AN10706

Handling bare die

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Document information

Info	Content
Keywords	bare die, handling, ESD, clean room, mechanical damages, delivery forms, transport conditions, store conditions
Abstract	This application note is intended for introducing customers in assembly technologies requiring bare die handling.The aim of this document is to rise the sensitivity and awareness of special physical effects which could harm the quality and yield of the production.

Revision history

Rev	Date	Description
v.2	20110610	extended revision
v.1	20080617	new application note, first revision

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1. Introduction

This application note shall be understood as a guideline of how to handle bare die[1] unlike chips in a package.

It is intended for introducing customers in assembly technologies requiring bare die handling like in Chip On Board (COB), Chip On Glass (COG) and flip chip technologies. This document is aimed to rise the sensitivity and awareness of special physical effects which could harm the quality and yield of the production.

1. **die (singular or plural) -** separated piece(s) of semiconductor wafer that constitute(s) a discrete semiconductor or whole integrated circuit. International Electrotechnical Commission, IEC 62258-1, ed. 1.0 (2005-08).

2. Delivery forms

Bare die are delivered in following forms:

Fig 1. Unsawn wafer

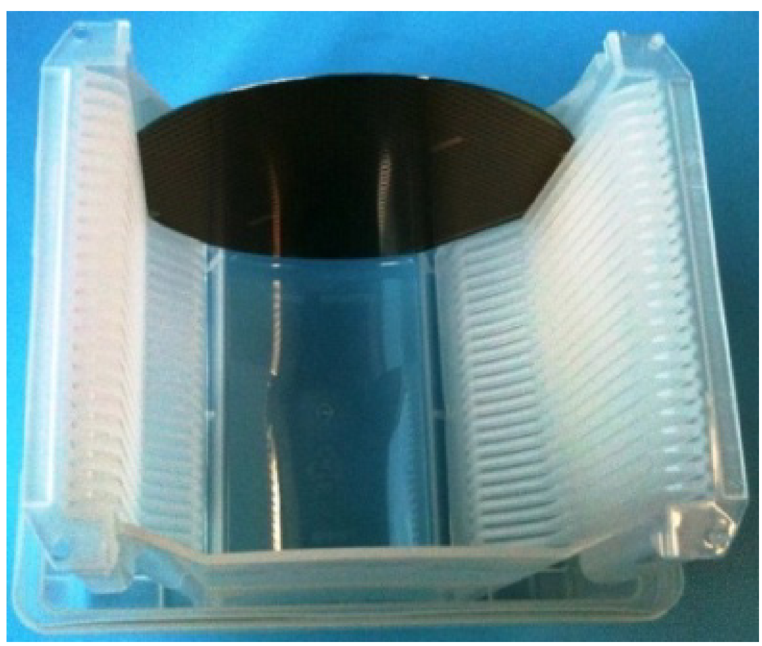
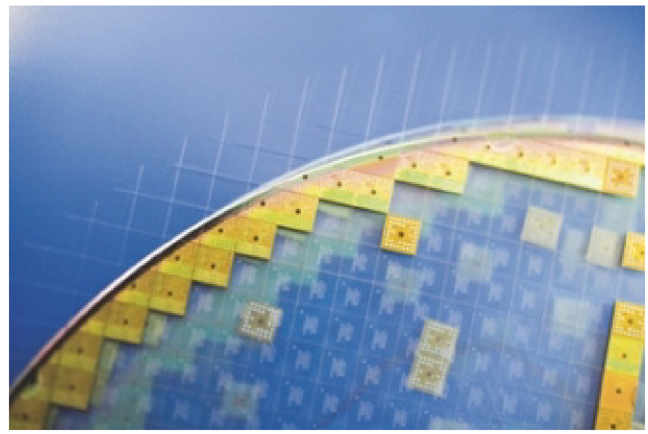


Fig 2. Unsawn wafer in open wafer box

The wafer is sawn.



Partially picked Film Frame Carrier (FFC). Chips not in spec are marked with an ink dot.

Fig 3. Wafer on Film Frame Carrier (FFC)

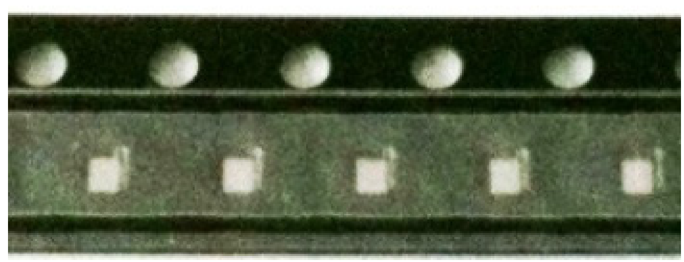


Fig 4. Die on tape and reel

Fig 5. Bare die in tray

3. Sensitivity

Integrated circuits are sensitive in respect to

- electric fields and overvoltages
- mechanical damage and
- surface contamination

3.1 Electrical fields

Chips are protected against ElectroStatic Discharge (ESD) up to a certain level defined in the Quality and Reliability Specification (QRS) and circuit specification. Depending on the design of the device protection the ESD protection can reach values up to some kV.

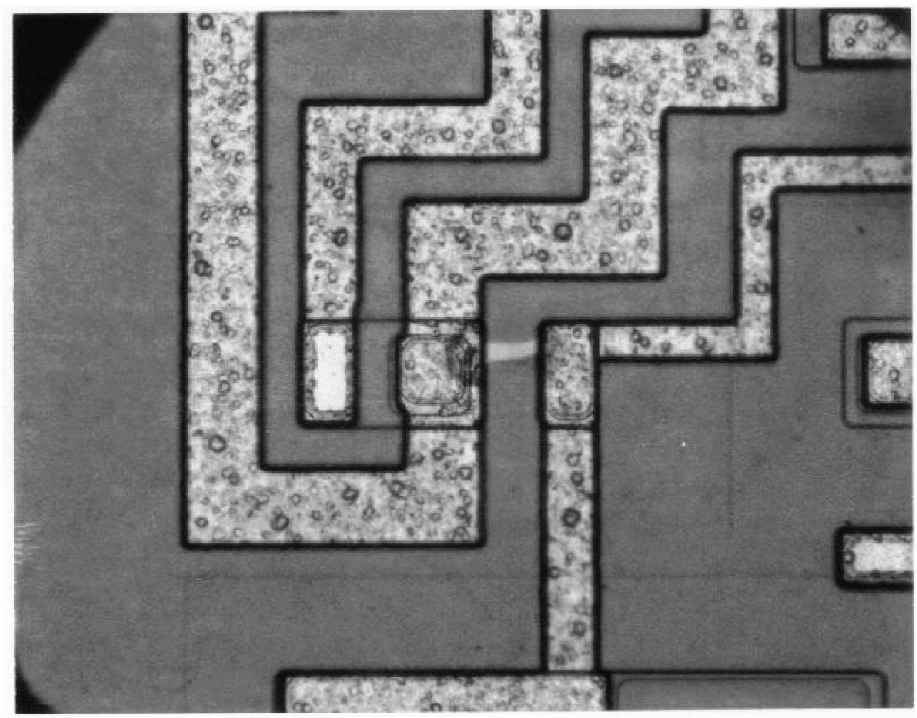
Electric fields are mostly generated by moving objects or persons. A person, for example walking on a carpet, can easily be charged up to 35 kV (see Table 1). But not only high voltages even small electric charges can be sufficient to damage sensitive electronic components (see Figure 6). Devices which have been exposed to a certain electrical field must not be destroyed but the reliability of the IC may be affected.

Therefore it is necessary to handle bare die in a electrostatic protected environment as described in Section 4.

Table 1. Static generation [1]

Means of static generation	Humidity		Unit
	10 % to 20 %	65 % to 90 %	
walking across carpet	35000	1500	V
walking over vinyl floor	12000	250	V
worker handling components at bench	6000	100	V
rubbing of vinyl sheet protectors	7000	600	V
lifting common poly bag from bench	20000	1200	V
sliding on chair padded with polyurethane foam	18000	1500	V

[1] Voltage generated at relative humidity: 10 % to 90%.



The picture shows a metal arc or spike between emitter and base contact. The white arc is composed of aluminum and silicon and is near the surface of the silicon under the oxide. Basically, the arc took the shortest path.

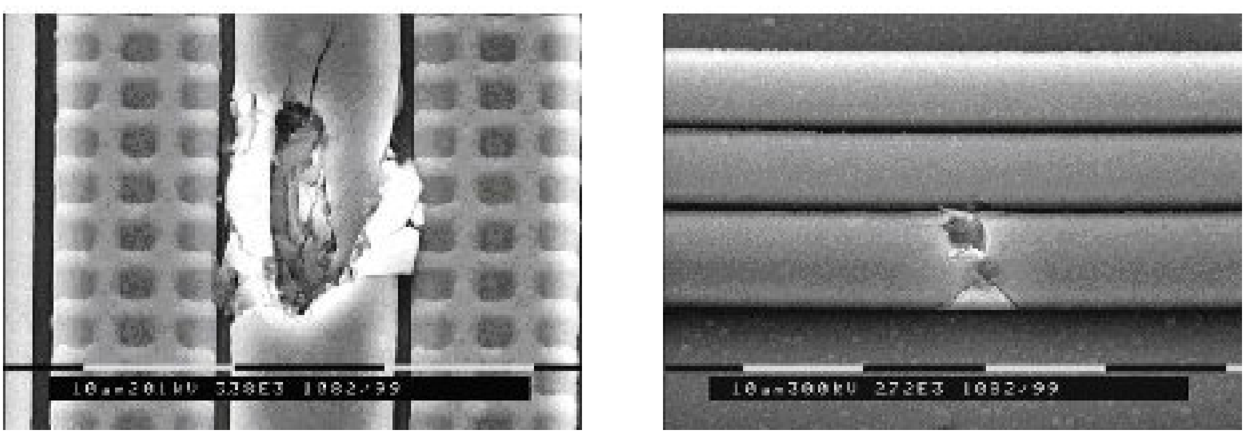
Fig 6. Electrical overstress, spiked junction

3.2 Mechanical damages

A glass protection layer protects the circuits against certain mechanical influences, but the pads and bumps are exposed. Applying of mechanical forces has to be avoided under any circumstances. Uneven forces to the die can bend it and generate piezo voltages damaging the circuits or generating cracks (Figure 7) and indents (Figure 8). Therefore it is necessary to use the appropriate tools to handle bare die avoiding damages (see Section 4).

Passivation cracks radiating out from central impact point (dent), ultimately leading to a top to bottom metal short at that location.

Fig 7. Dent and cracks in passivation



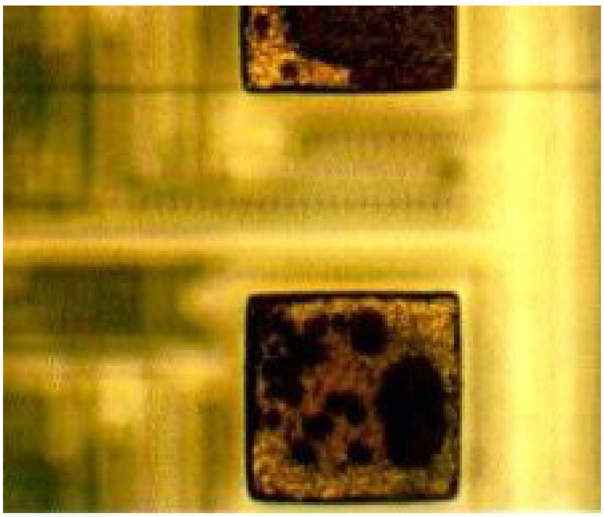
Indents (or “pressure points”) are local defects which show a destruction of the glassivation layer and penetrating (at least) down to metal or deeper. Frequently, the glassivation is cracked around the defect, and the underlying metal is considerably deformed.

Indents differ from scratches by their “one dimensional” nature. They are generated by virtually vertical forces pressing onto the IC surface, therefore no trace of lateral movement of the indenting part (particle, tool) is seen, as it would be the case with scratches.

Fig 8. Indents (pressure points) in glassivation

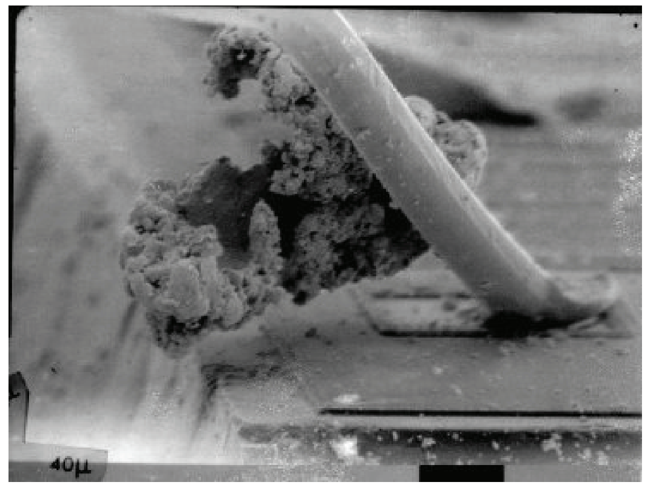
3.3 Surface contamination

Interconnection and molding steps are very sensitive to microscopic and macroscopic surface contaminations. Polluted surfaces can be the reason for issues during assembly or lead into long term instability (see Figure 9 and Figure 10).



Foreign matter of any kind on top or on the walls of a bump.

Fig 9. Contamination on Bump



Loose particle under a bond wire.

Fig 10. Particle failure

4. Work place requirements

4.1 Clean room

Bare die must always be handled in a clean room environment of at least class 1000 (ISO 6) or better.

A clean room is a environment that has a controlled level of contaminations, such as dust, aerosol particles or microbes. They are used in laboratory work and in the production of precision parts for electronic or aerospace equipment. The level of contamination is classified by the number of particles at a certain size per cubic feet or cubic meter.

Table 2. US FED STD 209E clean room standard [1]

Class	Maximum particles / ft^3					ISO equivalent
	≥0.1 μm	≥0.2 μm	≥0.3 μm	≥0.5 μm	≥5 μm	
1	35	7	3	1	-	ISO 3
10	350	75	30	10	-	ISO 4
100	-	750	300	100	-	ISO 5
1 000	-	-	-	1 000	7	ISO 6
10 000	-	-	-	10 000	70	ISO 7
100 000	-	-	-	100 000	700	ISO 8

[1] US FED STD 209E is outdated since November 2001, but is still used in the industry and the related literature.

Table 3. ISO 14644-1 clean room standards

Class	Maximum particles / m^3						FED STD 209E equivalent
	≥0.1 μm	≥0.2 μm	≥0.3 μm	≥0.5 μm	≥1 μm	≥5 μm	
ISO 1	10	2	-	-	-	-	-
ISO 2	100	24	10	4	-	-	-
ISO 3	1 000	237	102	35	8	-	Class 1
ISO 4	10 000	2 370	1 020	352	83	-	Class 10
ISO 5	100 000	23 700	10 200	3 520	832	29	Class 100
ISO 6	1 000 000	237 000	102 000	35 200	8 320	293	Class 1000
ISO 7	-	-	-	352 000	83 200	2 930	Class 10 000
ISO 8	-	-	-	3 520 000	832 000	29 300	Class 100 000
ISO 9	-	-	-	35 200 000	8 320 000	293 000	normal room environment

The external and internal air for the clean room is filtered through high efficient filter systems to exclude particles and remove internally produced contaminations (Figure 11).

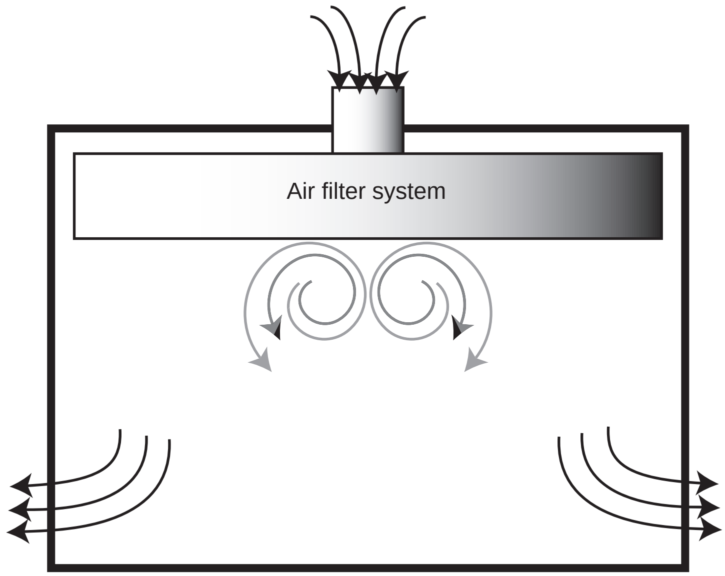


Fig 11. Clean room air filtering

Entering the clean room has to be done by passing an air or vacuum shower to remove adherent particles (Figure 12).

Fig 12. Entering a clean room through a vacuum shower

Staff, working in the clean room has to wear special protective cloths: heads, face masks, gloves, boots and cover-alls (Figure 13).

Fig 13. Precaution are special cloth and masks

All equipment used in a clean room has to be designed to avoid emissions. Special supplies are available for example:

- Clean room ball point pen, which have low-sodium ink to provide protection from ionic contamination (pencils and erasures are not allowed in clean rooms)
- Clean room paper, which is designed not to emit particles
- Clean room binders, which are solvent resistant

4.2 Electrical grounding

Every possible device which could be in contact with the die must be on the same electrical potential, this is also true for the operators dealing with the equipment. To achieve this, every body and everything must be grounded to same potential. Dedicated equipment is readily available:

- Grounded workbench surface
- Conductive carpets
- Grounded chairs
- Low impedance place mats
- Grounding wrist straps
- ESD save shoes, coats, gloves and finger cots

The goal is, that nothing can get charged up due to motion or separation.

4.3 Special working behavior

- Access to clean room areas should be limited to only persons necessary for the area operation.
- Eating, drinking, chewing gum and smoking is not allowed in clean rooms.
- Nervous relief type mannerisms such as scratching head, rubbing hands or parts of the body, or similar type action are to be avoided.
- All material can only be moved from one clean room to another in the same or a lower clean room class, but never in the other direction.

5. Die handling

Bare die must be handled always in a class 1000 (ISO 6) clean room environment: unpacking and inspection, die bonding, wire bonding, molding, sealing. Handling must be reduced to the absolute minimum, un-necessary inspections or repacking tasks have to be avoided. (Assembled devices do not need to be handled in a clean room environment due to the product is already packed well.)

Use of complete packing units (tray, FFC, tape and reel) is recommended and remaining quantities have to be repacked immediately after any process (e.g. picking) step.

To avoid contaminations and damages (scratches, cracks)

- Die or wafers must never be handled by bare fingers
- The active side of a die should never be touched
- The mechanical pressure has to be limited
- Do not store and transport die outside protective bags, tubes, boxes
- Work only in ESD save clean room environments

Special tweezers are suitable for grabbing die and wafers on its edge. Vacuum tweezers are used to move die from the packing to the target (see Figure 14 and Figure 15).

A dedicated vacuum pick up tool is used to manually move die.

Fig 14. Vacuum pick up tool

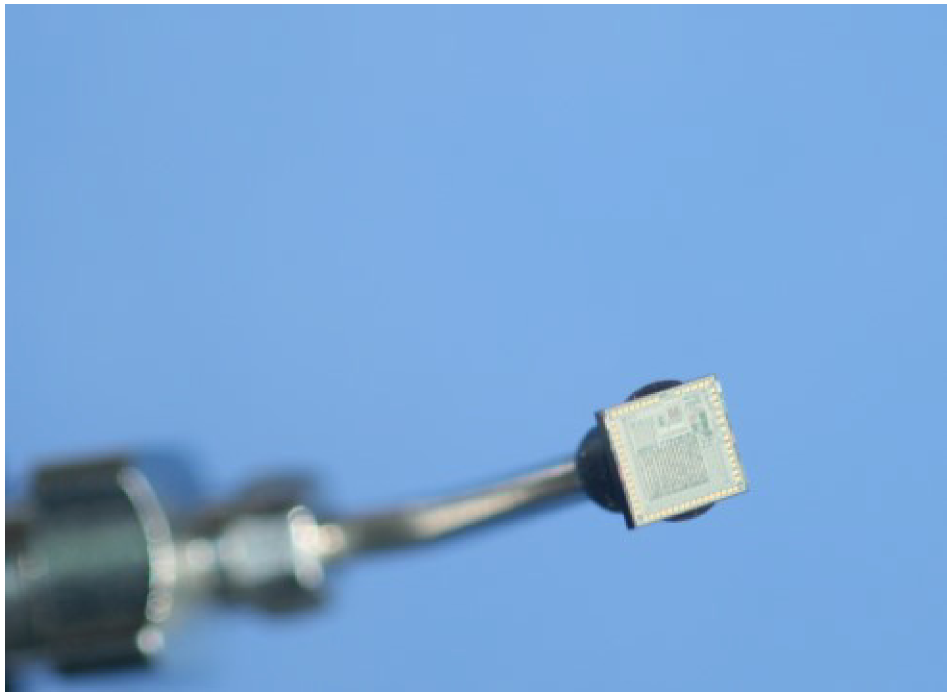


Fig 15. Die on a vacuum pick up tool

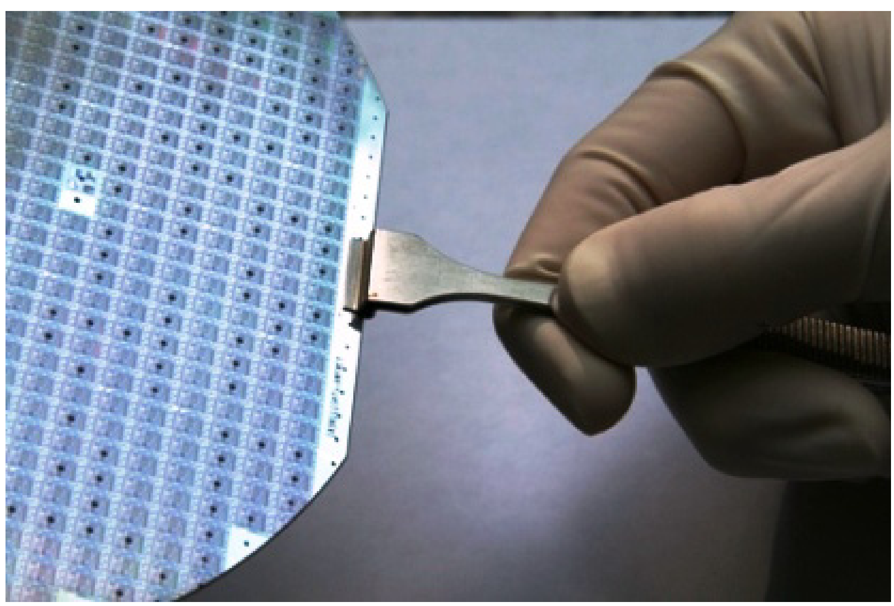
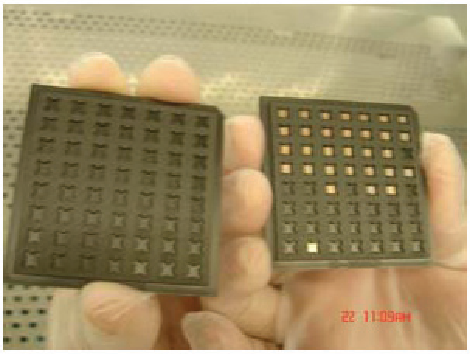
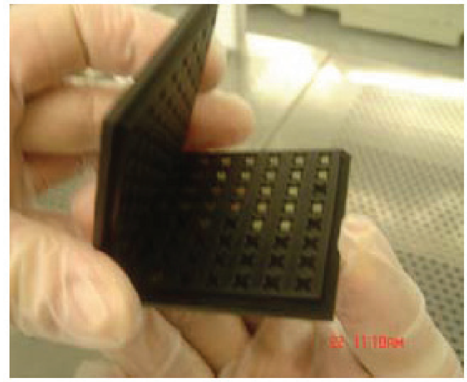


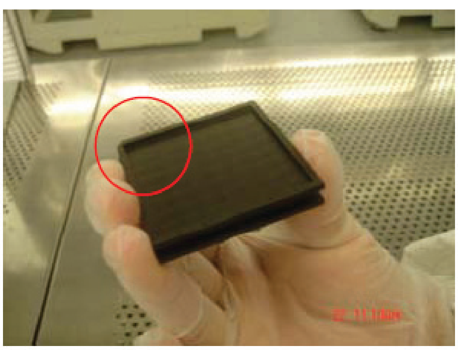
Fig 16. Special tweezers for grabbing a wafer



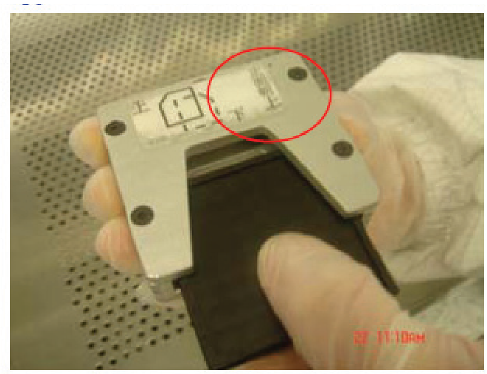
a. To turn the die in the tray...



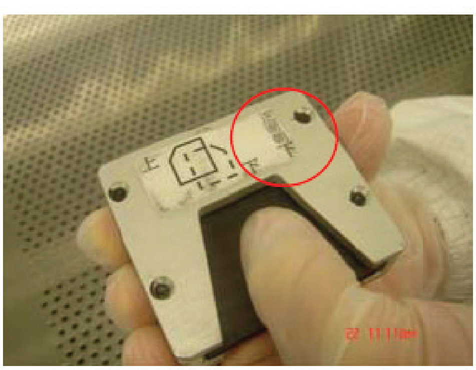
b. ... put another tray of the same type on top to cover the source tray.



c. Both trays have to have the same notch location.



d. Insert both trays into the tray turner considering the upside mark.



e. Then turn the tray turner considering the downside mark.

f. The die have been successfully turned over.

Fig 17. Procedure to turn die in tray for backside inspection or flip-chip assembly

Some product types are delivered in double-sided trays which can be turned over without special tray turners.

6. Transport and store conditions

6.1 Delivery and package forms

Wafers and bare die are delivered in dry pack (see Figure 18). The dry condition of dry pack is guaranteed for one year. This does not affect the shelf life (see Section 6.3.3) if the transport and store conditions, described hereafter, are kept. If the conditions of Section 6.3.2 cannot be kept, the dry pack has to be renewed after 1 year.

Fig 18. Dry pack

6.2 Transport conditions

6.2.1 General transport conditions

During transport, the packing and the products have to be protected, among others, against extreme temperatures, humidity, direct sunlight, and mechanical forces. The temperature has to be between 8 °C to 60 °C. The total transport time should be as short as possible. When the transport time exceeds five days the transport conditions shall be the same as the store conditions described in Section 6.3, or the products has to be sealed with inclusion of a dry-agent.

6.2.2 Conditioned air transport

For dry pack, conditioned cargo rooms are mandatory for air transport. The temperature has to be between 8 °C to 45 °C with an average humidity of 16 %. The air pressure has to be between 700 hPa to 1060 hPa.

6.3 Store conditions

6.3.1 General store conditions

Secure and clean store areas shall be provided to isolate and protect the products. Conditions in the store areas shall be such that the quality of the products does not deteriorate due to, among others, harmful gasses or electrical fields.

The following conditions have to be kept:

- Temperature between 8 °C to 45 °C
- Humidity between 25 % to 75 %, no condensation under any condition is allowed
- No exposure to direct sunlight

Die are best stored in the package as delivered. Chips on film frame carrier (FFC) will stick stronger on the foil with time and will require more effort to pick them off the foil. In worst case some residual foil (glue) might stick on the rear side of the die.

6.3.2 Store conditions if not packed in dry pack

If wafers and bare die are not packed in dry pack, they have to be stored under following conditions: inert gas, dry air, dry nitrogen or in so called nitrogen flow boxes, relative humidity below 30 % and temperature between 18 °C to 24 °C.

6.3.3 Shelf life

The shelf life is the possible storage life before the product is used. Typically shelf lifes are:

Bare die in tray — 3 years

Wafer on FFC — 0.5 years

Unsawn wafer — 3 years

7. References

[1] **AN10170 —** Design guidelines for COG modules with NXP monochrome LCD drivers

[2] **AN10439 —** Wafer Level Chip Size Package

[3] **AN10853 —** ESD and EMC sensitivity of IC

[4] **IEC 61340-5 —** Protection of electronic devices from electrostatic phenomena

[5] **JESD625-A —** Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices

[6] **NX2-00001 —** NXP Semiconductors Quality and Reliability Specification; (company internal document)

[7] **NX3-00092 —** NXP store and transport requirements; (company internal document)

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