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Considerations for Long-Time Die & Wafer Storage

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Initial Considerations

- The die or wafer is going to be stored for upto 25 years.
- The die must be “process-able” after storage
- The die (once processed) will be expected to work as if it were a new device.
- The inherent reliability or specification of the die shall not be compromised.

Preparing for storage

- Only TESTED product should be stored.
- If wafer is to be stored, then the wafer should
  - either be inked,
  - or stored with the wafer map in future-readable form !!!
- If die product is to be stored, then separated singulated known-good-die only should stored.
- Multi-site storage ... is this an issue ?

Historical Storage

- We have been storing die/wafers for over 35 years, with few problems, but :
  - This is OLD technology !
    - 10u to 7u SLM/DLM, poly if you're lucky !
  - It was BUILT and DESIGNED to last
    - Generally military-type or military sponsored.
  - The technology was COARSE, RUGGED and ROBUST
    - Bipolar, PMOS, NMOS or MG CMOS
    - ESD specifications easily met (most of the time)

Accompanying Paperwork ?

- Documentation needed
  - Data sheets, Specifications
  - Test results, Wafer maps
- What storage medium ?
  - Electronic media
    - Long-term reliability
      - Oxide shedding on magnetic media
      - CD's & CDR's unreadable
    - File Format issues
  - At least Paper has a reasonable track record !

How to damage die product ...

- Methods of destroying die products …
  - Mechanical & Thermal
    - Breakage's and fractures
    - Visual defects, changing criteria
  - Chemical
    - Ionic contamination
  - Electrical & Radiation
    - ESD Damage
    - Prolonged UV

Mounting Properties of Tape

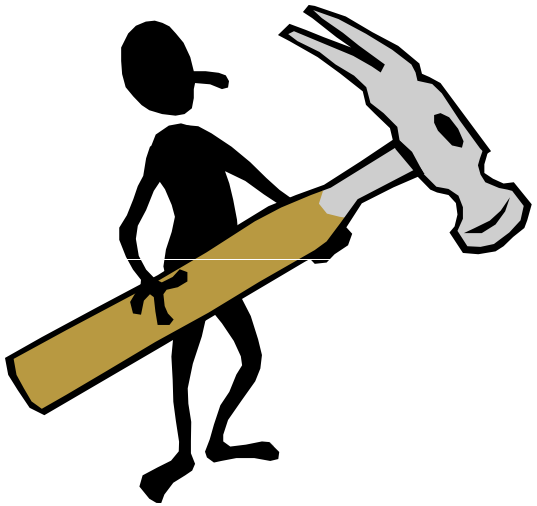
- Chemical Properties
- Tack / adhesion level
- Movement
- Migration
- UV exposure (for UV release tape)

Die Storage Containers

- Wafer Vial
- Wafer Cassette
- Sawn wafer on film & frame
- Tape and Reel
- Waffle Pack
- Gel Pack®

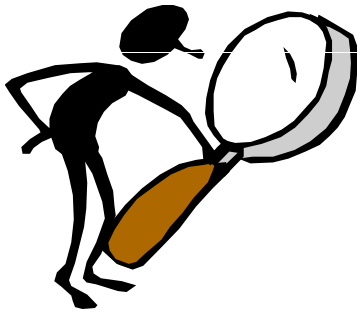
Mechanical Damage

- Damage to active area of die / wafer
- Cracking or crazing of passivation
- Damage to die underside
- Damage to exposed contact areas
  - e.g. Bond Pads
- Failure at visual inspection
  - Mechanical surface contaminants
  - Compromised integrity of seal-ring
- Piezo-effect
  - Changing electrical parameters through in-built stress



The Storage conditions Mechanical (1)

- Die mechanical protection
  - Initial placement (accuracy of carrier geometry)
  - Whilst in storage
  - Die removal
- Vibration
  - Movement during storage
  - Inappropriate inspection
- Die / wafer orientation
  - MEMS product
  - Abrasion and adhesion of foreign matter to surfaces.
  - “dust collects on flat surfaces ….”
  - Anti-bug & bacterial protection !!!

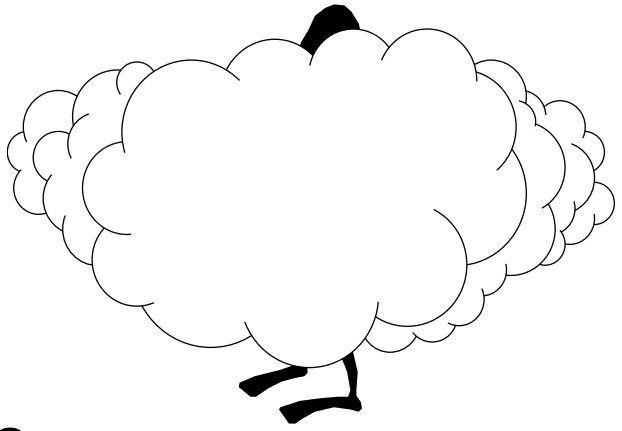


The Storage conditions Mechanical (2)

- Anti-vibration // Anti-shock packing.
- Thermal Conditions : ~ 17-25ºC
  - Min & Max conditions
  - Abnormal temperature excursions
- Humidity: ~ RH 10%-40%
  - Not too low (< 10%)
    - to prevent build-up of electrostatic fields.
  - Not too high (> 40%)
    - to prevent condensation and moisture ingress.
- Use of dessicants ?
  - Mechanical abrasion of particulates
  - Long-term effects ?

Chemical Damage

- Ionic contamination of active area
  - Induced by poor pre-storage handling
  - Contaminant mobility through Silicon
  - Direct contact of contaminants
  - Proximity of contaminants
- Intermetallic growths
  - Contact areas
  - Active areas
  - Backside contacts
- Exotic III-V material sensitivities



The Storage conditions Chemical (1)

- Vacuum packing
  - Encourages ingress of contaminants through packing materials
  - Addition of desiccants can cause minor particles to be present
- Positive pressure systems
  - Require good inlet filtering
  - Keeps major contaminants out
  - Abnormally high N_2 content in atmosphere
    - monitor O_2 levels for any human operation in proximity !!!
- Use of bio-degradable material
  - Issues with known deterioration

The Storage conditions Chemical (2)

- Airborne contaminants
  - High content of airborne Sulphur compounds in many 3rd world countries
- Storage in inert atmosphere
  - Dry Nitrogen preferred
  - Alternatives include the noble gasses : Helium, Argon, Neon etc.,
- Proximity of “active” reagent sources
- Anti-static coatings can “flake” or rub off.
- Ingress of active reagents (deterioration)
  - Sulphur from rubber bands
  - Chlorine from cardboard / paper
  - Fluorine from “Pink” antistatic foam
  - Ammonia from some papers & plastics
  - Formic & Acetic acids from some plastics & silicone sealants
  - Other chemical attacks

Electrical Damage

- ESD field damage
  - PN Junction damage
  - FOX-GOX breakdown / puncturing
- Sensitive parameter shifting
  - Change Vt from trapped Qss charge
  - Change Ioff/Voff parameters

The Storage conditions Electrical (1)

- ES damage
  - Inappropriate packing materials
  - RH too low
  - Proximity to ES or EM field sources
- Poor initial testing
  - Stored with initial damage
    - “Walking wounded” scenario

The Storage conditions Electrical (2)

- Subjection to irradiation
  - Nuclear (high background)
  - EMR … local RF and microwave sources
    - Mobile Phone transmitters, microwave heaters
  - U.V. & X-Ray sensitivity
  - Photovoltaic effects on sensitive analog die.
- Effects caused by “ageing” on proximity materials
  - Polymerisation of specific plastics

Who's involved ?

The Manufacturer

The Storage house

The Packing material supplier

The End User / Customer

Information needed from the MANUFACTURER

- Recommendations from Manufacturer as to known issues with packing materials
  - "Tacky-back" permitted for 12 months max.
- Expected lifetimes of Manufacturer supplied packing materials
  - Particularly those regarded specifically as
    - Transient packing
    - Temporary packing
- Known sensitivities of specific technologies
- Any recommended pre- and post-storage processes that may enhance the storage life.

Information needed from the STORAGE house.

- Die & wafer traceability
- Actual age of silicon die
  - Not shown on final date code
- Silicon technology
  - Known sensitivity to external effects
  - Clearly marked packages, including static sensitivity
- Storage conditions (die history)
  - Min-Max conditions
  - Abnormal or adverse conditions that have been applied to die or wafers during storage

Information needed from the PACKING MATERIALS supplier.

- Are there any known mechanical, electrical or chemical degradation ?
- What known sensitivities of the supplied materials ?
  - Existing reports
  - Material details and processing
  - susceptabilities to chemical reagents, radiation, etc.,
- Recommendations on storage and lifetimes

Information needed from The Customer

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- How long do the components need to be stored ?
  - This will affect the approach taken for storage.
- What call-off rate is expected ?
  - How often do the containers have to opened
- What periodic inspection is required ?
- Are there any pre- or post-conditioning requirements ?

Unknown Issues (1)

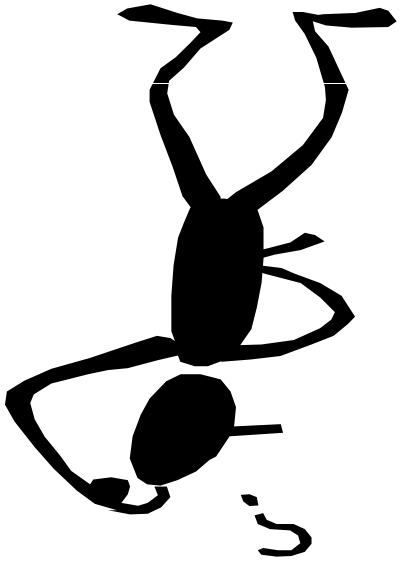
- New processing materials and properties :
  - Copper metalization
    - Copper is chemically active,
      - has active oxides : Cuprite, Chalcotrichite, Tenorite etc.,
      - has active sulphides : Chalcocite, Bornite etc.,
    - Aluminium relatively passive, inert oxide
  - Bump materials
    - Novel intermetallics
    - Tin “whiskering” on new Pb-free Solder bumps ?
  - Passivation / Glassivation materials
    - Lifetime of new polyimides etc.,
  - Exotic semiconductor materials

Unknown Issues (2)

- Die geometry shrinking
  - Increased sensitivity to ES field damage
  - Increased sensitivity to minor contamination
  - Increased sensitivity to marginal processing and in-built defects
  - Unknown “survivability” beyond the life of a PC or cell-phone
- Some product now is neither designed nor manufactured for longevity.
- Unknown issues when re-packaging / re-assembling
  - Availability of “other” items in build list.
- Consider the total operation of storage and it’s possible effect on the environment and local health / safety legislation and regulations

Unknown Issues (MEMS)

- Storage sensitivities will be dependant upon MS type :
  - Biological
  - Chemical
    - Gas or liquid
  - Mechanical movement
    - Electrostatic
    - Thermo-cycle
    - Piezo-mechanical
  - Fluidic (pressure etc.,)
  - Mechanical sensing
    - Acceleration
    - Vibration
  - Field/extraneous sensing
    - Magnetic
    - Electrostatic
    - Radiation



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Die Bank

Typical Die Bank at Micross Components Ltd.

Initial conclusions

- Manufacturers consider the delivery packing to be TEMPORARY only
- Traceability needed throughout storage.
- Controlled Temperature & Humidity
  - 21ºC, ± 4ºC and 30%RH ± 10% @ 1 At (STP)
- Consider localised conditions
  - Anti-static precautions
  - Proximity of unknown or hazardous materials
  - Anti-shock & anti-vibration
  - Limit exposure to radiation where possible
  - Orientation of storage

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… and finally

If, in 5,000 years time, archaeologists discover our die and wafer bank in a pristine, ready-to-use condition …

… this presentation may have proven useful !