shipping carriers or systems. Wafer breakages easily occur when a carrier intended for transportation of wafers within a facility is used to ship wafers to a different facility. These carriers are designed to hold the wafers securely for hand or robotic transportation within a facility, but they are not designed for packing in a box and sending via a transport company.

Care should be exercised in choosing the best shipping or process carrier. Damage to the edge of the wafer, in unsawn form, can cause micro-cracks to form which may propagate through the wafer at a later stage, for example during mounting on film, back-grinding or sawing. This may lead to the wafer breaking into pieces or shattering when handled.

Wafer cassettes should be handled from the ends, touching only the exterior surfaces. Avoid picking up a cassette from the top.

If it is necessary to transfer wafers to a different carrier, slide transfer of wafers (cassette to cassette) should be used whenever possible. Wafers should slide gently. Dump transferring wafers from cassette to cassette should never take place since this is likely to damage or contaminate wafers.

6.2 In-process carriers and transport systems

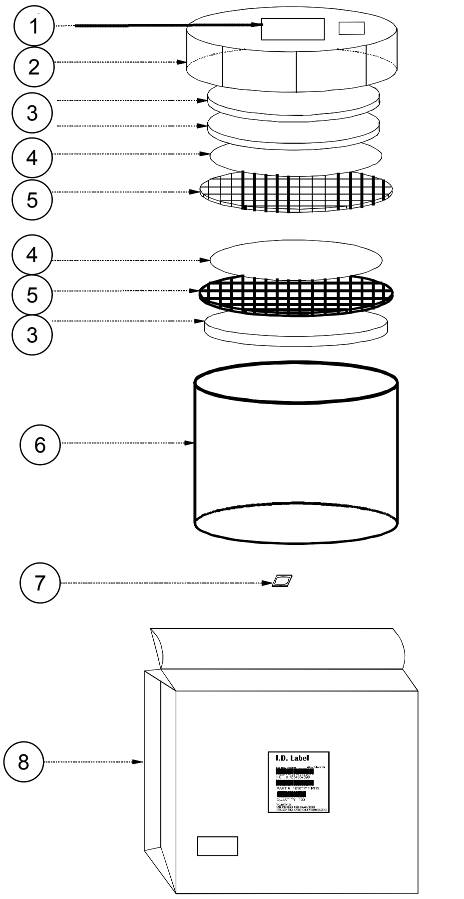
A wafer cassette is the primary form of container used in transporting and storing wafers. Whenever practical, cassettes of wafers should be handled as a unit rather than handling individual wafers. Many types of carriers are available for use with sawn or unsawn wafers and are designed for moving wafers around the processing area or for temporary storage. They are not designed for shipping wafers.

Two versions are available for sawn mounted wafers on film frame or grip ring. It should also be noted that there are a large variety of film frame sizes and types, and careful selection of the correct carrier is necessary.

6.3 Packing for shipment of unsawn wafers

Wafer tubs or jars are often used to transport unsawn silicon wafers. The manufacturer's packing instructions should be followed during loading and unloading to ensure that wafers are not damaged when using this packing method.

The structure typically comprises a lid and base with a lining made of static dissipative material in which the wafers are placed, interleaved with separators. The number of wafers in a single jar is normally limited to less than 50. It is recommended that only wafers from a single wafer lot are contained in each wafer shipping jar. After the lid is secured to the base, a label detailing the primary product identification and traceability information should be placed on top of the lid. The jar should then be placed into an ESD shield shipping bag and a final label placed on the outside of the bag. Figure 3 provides a pictorial view of this structure. To prevent wafer breakage, it is critical that the jar is overfilled. This overfill creates a light compression on wafers when the lid is snapped onto the jar, preventing wafer movement inside the jar, which in turn helps to avoid wafer damage.



Key

1 ID and ESD label
2 Wafer container cap
3 Static dissipative foam
4 Spun-bonded lint-free disk
5 Wafer
6 Wafer container with static dissipative foam
7 Desiccant
8 ESD shield bag with ID and ESD labels

Figure 3 – Wafer jar structure

Removal of wafers from the shipping jars should only be effected in a cleanroom environment while following proper ESD procedures so as not to affect product quality. It is recommended that air ionizers be used when handling wafers and wafer cassettes during removal and processing. Care should be exercised in removing wafers from the shipping jars; damage in the form of micro-scratches can occur if the active surface of the wafer comes in contact with a tool such as a pick-up wand or tweezers. Manual handling of the wafers should be discouraged.

It should be noted that wafer jars are not suitable for long-term storage of wafer products. The foam liner most commonly used degrades with time and exposure to light, giving off fluorine which is harmful to the wafer. However, special closed-cell foams are available which are filled with nitrogen and do not degrade or give off gases (see long term storage – Use of bio-degradable material, 9.6.3). If in doubt, consult suppliers for details of the type of foam used.

6.4 Packing for shipment of sawn wafers

When the wafer is sawn it is mounted onto adhesive film which is held by either a film frame or a grip ring. Wafers sawn on frame may be transferred to grip rings providing additional stretching of the film. This helps separate the die to aid the offload operation.

Shipping wafers using this method may have a limited storage time before the die have to be offloaded. The adhesive commonly used in this type of film changes strength over time. Immediately after the wafer is mounted, the adhesive strength begins to increase. While this can be beneficial to the sawing process, it is detrimental to the die offload process since die are more difficult to remove the longer they are left on the film. Ideally, die should be removed as soon as possible after the sawing process.

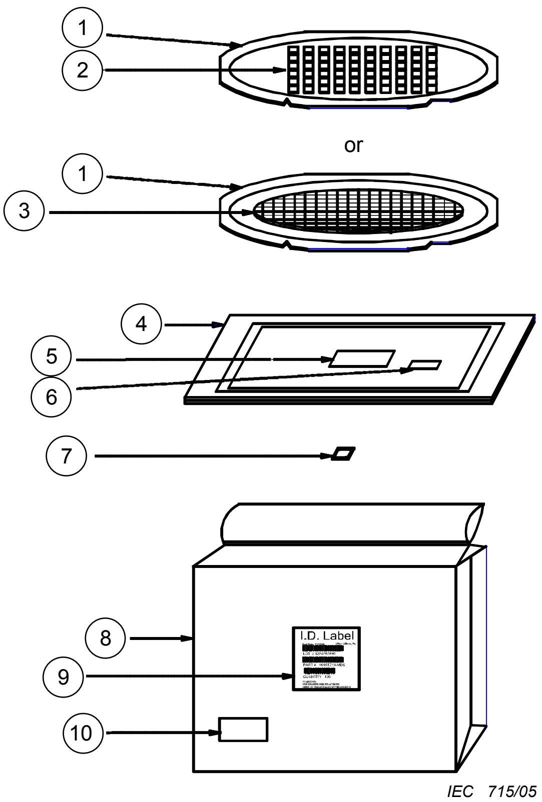
Other film types are available which have different adhesive properties, for example UV film. With these films, light of a particular wavelength and/or heat are applied after sawing to reduce the strength of the adhesive. This makes the die easier to remove from the film.

Whichever film system is used, sawn wafer on film should not be used for long-term storage of wafers.

6.4.1 Film frames

‘Film frame’ is an industry term used to describe a frame, in which an adhesive film and wafer are mounted, used for die processing and transportation. Film frames are manufactured from several materials and come in various sizes to accommodate differing equipment needs and wafer sizes, usually designed with two registration notches on one edge to facilitate handling through automatic equipment.

Film frames are placed in shipping frames and a label is attached to the lid. The assembly is then placed in an ESD shield bag with desiccant and a final label is attached to the outside. Figure 4 provides a pictorial view of this structure.



Key

1 Film frame

2 Sorted die

3 Wafer

4 Wafer shipper

5 ID label

6 ESD label

7 Desiccant

8 ESD shield bag

9 ID label

10 ESD label

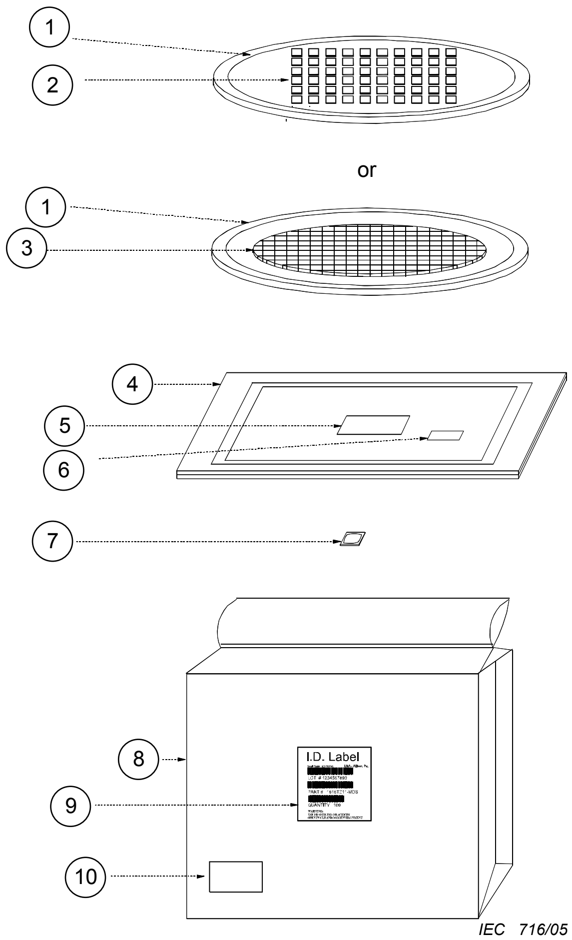
Figure 4 – Film frame

The quality of the wafer depends a great deal on the environment in which wafers are opened and stored. It is recommended that die shipped in this format be used as quickly as possible due to a tendency of the tack level of the film to increase over time (see 5.2.5). Advice on recommended storage times should be sought from the supplier or manufacturer.

6.4.2 Grip rings/expander rings

'Grip ring' is an industry term used to describe a two-part circular frame on which an adhesive film and wafer are mounted, used for die processing and transportation. Grip rings are manufactured from several materials and come in various sizes to accommodate equipment needs and wafer sizes.

Grip rings are designed with no registration notches to facilitate handling through automatic equipment. Grip rings are placed in a shipping container with a label attached to the lid. The assembly is then placed in an ESD shield bag with desiccant and a final label is attached to the outside. Figure 5 provides a pictorial view of this structure.



Key

1 Grip ring
2 Sorted die
3 Wafer
4 Wafer shipper
5 ID label
6 ESD label
7 Desiccant
8 ESD shield bag
9 ID label
10 ESD label

Figure 5 – Grip ring

6.4.3 Holding fixture

The ring or frame should be well positioned on a holding fixture. The fixture should securely hold the ring during any indexing, loading, unloading or die removal.

6.4.4 Vacuum

See 5.2.2.

6.4.5 Pick-up tools

See 4.4.4.1.

6.4.6 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, and 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 membrane has occurred. Rapid ascent may cause large die to separate from the tool before the die has separated from the membrane. A minimum of three needles should be used for film penetration and die presentation, except for very small die where there is only room for one needle. In order to neutralize electrostatic charge on the die and equipment during removal, ionized air should be continually blown onto the surface of the wafer.

6.5 Packing for shipment of single wafers

These carriers are for use with sawn or unsawn wafers mounted on film and are designed for shipping single wafers.

6.5.1 Carriers

A carrier specially designed for shipping single wafers is preferred.

Versions are available for wafers mounted on film frame or grip ring. Although there is a large variety of film frame sizes and types, most should be accommodated by this system.

6.5.2 Vacuum bags

Another technique involves placing the film frame or ring with a rigid support into a vacuum–sealed, ESD shield bag. This shipping method is suitable only for sawn wafers.

A custom separating disk is placed over the face of the wafer to protect the surface of the die. A disk of low-lint laboratory grade filter paper disk is placed over the separating disk to cover the whole interior width of the frame. A disk made of card or thin board is then placed over the filter paper. This disk has a diameter smaller than the inside diameter of the frame and a thickness equal to approximately half the thickness of the frame. A second card or thin board disc is placed on the underside of the film frame. The assembly is then placed carefully into a ESD shield bag and sealed using a vacuum sealer.

The sealed bag is then placed into an anti-static cardboard box for shipping. This box may be designed with a cushioned interior for a single wafer, or may contain several wafers stacked together with each wafer individually vacuum-packed.

In the case of a sawn wafer on film mounted in grip rings, a similar packing method may also be used.

6.6 Packing for shipment of die using trays

Die products may be presented to placement machines in a variety of ways including waffle packs, vacuum release trays, die on tape and sawn wafer formats.

The particular packing form selected may be based on volume and throughput considerations. Whereas both waffle pack and tape feeding require die-sort/pick-and-place processes upstream from chip attach, tape feed is better suited to higher volumes.

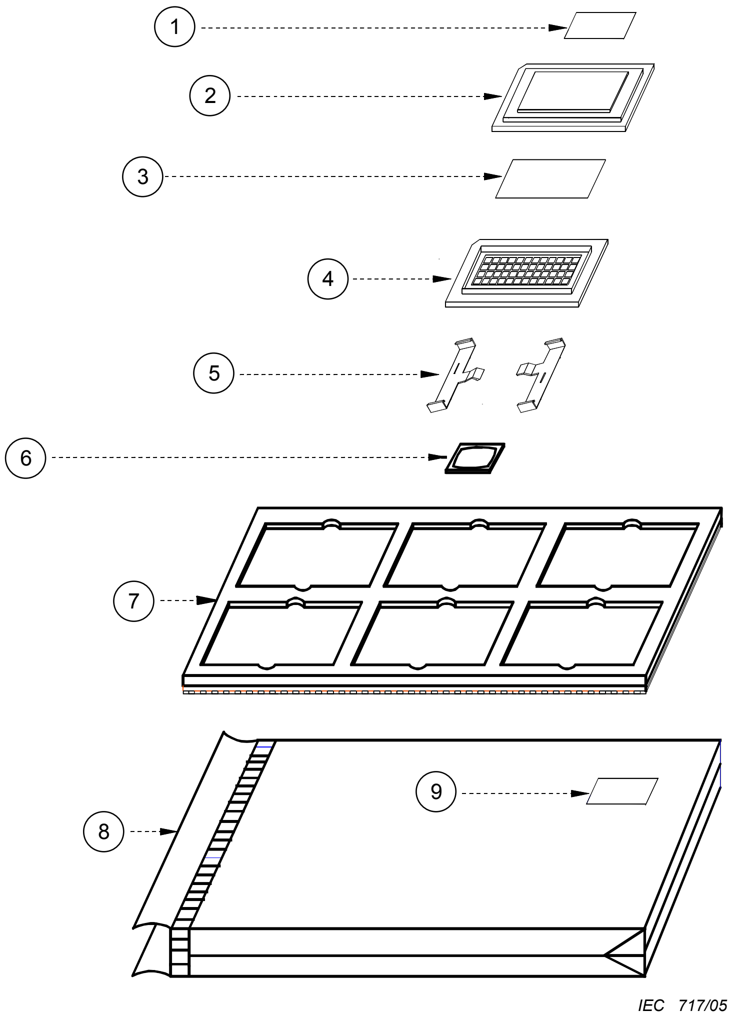
6.6.1 Waffle packs

Waffle packs, or chip trays, are commonly used for handling and shipping die products including bare die, CSP, opto-electronics and other microelectronic devices. They are made using a variety of materials for particular applications. Materials which are ESD-safe should be used for die products. Each pack or tray is specific to a narrow range of die sizes with compartments designed to hold the die in a specific position. Waffle packs or chip trays are normally available in 50 mm^2 or 100 mm^2 sizing.

Each pack or tray has a matrix of cavities in which die are placed. A wide variety of pack or tray types is available with different cavity width, length and depth. Issues in handling include controlling the aspect ratio and size of the die relative to the cavity size of the pack or tray. This requirement is needed to reduce die movement during handling which may damage the die, to shorten search time for die fiducials and to allow the optimum pick tools to be used.

Ideally, the cavity size should be no more than 10 % larger than the die size in each axis. A lid and clips, are applied after a lint-free sheet is placed over the die. The waffle packs are then placed in the ESD shield bag with desiccant and a final label is applied to the outside of the bag.

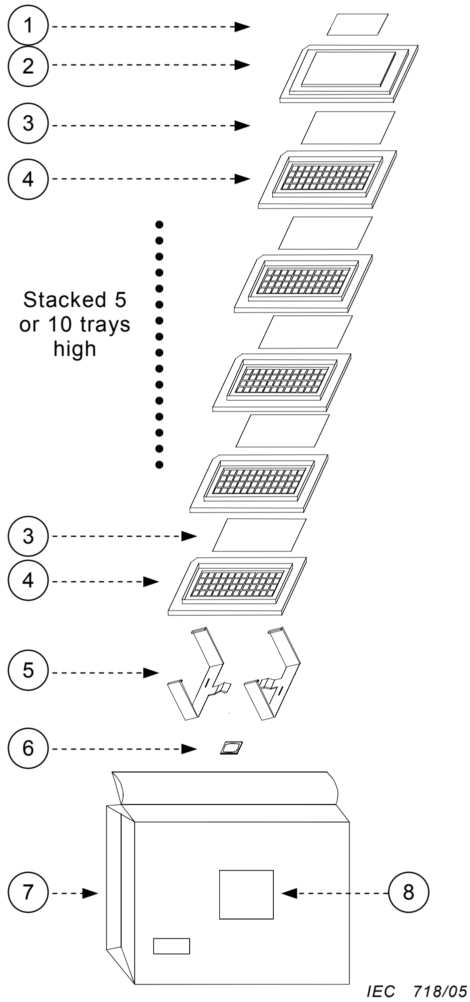
Waffle packs may be in a single (see Figure 6) or stacked (see Figure 7) configuration. Different clips are available for these configurations



Key

1 Product ID label
2 Lid
3 Lint-free sheet
4 Matrix tray
5 Clips
6 Desiccant
7 Pallet (optional)
8 ESD shield bag
9 ID label

Figure 6 – Single waffle pack



Key

1 Product ID label

2 Lid

3 Lint-free sheet

4 Matrix tray

5 Clips

Figure 7 – Stacked waffle packs

After removal of the clips, lid and lint-free sheet, the die can easily be removed using a vacuum pick-up tool. The tray should be well positioned on a holding fixture which should securely hold the tray during any indexing, loading, unloading or die removal.

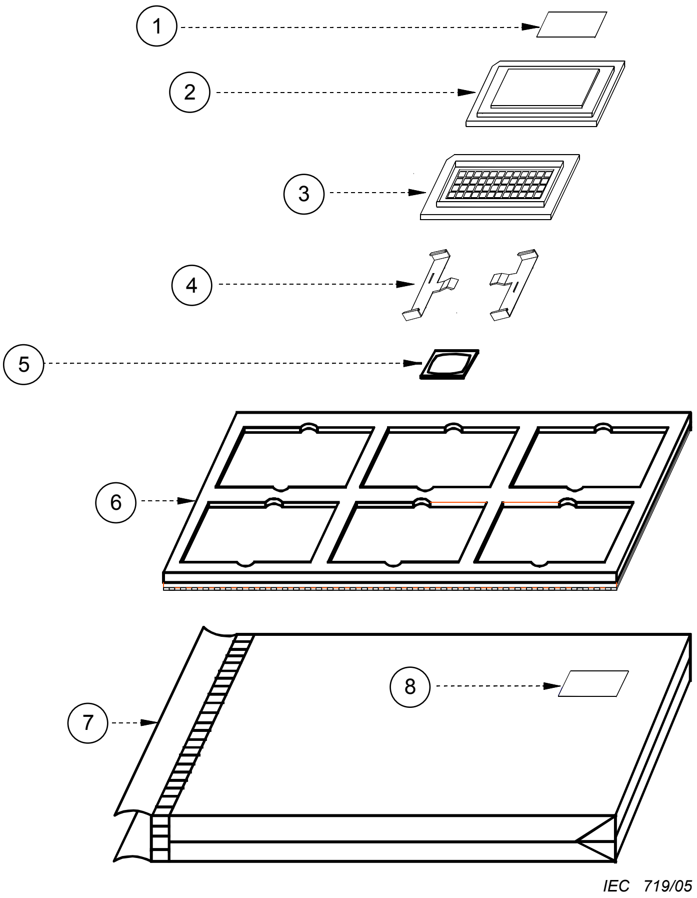
6.6.2 Vacuum-release (VR) trays for die products

These trays are similar to waffle packs, but instead of holding the die in cavities, the surface of the VR tray is comprised of a proprietary gel membrane placed over a mesh material. Die placed on the surface of the membrane are held securely in place for handling and shipping. Die are released on demand by drawing a vacuum under the membrane through a hole in the bottom of the tray. Die may then be removed using normal pick-up tools. Various die sizes can be loaded on the same VR tray since there are no pockets.

The trays are designed to be re-used and are especially good for handling small or fragile die products and for use on high speed pick-and-place equipment. The proprietary gel membrane holds the die in place, preventing damage to the edges and top surface. There is no contact to the top surface and a lid insert is not required. The depth of the cover ensures that there is adequate clearance between the inside of the lid and the top of the die. Once loaded on the tray, the orientation of the die is controlled which reduces the need for correction by the pick-and-place equipment.

Die are normally loaded in matrix form, rows and columns, with X and Y references taken from the reference corner of the tray. Sufficient gaps are left between rows and columns to allow removal of any single die without touching or disturbing adjacent die.

The depth of the lid should ensure that there is a gap between the inside of the lid and the top of the die. A lid with a product label and clips are applied after die have been sorted into the tray. The trays are then placed in an ESD shield bag with desiccant and a final label applied to the outside of the bag. Figure 8 provides a pictorial view of this structure.



Key

1 Product ID label
2 Lid
3 Gel tray
4 Clips
5 Desiccant
6 Pallet (optional)
7 ESD shield bag
8 ID label

Figure 8 – Vacuum-release trays

6.6.2.1 Guidelines for handling vacuum-release trays

6.6.2.1.1 Holding fixture

The tray should be well positioned on a holding fixture designed to deliver a vacuum to the underside of the tray. The holding fixture should have a rubber gasket or O-ring to prevent leakage in the system.

6.6.2.1.2 Vacuum

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

NOTE The gel membrane may appear to be in a release mode even under relatively low vacuum conditions. Therefore, one should not rely on the appearance of the gel membrane as evidence for adequate vacuum.

6.6.2.1.3 Pick-up tools

Due to the nature of the membrane material, heated collets or pick-up tools should not be used for die removal from the tray. If heated tools are required, initial pick-up should follow the guidelines above with the die transferred to an intermediate stage for final pick and bond.

6.6.2.2 Membrane tear

The membranes are somewhat fragile and should be handled with care. If a membrane tears, then vacuum leakage at the tray will occur, inhibiting die removal. If a tear prevents proper die removal it may be necessary to overcome this by placing a small piece of tape over the torn area.

6.6.3 Recommendations for die orientation in trays

Orientation of die in trays is an issue with many facets. The die user needs to take into account the die assembly methods, applicable standards and cost.

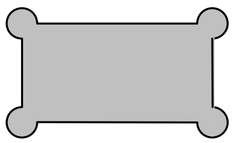
Die should be consistently placed in the tray using the same orientation. Where necessary, the die orientation should be specified.

Each tray should contain die from a single chip lot or bump lot exclusively. Partially filled trays may be permitted as long as the proper quantity is reflected on the labels and within the documentation.

For flip-chip products, die are loaded into the vacuum release tray with the bumps facing up, or away from the gel.

6.6.4 Corner relief

During transportation, the corners of the dies are sensitive to damage due to their free movement in the cavity. This problem may be overcome by using chip trays cavities with so-called half-moon corners as shown in Figure 9.



IEC 720/05

Figure 9 – Corner relief in the cavity of a chip tray

6.7 Packing for shipment of die using tape-and-reel

Tape-and-reel packing systems are primarily intended for high volume and automated handling.

The International standard covering tape-and-reel packing systems for surface mount components is IEC 60286-3. This standard serves as a guideline for the selection and design of tape-and-reel packing systems for surface mount components including die products. Details about embossed, adhesive backed and punched tape are fully defined in IEC 60286-3.

6.7.1 Embossed tape with cover tape

Embossed tape, or pocketed tape, is a standard form of delivery for components intended for assembly on high-speed automation equipment. Components are placed into individual pre-sized pockets or tub-like cavities along the length of a strip of tape; each pocket is sealed by a cover tape. The tape is then wound onto a reel for ease of handling.

Versions of embossed tape exist for shipping and handling die products. These use a special embossing method to produce a pocket with precise dimensions and a bottom formed to avoid die damage or scratch, including a flat bottom. Corner relief may also be provided to help prevent damage to the corner edges of the die. Embossed, or pocket tape is used to ship bare and bumped die from a supplier to the customer. Die can be loaded either active side up or active side down, as required.

The structure comprises a base tape of conductive material in which pockets are formed, customized to the die size specified. A static dissipative cover tape is then applied along the length of the tape to secure and protect the die during shipping and assembly. A product ID label is applied to the reel and then the reel is placed in a ESD shield bag with a product ID and ESD label attached.

6.7.2 Punched tape with top and bottom cover tape

Punched tape consists of a conductive carrier tape with cavities appropriate to the dimensions of the device. The tape has industry standard sprocket holes and static dissipative cover tapes on the top and underside of the carrier tape. Similar tape made from paper products is not suitable for use with die products.

The thickness of the carrier tape is directly proportional to the thickness of the device, thus providing protection to the device while preventing tilting or inversion of the device.

Clear cover tapes on the top and bottom of the carrier tape allows for visual inspection of both sides of the device. Punched tapes also allow for bare die and wafer level packages to be taped and reeled with the active side either on the top or the underside, thus eliminating the flipping operation either at tape-and-reel or pick-and-place.

Corner reliefs may be included in the cut-outs to ensure there is no damage to the corners of the devices and to ensure a clean pick-and-place operation.

6.7.3 Adhesive-backed punched carrier tape (without cover tape)

Adhesive-backed punched carrier tape is a punched conductive plastic carrier containing pressure-sensitive adhesive (PSA) tape affixed to the bottom side. Die are retained by the PSA tape in a fixed orientation, as placed, until picked. A cover tape is not required. Thus, there is no component displacement during peel back, while leaving components accessible for inspection, testing, marking and other processing by automated means. Adhesive-backed tape is intended for use in packing singulated bare die for high-speed automated chip-on-board (COB) and flip-chip assembling.

This system is especially good for handling very small or fragile die and for use on high-speed pick-and-place equipment. Die are placed within oversized compartments so that one tape size can accommodate a range of different die sizes. The die are secured in fixed, repeatable positions when taped and are individually centred at a reference point relative to the sprocket drive holes. Each die may then be 'blind picked' from the tape without the need for machine vision.

6.7.4 Cover tape recommendations

When applying cover tape to embossed or punched carrier tape, the sealing process should ensure that a very smooth peel can be achieved during de-taping. The de-taping of bare die requires extreme care to prevent the die from bouncing out of the carrier.

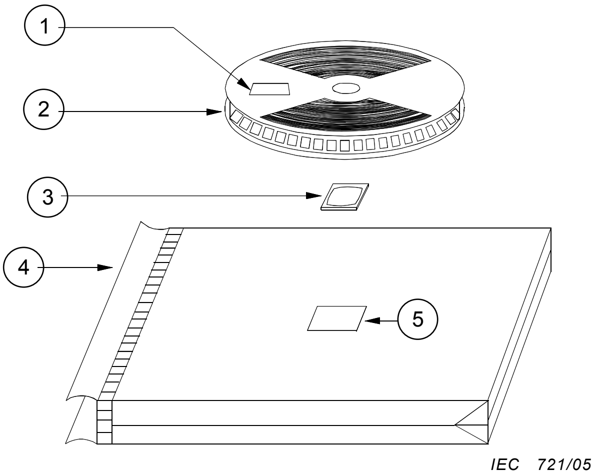
6.7.5 Orientation of die in tape-and-reel

Orientation of die in tape-and-reel is an issue with many facets. The die user needs to take into account the die assembly methods, applicable standards and cost. However, since tape-and-reel is designed for high-speed assembly lines, correction of the orientation by the pick machine may reduce the speed and accuracy of placement.

Die orientation should be agreed between customer and supplier. Die should be consistently placed in the tape using the same orientation. Any die not in the proper orientation may be considered defective. Any change to the die orientation of an existing product should be considered a product re-design requiring sufficient notification.

6.7.6 Tape-and-reel packing structure

The inner shipping structure for shipping the product in a tape and reel is represented in Figure 10. After die are placed into the tape and the tape is spooled onto the reel, a label is attached to identify the product. This is then placed into a vacuum bag along with desiccant and sealed. After sealing the bag, a final label with the same information is placed on the outside of the bag.



Key

1 Label

2 Tape-and-reel

3 Desiccant

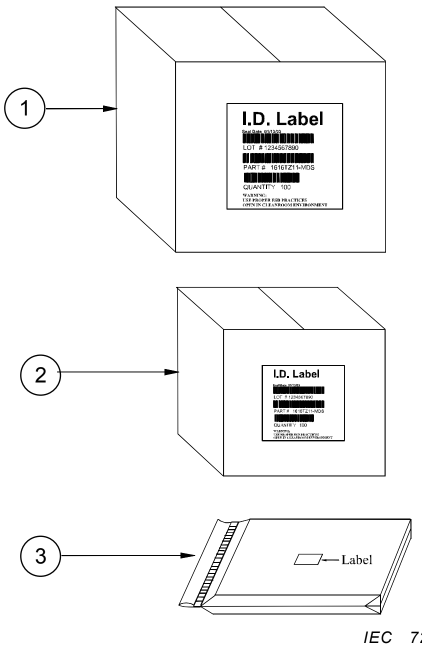
4 Vacuum bag

5 Label

Figure 10 – Tape-and-reel packing structure

6.8 Secondary packing for shipment

All materials used in the final shipping structure are selected for their ability to protect the devices from damage during shipment and to support environmental requirements on leaving the control of the die supplier and entering the customer's facility. Protection is provided for mechanical, electrical and environmental hazards. The product, sealed in a specialized static protective vacuum bag, is placed in an inner shipping box lined with a static protective shock-absorbent material. A label identifying the product is then placed on the box. The inner shipping box is then placed in an outer shipping box that is lined with shock-absorbent material. A final label identifying the product is then placed on the outer box. Figure 11 provides a pictorial view of this structure.



Key

1 Outer box with label

2 Inner box with label

3 Vacuum bag with label

Figure 11 – Packaging material for shipment

7 Storage good practice

7.1 Die and wafer storage

Die and wafers may be stored briefly in open containers during operation if they are exposed only to clean air, preferably supplied by uninterrupted laminar air flow. At all other times, die and wafers should be stored in clean containers in a controlled environment. This method of storage is commonly referred to as short-term storage. When a container is opened, contaminants from the outside are able to enter and contaminate the die products, the container, and the interior of the container. For this reason, containers should be stored in a clean environment and care should be taken to open the lid gently. Containers should be opened in filtered air only. Unsealed containers should be stored in a controlled environment. Doors on cabinets should be kept closed at all times when not in use.

7.2 Short-term storage environment and conditions

When not in process, devices should be stored in an inert (dry air or nitrogen) environment, preferably in the manufacturer's original container or one suitable for the storage of bare die or wafers. The following storage conditions are recommended for most die devices:

a) Atmosphere: 99 % nitrogen or dry air

b) Temperature: 17 °C – 28 °C

c) Humidity: RH minimum of 7 %, maximum of 30 %
(A minimum of 7 % RH is desirable to avoid electrostatic damage)

d) Particle count: ISO 14644-1, Class 6.

In short-term storage environments, the humidity conditions are normally satisfied by supplying the environment with a continuous purge of filtered dry air or dry nitrogen. However, care should be taken to ensure that any static charge build-up resulting from the dry atmosphere does not damage die or wafers.

7.3 Storage time limitations

Maximum recommended storage times are governed by several different modes of deterioration, for example:

– wire bondability is limited by both build-up of oxide and deposit of organic contaminants;

– solderability of flip-chip with solder bumps may be limited by build-up of oxide;

– die stored on wafer film frames may be subject to problems of removal from the adhesive which tends to increase in strength over time;

– retrieval of die stored in embossed or punched tape may be subject to problems in removing the cover tape due to increasing strength of adhesive;

– die with organic passivation (polyimide or BCB) tend to absorb moisture which will subsequently outgas during high-temperature processing;

– all bare die and wafers should be protected from contaminants that could lead to corrosion and semiconductor junction failures during use.

The temperature, humidity, oxygen level and purity of the ambient conditions during storage will have an impact on all these factors. Die in carrier tape or wafers in cassettes should be considered as bare die or wafers. The tapes or cassettes themselves are not barriers to moisture or other contaminants.

7.4 Sawn wafer on wafer frame or ring

Die should not be stored on wafer frames containing a solid sticky tape membrane. The adhesion level of most widely used adhesion tapes increases by five or more times within two weeks when exposed to atmosphere. This may result in difficulties when picking die from wafers and may result in die breakage, edge chipping and potential latent defects caused by undue stress.

7.5 Die products in the production area

Exposed die or wafers should not be kept for more than 8 h in the atmosphere of the production area. They should be transferred to a suitable storage container when not in use in production or at the end of the production shift.

7.6 Die in tape-and-reel

Die in tape-and-reel should be used typically within 12 months when stored in a controlled environment. Beyond this time the cover tape adhesive may lose its strength or adhesion may increase and the cover tape will be difficult to remove.

7.7 Dry-packed die products

Dry-packing has a finite effective life due to the deterioration of the desiccant and moisture penetration through the packing material.

8 Traceability good practice

8.1 General

Traceability is an important issue for die products since most die or wafers have no marking that uniquely identifies the product type and lot number. MPDs or CSPs are normally marked in the same way as packaged products and do not require special traceability considerations.

8.2 Wafer traceability

Wafers normally have some form of lot marking scratched or etched on the edge or back side of the wafer. This may uniquely identify the wafer or may relate to the lot of wafers that were processed in the same batch.

If the wafer is to be thinned before use, then any marks on the back of the wafer will be lost. Care should be taken to ensure that traceability of the wafer is not compromised if these marks are lost.

Normally, traceability is only required to the process lot which may comprise anywhere from 20 to 50 wafers. However, some applications require that individual wafers are traceable within the lot.

8.3 Die products traceability

Care should be taken to ensure that any information from labels on the primary packing are kept with the batch of die until assembly is complete or until the die are placed in alternative primary packing containers.

Die from different lots should be kept segregated. Die from different lots should not be placed in the same chip tray.

A reel of taped die may contain product from different wafers of the same lot or even wafers from different lots. In order to maintain traceability, the die user may need to identify different lots or wafers within the reel. This may be done by inserting a series of blank pockets between die taken from different wafers or lots. The order in which the wafers are loaded on the tape should be identified with the list of wafer traceability information for all die contained on the reel. During assembly of the die product, automatic pick-and-place machines may be set up to stop if two or more empty pockets are found in the reel. This would enable the operator to identify a lot change in the reel and update any traceability information that is being used.

Some programmable devices may contain lot traceability in electronic form in the on-chip memory. Where this is the case, subsequent processing should ensure that the electronic lot traceability information is not erased.

8.4 Wafer and die back side marking

Die or wafers may be marked on the back to aid identification and traceability, especially for flip-chip products.

Commercial wafer marking may be performed using a laser. The laser type and parameters should be selected carefully to ensure legible marking without damaging the back side of the wafer. In particular, the laser mark should not penetrate too deeply into the material or damage diffusion zones by localized heating.

Die with laser marking may need special die attach methods or conditions.

Back side marking may also be performed using suitable ink. This should be a permanent mark that is not affected by subsequent processing such as wafer saw and wash. Tests should be performed to assess the marking permanence and to ensure the ink does not damage the wafer or die material. Die marked using ink are normally used for flip-chip attach.

A complete wafer may be marked on the front surface around the edge of the wafer. All active areas of the wafer should be avoided.

9 Guidelines for long-term storage (die banking) of bare die and wafers

9.1 General

Long-term storage assumes that the die or wafer is going to be placed in uninterrupted storage for a number of years. It is essential that the die are useable after storage. Particular attention should be paid to storage media surrounding the die or wafer together with the local environment. Care should be taken that data or information required for subsequent processing of the product, such as wafer maps, is useable after storage.

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

9.2 Preparing for storage

Only a product with a demonstrable expectation of correct functionality should be stored. If in wafer form, the wafer should be inked or else stored with the wafer map in a human-readable form. Wafer maps on electronic media may not be legible at the end of the storage period and should not be relied upon.

The best conditions for accelerated testing of storage reliability are through temperature cycling or humidity cycling or a combination of the two.

9.3 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.

9.3.1 Long-term storage failure mechanisms

Failure mechanisms that may occur during long-term storage include:

- outgassing of packing materials causing ionic contamination;
- humidity infiltration of packing material causing metal corrosion;
- interactions between incompatible packing and/or IC materials causing hazardous reactions;
- temperature cycling causing metal fatigue, solder creep or glassivation crazing;
- improper handling causing cracking, scratches or contamination to die surfaces;
- non-specific electrical or radiation events in the atmosphere causing gate oxide and metallization failures;
- piezo-electric effect – changing electrical parameters through in-built stress,
- photovoltaic effect – changing electrical parameters through imposed charge,
- electrical overstress caused by ESD or other sources of radiation.

9.3.2 Mechanical storage conditions

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

During storage, sufficient protection needs to be given to the product to guard against movement or vibration. Die or wafer orientation may 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 should 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 should ensure that there is minimal abrasion and adhesion of foreign matter to surfaces.

9.4 Long-term storage environment

These conditions are more stringent than those for short-term storage (see 7.2), since the storage environment is critical to successful long-term storage. The methods suggested here may not be suitable for shipping, especially by air transportation:

a) Atmosphere:	99 % Nitrogen or inert gas
b) Temperature:	17 °C – 25 °C
c) 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.

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

9.5 Recommended inert atmosphere purity

Inert gas supply for the storage environment should satisfy the following:

Better than 99,5 % purity containing

– less than 0,5 % oxygen and argon,
– less than 0,01 % other gases,
– less than 1^{-6} halides, and
– less than 10^{-6} sulphurated gases.

9.6 Chemical contamination

Die and wafers should 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 should 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 should 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 should be removed, for example all paper, cardboard, foam or pink film. This should include any material that has been coated with a film to reduce static (ESD coated) since the film will outgas during storage.

9.6.1 Vacuum packing

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 can cause minor particles to be present.

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.

9.6.2 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.

9.6.3 Use of bio-degradable material

Some packing material is deliberately bio-degradable, such as the foam commonly used in wafer jars or tubs. Packing materials which are known to deteriorate over time should not be used since emission of chemicals during deterioration may contaminate the product. Examples here include:

– sulphur from rubber bands;

– chlorine from cardboard and paper;

– fluorine from antistatic foam.

Some foams are designed specifically for long-term use and are not biodegradable, e.g. closed-cell foams with nitrogen filling. If using a carbon-filled variant of this type of foam, take care to ensure that the carbon is fixed in the material and cannot shed particles when compressed or disturbed.

9.7 Electrical effects

Conductive or electro-static dissipative materials should be used wherever possible for packing materials and storage cabinet construction.

Possible damage due to ESD may be caused by using inappropriate packing materials, too low RH or proximity to ES field sources. This may lead to p-n junction damage, oxide breakdown/puncturing, sensitive parameter shifting, changed V_T from trapped Q_{SS} charge or changed I_{OFF}/V_{OFF} parameters.

9.8 Protection from radiation

Die exposure to illumination or radiation of any kind should be limited.

Care should be taken to ensure protection from nuclear radiation (high background), EMR (RF and microwave sources), ultraviolet, X-ray radiation and ambient illumination. Some die types, such as analogue devices, may be particularly sensitive.

9.9 Periodic qualification of stored die products

For long-term storage of individual die, it is possible to qualify the condition of the stored product by sample qualification. However, this may only be appropriate where large quantities of individual die are stored since sample testing necessarily involves using up some of the stored product. Where periodic qualification is required, additional die should be stored to allow for this.

In this case, representative samples of the product should be removed from storage at predetermined time intervals. The sample die should be checked for any signs of damage or deterioration and assembled into suitable packages for subsequent electrical test and reliability checks. The bondability of the die should be assessed during assembly.

Care should be taken to avoid unnecessary disturbance of stored products. A balance should be sought between the desire for periodic qualification and the need to maintain an undisturbed storage environment.

10 Good practice for automated handling during assembly

This clause contains particular information which may be required for handling of die products during automated assembly. This is in addition to recommendations from other clauses within this technical report.

10.1 Removal of die from shipping media

It is important to ensure that any pick-up tool coming into contact with the die does not induce damage to the die. Also, deformation of contact bumps on flip-chip devices should not occur.

10.1.1 Die supplied on adhesive-backed carrier tape

Die that are supplied on adhesive-backed tape may require the use of a feeder equipped with a lift device to assist in die removal from the adhesive backing.

10.1.2 Die supplied in pocketed or punched tape

Care should be taken that the tape does not vibrate as, and after, the cover tape is removed since this may cause the die to move, rotate or flip over.

10.1.3 Die especially sensitive to damage and contamination

Die that do not have passivation over the active surface and die fabricated with sub-micron geometry are especially vulnerable to mechanical damage and chemical contamination.

Some die, especially discrete transistors, IGBTs, and diodes have junctions extending to the edge of the die and may be very vulnerable to edge chipping and contamination from solder flux, solder, or epoxy at die attach. The resulting failure mechanism would be electrical leakage or shorts.

10.1.4 Die or wafer with back side marking

Certain techniques exist to mark the back of die or wafers. However, scribing, laser marking or other marking may initiate cracking of die. This cracking may propagate in shipping, handling and/or die attach. Methods used should be thoroughly investigated via analytical techniques to ensure no damage occurs to the wafer or die.

When die that have been marked are removed from the packing media using a push-up needle or lift platform, care should be taken to ensure that neither the marking nor the die are damaged. Die or wafers with laser marking may be more fragile than unmarked products.

10.2 Equipment out of service

Whenever equipment is out of service, for example for preventive maintenance or repair, all die and wafers should be removed and placed in a controlled protective environment.

Annex A
(informative)

Planning checklist

This table contains example questions that may be used in a planning checklist.

Table A.1 – Planning checklist

Good practice item	Question	IEC 62258-3, clause reference	Answer
Handling good practice		**4**	
Work area environment	Is the work area classed as a cleanroom?	**4.2**	
Controls	How is the environment of the work area controlled? Is the work area suitable for the die products that are used?	**4.2**	
Temperature	What is the allowable temperature range?	**4.2**	
Humidity	What is the allowable humidity range?	**4.2**	
Classification	What is the cleanroom classification?	**4.2**	
Particle counts	Are particle counts performed? How? When?	**4.2**	
Handling – General	Are the handling methods used suitable for die products?	**4.3**	
Cleanroom good practice	Are die products only handled in a cleanroom?	**4.4**	
Cleanroom rules	What rules are practised in the cleanroom? What routine work area cleaning is done?	**4.4.1**	
Hats, hoods, nets, masks and shoes	Are hats, hoods or nets used? - Is head and facial hair adequately covered? Are face masks used? - How often are they changed? Are overshoes used? - How often are they changed?	**4.4.2.1**	
Smocks and gowns	Are smocks or gowns used? - Do they adequately cover clothing? - How often are they changed? - What material is used? - Is this material suitable for use in the cleanroom class?	**4.4.2.2**	
Gloves	For which operations involving die products are gloves used? Is the glove type suitable for use in a clean room? How often are gloves changed?	**4.4.2.3**	

Table A.1 *(continued)*

Good practice item	Question	IEC 62258-3, clause reference	Answer
Finger cots	For which operations involving die products are finger cots used? How often are finger cots changed?	**4.4.2.4**	
Cleanroom conduct	What rules of conduct operate in the cleanroom? Are these displayed and visible?	**4.4.3**	
Tools		**4.4.4**	
Pick-up tools and collets	What wafer or die pick-up tools are used? Are they ESD safe? How and when are they checked for damage? What cleaning routine is used?	**4.4.4.1**	
Tweezers	Which operations use tweezers? How is damage to die or wafers prevented?	**4.4.4.2**	
Protocol	What protocols exist to control the movement of product and personnel?	**4.4.5**	
Process handling issues		**5**	
Wafer sawing	What type of wafer saw is used? What controls are used during wafer sawing? How are wafers checked to ensure they have been sawn correctly?	**5.1**	
Wafer mounting	How are wafers mounted in preparation for sawing? What type of tape is used?	**5.1.1**	
Sawing water	What is the purity level of the sawing water? How is the resistivity of the water controlled? What additives are used? - Gas (CO_2, etc.) - Fluids (surfactants etc.)	**5.1.2**	
Wafer washing and drying	How are wafers washed? How are wafers dried?	**5.1.3**	
Die sorting		**5.2**	
Fixtures for wafer frames or rings	How are frames or rings held during die removal?	**5.2.1**	
Vacuum	How is vacuum used in the die sorting? What level of vacuum is used?	**5.2.2**	
Removal from wafer film	How are die removed from wafer film? How is increase in adhesion during storage controlled?	**5.2.4, 5.2.5**	

Table A.1 *(continued)*

Good practice item	Question	IEC 62258-3, clause reference	Answer
Needle marks	How are needle marks on the back of die controlled?	**5.2.6**	
Unpassivated die and MEMS	What special handling methods are used for unpassivated or MEMS die?	**5.2.7**	
Die and wafer transport and storage media		**6**	
Wafer carriers and cassettes	What types of wafer carriers or cassettes are used?	**6.1**	
In-process carriers and transport systems	What handling precautions are used for wafer carriers or cassettes? What cleaning routine is used?	**6.2**	
Packing of unsawn wafers	What wafer packing methods are used for shipping unsawn wafers? How is the container packed? How are wafers removed from the wafer container?	**6.3**	
Packing of sawn wafers	What wafer packing methods are used for shipping sawn wafers? How is the shipping container packed? What shelf-life is used for sawn wafer on film?	**6.4**	
Packing of single wafers	What methods are used to pack individual wafers?	**6.5**	
Die packing in trays		**6.6**	
Waffle packs	How is the correct chip tray and lid selected? How are chip trays cleaned? What kind of insert is used? Are the chip trays ESD safe? How are die oriented in the pack? How are the chip trays packed for shipment? If trays are stacked, how is this done and how is the lid secured on the stack?	**6.6.1**	
Vacuum release trays	How is the correct vacuum release tray selected? How are die oriented in the pack? How are the chip trays packed for shipment?	**6.6.2**	
Die orientation	How are die oriented in the trays?	**6.6.3**	
Die packing using tape and reel		**6.7**	
Embossed tape	What type of embossed tape is used? How are die oriented in the tape? How is the tape sealed?	**6.7.1**	

Table A.1 *(continued)*

Good practice item	Question	IEC 62258-3, clause reference	Answer
Punched carrier tape	What type of punched carrier tape is uses? How are die oriented in the tape? How is the tape sealed?	**6.7.2**	
Adhesive-backed punched carrier tape	How is the correct tape selected? What shelf-life is used? How are die oriented in the tape?	**6.7.3**	
Orientation	How are the die oriented in the tape? Does the packing method adequately maintain this orientation during shipping?	**6.7.5**	
Tape and reel packing structure	How are the filled reels packed for shipment?	**6.7.6**	
Storage good practice		**7**	
Die and wafer storage		**7.1**	
Short-term storage environment and conditions	How are die and wafers stored? What is the storage environment? Atmosphere Temperature range Humidity range Particle count class How is the environment controlled? What happens if limits are exceeded?	**7.2**	
Storage times limitations	What is the maximum storage time used for die or wafer products?	**7.3**	
Sawn wafer on wafer frame or ring	What is the maximum time that die products are stored on wafer ring or frame?	**7.4**	
Die products in the production area	What is the maximum time that die products are left exposed in the production area? How are die products stored **while** they are awaiting production or quality checks?	**7.5**	
Die on adhesive-backed carrier tape	What shelf life is used for die on adhesive backed carrier tape?	**7.6**	
Die in punched or embossed carrier tape	What shelf life is used for die in punched or embossed carrier tape?	**7.6**	
Dry-packed die products	What shelf life is used for die products stored in a moisture barrier bag?	**7.7**	

Table A.1 *(continued)*

Good practice item	Question	IEC 62258-3, clause reference	Answer
Traceability good practice		**8**	
General	How is traceability of die products maintained?	**8.1**	
Wafer traceability	How is lot traceability performed for wafer products? Is traceability required for each wafer or each lot of wafers? What traceability marks are there on the wafers?	**8.2**	
Die products traceability	How is the primary packing marked? What controls are enforced to ensure different lots of die are not mixed?	**8.3**	
Wafer and die back side marking	Are wafers or die marked on the back for traceability? How is the marking done? What is the marking permanence?	**8.4**	
Long-term storage of bare die and wafers (die banking)		**9**	
General	What facility is used for long-term storage of die products?	**9.1**	
Preparing for storage	What preparation is carried out before die products are stored?	**9.2**	
Damage to die products during long term storage	How is mechanical damage to die products prevented during long-term storage?	**9.3**	
Storage environment	What is the storage environment? Atmosphere Temperature range Humidity range Particle count class How is the environment controlled? What happens if limits are exceeded?	**9.4**	
Atmosphere purity	What is the purity level of the gas used? What is the level of residual gases?	**9.5**	
Protection from chemical damage and contamination	How are die products protected from chemical damage or contamination?	**9.6**	
Vacuum packing	Is vacuum packing used for storage? Are desiccants used? Is any foam used inside the vacuum pack?	**9.6.1**	

Table A.1 *(continued)*

Good practice item	Question	IEC 62258-3, clause reference	Answer
Positive pressure systems	Is a positive pressure system used for storage? What gas is used? What is the quality of the gas? How is the pressure maintained?	**9.6.2**	
Use of bio-degradable material	What steps are taken to ensure that the storage carriers (primary packing) do not contain bio-degradable materials?	**9.6.3**	
Electrical effects	What steps are taken to guard against ESD damage? Is there any local source of electro- magnetic or electrostatic fields that could damage the product?	**9.7**	
Protection from radiation	What steps are taken to guard against radiation damage?	**9.8**	
Periodic qualification of stored die products	Are products periodically qualified? What qualification method is used? What is the period between qualifications?	**9.9**	
Automated handling and removal of die from shipping media		**10**	
Removal of die from shipping media	How are die removed from the shipping media?	**10.1**	
Die supplied on adhesive-backed carrier tape	What type of feeder is used? What type of pick-up tool is used?	**10.1.1**	
Die supplied in pocketed or punched tape	What type of feeder is used? What type of pick-up tool is used?	**10.1.2**	
Die especially sensitive to damage and contamination	Are any unpassivated die used? What precautions are taken to avoid damaging these die?	**10.1.3**	
Back side marking of die or wafer	Are any die products marked on the back? What precautions are taken to ensure that the marking on the die is not damaged when removed from the packing media?	**10.1.4**	
Equipment out of service	What precautions are taken when equipment is taken out of service for repair or maintenance?	**10.2**	

Annex B
(informative)

Material specifications

The following items of material specifications for packing items should be considered and detailed for any materials used for handling die products:

B.1 Wafer tubs or jars

B.1.1 Wafer jar information:

Material:

Colour:

Static protective: See note

Dimensional stability: Poor/good

Chemical resistance Poor/good

Temperature limit:

NOTE Some wafer jars may not be made of static protective materials and it is recommended that air ionizers are used during the removal of wafers from the jar.

B.1.2 Foam liner information:

Material: Type of foam and structure

Colour:

Static protective:

Dimensional stability: Poor/good

Chemical resistance Poor/good

Temperature limit:

B.1.3 Paper liner information:

Material:

Colour:

Static protective:

Dimensional stability: Poor/good

Chemical resistance Poor/good

Temperature limit:

B.2 Wafer frames

B.2.1 Frame material information:

Material:

Colour:

Static protective: Note

Dimensional stability: Poor/good

Chemical resistance Poor/good

Temperature limit:

NOTE Some wafer frames may not be made of static protective materials and it is recommended that air ionizers are used during the removal of die from the wafer frames.

B.2.2 Film material information:

Material: Base material and adhesive

Colour:

Static protective: Note

Dimensional stability: Poor/good

Chemical resistance Poor/good

Temperature limit:

NOTE Air ionizers should be used during the removal of die from the tape.

B.2.3 Film frame shippers (box) material information:

Material:

Colour:

Static protective:

Dimensional stability: Poor/good

Chemical resistance Poor/good

Temperature limit:

B.3 Waffle packs

B.3.1 Tray, lid and clip material information:

Material:

Colour:

Static protective:

Surface resistivity (Ω^2):

Triboelectric properties:

Dimensional stability: Poor/good

Chemical resistance: Poor/good

Temperature limit:

B.4 Vacuum release tray material specifications

B.4.1 Tray, lid, clip material information:

Material:

Colour:

Static protective:

Surface resistivity (Ω^2)

Triboelectric properties:

Dimensional stability: Poor/good

Chemical resistance: Poor/good

Temperature limit:

B.4.2 Mesh:

Material:

B.4.3 Gel:

Material:

Shelf life:

B.5 Tape and reel material specifications

B.5.1 Tape material information:

Material:	Tape and filler materials
Colour:	
Static protective:	
Surface resistivity (Ω^2)	
Triboelectric properties:	
Dimensional stability:	Poor/good
Chemical resistance:	Poor/good
Temperature limit:	

B.5.2 Cover tape material information:

Material:	
Colour:	Including whether transparent or translucent
Static protective:	
Surface resistivity (Ω^2)	
Triboelectric properties:	
Dimensional stability:	Poor/good
Chemical resistance:	Poor/good
Temperature limit:	

B.6 Electrical properties

A material is electrically static-dissipative if it exhibits a nominal surface resistivity of >=10^4 Ω^2 and <=10^8 Ω^2. The surface resistance of the material minimizes dv/dt, giving ESD protection to devices in Classes I to III. The material may also exhibit tribo-electric properties, which may be appropriate for the packing of devices that are sensitive to electrostatic charges.

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[3] To be published.

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