

Precautions for Use of Hitachi High-Voltage Monolithic ICs

Be sure to read this information before use.

HITACHI

**Hitachi, Ltd. Power Systems
Power & Industrial Systems Division
Power Device Division
Management Department**

Precautions for Safe Use and Notices

Precautions for Safe Use and Notices

If semiconductor devices are handled in inappropriate manner, failures may result. For this reason, be sure to read "Precaution for Use" before use.



This mark indicates an item about which caution is required.



CAUTION

This mark indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury and damage to property.



CAUTION

- (1) Regardless of changes in external conditions during use "absolute maximum ratings" should never be exceeded in designing electronic circuits that employ semiconductors. In the case of pulse use, furthermore, "safe operating area(SOA)" precautions should be observed.
- (2) Semiconductor devices may experience failures due to accident or unexpected surge voltages. Accordingly, adopt safe design features, such as redundancy or prevention of erroneous action, to avoid extensive damage in the event of a failure.
- (3) In cases where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, life-support-related medical equipment, fuel control equipment and various kinds of safety equipment), safety should be ensured by using semiconductor devices that feature assured safety or by means of user's fail-safe precautions or other arrangement. Or consult Hitachi's sales department staff.

(If a semiconductor device fails, there may be cases in which the semiconductor device, wiring or wiring pattern will emit smoke or cause a fire or in which the semiconductor device will burst)

Notices

1. This Data Sheet contains the specifications, characteristics (in figures and tables), dimensions and handling notes concerning power semiconductor products (hereinafter called "products") to aid in the selection of suitable products.
2. The specifications and dimensions, etc. stated in this Data Sheet are subject to change without prior notice to improve products characteristics. Before ordering, purchasers are advised to contact Hitachi's sales department for the latest version of this Data Sheet and specifications.
3. In no event shall Hitachi be liable for any damage that may result from an accident or any other cause during operation of the user's units according to this Data Sheet. Hitachi assumes no responsibility for any intellectual property claims or any other problems that may result from applications of information, products or circuits described in this Data Sheet.
4. In no event shall Hitachi be liable for any failure in a semiconductor device or any secondary damage resulting from use at a value exceeding the absolute maximum rating.
5. No license is granted by this Data Sheet under any patents or other rights of any third party or Hitachi, Ltd.
6. This Data Sheet may not be reproduced or duplicated, in any form, in whole or in part, without the expressed written permission of Hitachi, Ltd.
7. The products (technologies) described in this Data Sheet are not to be provided to any party whose purpose in their application will hinder maintenance of international peace and safety nor are they to be applied to that purpose by their direct purchasers or any third party. When exporting these products (technologies), the necessary procedures are to be taken in accordance with related laws and regulations.

Precautions for Use of High-Voltage Monolithic ICs

1. Device selection

1.1 Maximum ratings

The values listed in the maximum rating tables are absolute maximum ratings, and are not to be exceeded under any conditions.

If the maximum ratings are exceeded even momentarily there is a possibility of degradation or destruction. Absolute maximum ratings should never be exceeded regardless of changes in external conditions, since operation above absolute maximum rating values can shorten the life of a device a great deal. Caution must be taken that more than one rating are not allowed to reach their maximum values simultaneously. For example, the voltage and current added to a transistor may each be below the maximum ratings, but the power consumed is the product of the two and must be within the permitted collector loss for that transistor. This applies not only to direct current maximum ratings, but also to pulse use where the safe operating area (SOA), load locus, peak voltage,

and current must be considered.

1.2 Derating considerations

Determining the derating degree for absolute maximum ratings is an important problem in reliability design. Although derating items to be considered at the system design stage vary slightly depending on the device type, they include electrical stress deratings such as voltage, current, power, load, and environmental conditions such as temperature and humidity, and mechanical stress deratings for vibration or shock.

Consideration of derating standards is desirable at the device design stage to ensure reliability. When designing within standards is difficult, other steps become necessary such as selecting a device with higher absolute maximum ratings. Please consult our technical department beforehand. Derating standards that should be considered during reliability design are shown in Table 7.1.

Table 7.1 Examples of derating design standards (Note 1)

Derating factor (Note 2)		IC
Temperature	Junction temp. (Note 3)	Under 110°C (Under $T_J=60^\circ\text{C}$)
	Device ambient temp. (Note 3)	$T_{op\min}\sim T_{op\max}$ ($T_a=0\sim 45^\circ\text{C}$)
	Other	Power consumption, ambient temperature, heat radiation conditions, $T_J=P_d \times \theta_{ja}+T_a$
Humidity	Relative humidity	RH=40~80%
	Other	Normally, if there is condensation due to a quick temperature change, the printed circuit board is coated.
Voltage	Breakdown voltage	Follow catalog recommended operating conditions
	Excessive voltage	Use preventative measures for excessive voltage application including electrostatic destruction.
Current	Average current	$I_c \times 0.5$ or below (especially power IC)
	Peak current	$I_{c(\text{peak})} \times 0.8$ or below (especially power IC)
	Other	Give consideration to fan out and load impedance
Power	Average power	Maximum rating $\times 0.5$ or below (especially power and high frequency ICs)
Pulse (Note 4)	SOA	Do not exceed individual catalog absolute maximum rating values.
	Surge	$I_{c(\text{peak})}$ or below

Notes: 1. Except for special use conditions.

2. Fulfill as many of these derating factors as possible simultaneously.

3. The values in parentheses apply to high-reliability use.

4. For transient conditions, derate with the average values using less than the maximum ratings of voltage, current, power, and junction temperature including surges. Because the SOA differs according to the circuitry, please consult Hitachi's technical department beforehand.

2. Precautions in system design

(1) Input capacity

If the input circuit has a CMOS configuration, electrostatic capacity exists between the input and the ground. The main part of that capacity is between the gate and the substrate, but the capacities of the package and the lead and of the input-protective circuit are added to it. Changes of input capacity based on input voltage are principally attributable to gate-substrate capacity, and the input voltage is usually about 1 5pF or less.

(2) Rise time and fall time of the input wave form

If the input circuit has a CMOS configuration, the rise and

fall time of the input wave form is to be 100ns or less (during when $V_{CC}=4.5\text{V}$), unless specifically provided for. Because the input/output characteristic of the CMOS IC is that the voltage amplification ratio is extremely high near the threshold, there are cases in which, if only a slight ripple component is added to the input voltage, the output operation will become unstable.

(3) Power supply line filter

For purposes of noise decoupling or noise filtering, insert a capacitor of about 1 μF between the power sources (both low-voltage and high-voltage power sources) and the ground. In this case, capacitance relations shall be the electrostatic

capacity of the low-voltage power source filter > electrostatic capacity of the high-voltage power source filter, in order to satisfy section (4) below.

(4) Sequence of power application

Because the Hitachi high-voltage IC is composed of low-voltage and high-voltage devices in a single chip, it is designed to operate on at least two power supply types: high-voltage power supply and low-voltage (usually 5V) power supply. Unless the sequence of power application is specified, be sure to arrange regarding the application that low-voltage power will be supplied first, to be followed by successively higher voltage power. In turning off the power supply, on the other hand, the reverse should be carried out, i.e., turn-off high-voltage power first, then, successively, lower voltage power. Make sure that no input signal is given until after all the types of power are supplied.

3. Circuit design

A reliable circuit design first must fulfill the initial characteristics, then margins must be designed in by applying derating and considering the variable characteristics.

3.1 General considerations

- (1) Make every effort to keep the area near semiconductor devices like ICs, transistors, etc. at a low temperature.
- (2) Keep supply voltage, input voltage, and power consumption within rated values, and consider derating.
- (3) Avoid causing or applying excess voltage due to unnecessary noise at the input, output, and power supply pins.
- (4) If plastic molded semiconductors are placed in a strong electric field, polarization of the plastic material and passivation film results, causing possible errors in operation. Also, strong electromagnetic fields sometimes cause incorrect operation and localized heat radiation, so use a shield in strong electric or magnetic field environments.
- (5) Radiation entering the IC may cause transient noise, sometimes resulting in a malfunction. Separate the IC from radiation sources or use with shielding.
- (6) Prevent static electricity discharges during operation.
- (7) In case IC electrical characteristics are described for ordinary temperatures (25°C), be aware of characteristic changes in the actual operating temperature range.
- (8) Prevent an imbalance in applied voltage in power supply on/off times. For example, if voltage is applied to the input or power supply pins while the circuit ground pin is floating, excessive stress is added.

3.2 Countermeasures against noise and voltage surges

Voltage surges, static electricity, and noise are problems common to all semiconductor devices; countermeasures are necessary to remove or reduce the factors in their occurrence.

Electronic appliances are generally designed on the premise that the output from commercial power supplies varies $\pm 10\%$. However, failures or malfunctions may still be caused by supply voltage changes. If electromechanical devices in which surges may occur are used nearby, they can cause problems as surges are built up in the supply line. Lightning may also cause an impulse surge. These can be reduced by placing a filter on the AC line side such as that shown in Fig. 7.1. Even without surges or static electricity entering directly from the AC line, shielding would be necessary if surges enter the circuit board parts or semiconductor devices directly. A shield's impedance to ground must be low; if it is not, it is ineffective. When there is a danger of noise such as directly applied surge pulses, use protective circuitry as shown in Fig. 7.2. The $R_i \times C_i$ time constant should be in a range that does not affect operation but absorbs surge pulses.

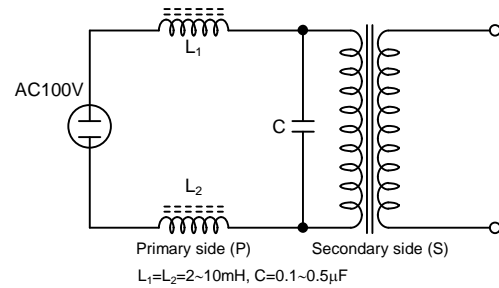


Fig. 7.1 Surge suppressor circuit example

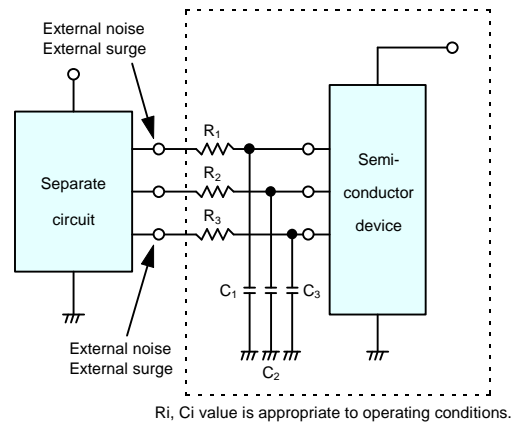


Fig. 7.2 Surge protection circuit example

(1) Countermeasures for noise elimination:

To build a system in which noise is not a problem, necessary countermeasures include finding noise sources in order to reduce or eliminate them, designing against noise pick-up, using circuits with a large noise margin, or establishing corrective circuitry.

(a) Countermeasures at noise sources

The most effective countermeasure is to address the noise-generating source when possible. This is done by reducing surge voltages with a relay coil in parallel with a diode, or by installing resistors and capacitors. For noise on the AC line, place a filter in the power supply line on the generating source side. Also, for devices that produce strong electrical fields, if the generating source side is shielded, fewer countermeasures are needed in the system receiving the interference. Other possible treatment such as separation from the generating source can also be considered. For electromagnetic noise generated by the equipment, caution is necessary also outside the system as this should publicly be controlled as electromagnetic interference waves.

(b) Countermeasures through ground lines

Establishing a ground line dedicated to the circuit system completely separate from such ground systems as those of other power supply lines eliminates interference in the circuit system due to current flowing in the ground system. Also, an having only one contact point between the circuit system and its case prevents the formation of a closed loop between them (Fig. 7.3).

(2) Countermeasures against surges:

Circuit systems are sometimes placed in environments where voltage surges take place; some major examples are shown here.

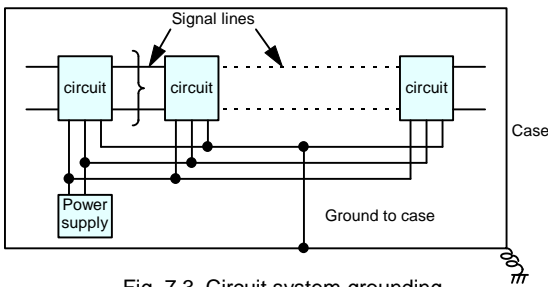
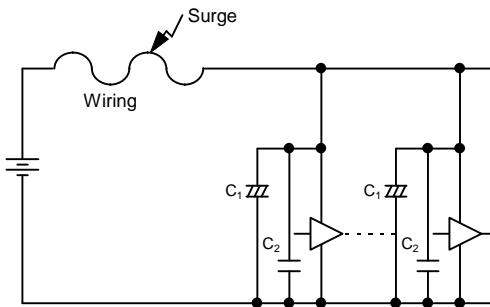


Fig. 7.3 Circuit system grounding

When a high-voltage circuit is near the ICs or transistors like in a unit containing a CRT, voltage surges sometimes occur, due to discharge. Surge voltage reduction is a big factor in improving reliability. Fig. 7.4 shows a circuit in a power supply to absorb surges, a countermeasure for surges due to ignition noise. Finding the surge intrusion route and pin and taking the above countermeasure are necessary to prevent destruction of the semiconductor device by a surge.



Capacitor added in parallel since a series resistance cannot be added to the power supply circuit. Large capacitor C1 and small capacitor C2 are added.

Fig. 7.4 Power supply line surge absorption

(3) Influence of strong electric fields:

Because MOS device operation is controlled by electrical fields, the device package itself polarizes and charges up if a strong electric field is applied from outside for a long period of time. This may change the device threshold voltage, sometimes resulting in characteristic degradation.

(4) Treatment of unused pins:

If ICs are operating with unused input pins exposed, malfunctions will sometimes occur due to crosstalk with other circuits. Input pins not in use should be either grounded through an appropriate impedance or connected to the power supply line.

In installation board design, NC pins should not be used as signal relay points. They should be connected together to the power supply line or the ground, or left open.

(5) Precautions for multiple power supplies:

For ICs requiring multiple supplies (+5V, +12V, etc.), IC destruction sometimes results from the power supply on or off sequence not being in order. Care is required for noise generation if there are many ground pins. (Refer to section 2.)

(6) Latch-up:

The latch-up phenomenon is a problem peculiar to CMOS. This potentially destructive phenomenon occurs when there are unexpected surges exceeding maximum ratings, current ripples, regulation or noise, or if the device is operated with two power supplies not starting up simultaneously. Consequently, sufficient consideration must be given to latch-up prevention during system design.

4. Measurement

When semiconductor devices are measured, the above-mentioned points and the precautions in "5. Precautions

against Static Electricity" below are required. Pay special attention to the following points.

(1) Precautions against static electricity:

During semiconductor measurements all pins are open and the possibility of each pin independently contacting persons, measuring instruments, handlers, or workbenches increases. Device destruction due to static electricity is possible. Care is especially necessary in automatic measuring using a handler, where static electricity easily occurs when the semiconductor slides along the magazine or guide rail. Also, repeated use of shipping magazines as handler loader/unloader cases should be avoided as the magazine anti-static treatment may lose its effectiveness.

(2) Preventing destruction due to power supply input sequence:

Semiconductor devices can be destroyed if the power supply on sequence is not in order. In power supplies having a negative characteristic, voltage will sometimes drop due to transient current flow, depending on the device characteristics, and will cause a malfunction in the device.

Even if the power supply on sequence of the test program is correct, the sequence may not be carried out correctly due to a faulty connection between the device and measuring instrument socket, or the actual power supply on sequence can become reversed due to a combination of the power supply rise speed and the input/output signal rise speed.

(3) Protection against surges voltage and current:

Take care that voltage surges do not occur, especially from the tester during measurement, or take countermeasures such as adding clamping circuitry to the tester, or make sure that abnormal voltages do not occur, due to a faulty connection during measurement with the current source.

When capacitors are inadvertently connected to input/output pins for noise prevention, there is a chance of semiconductor destruction due to capacitor charge/discharge peak currents. For example, when intermediate inspections with board testers or in-circuit testers are being carried out, semiconductor devices are often destroyed if the next board is tested while the tester capacitors are still charged. Also, in the case where capacitors on a board remain charged after a test, there is a possibility of discharge while the board is stored, so the tester and the board must be adequately discharged. In the same manner, when a large-capacity bypass capacitor is inserted on the tester-side power supply, care must be taken to prevent an unnecessary charge from remaining after the power supply is turned off.

(4) Precautions against noise and oscillation:

Even in circuits that normally operate correctly, load capacity becomes large due to the connection of oscilloscope probes or measuring instruments during measurement, and circuits can operate incorrectly due to noise or oscillation, causing semiconductor destruction.

(5) Prevention of semiconductor output and tester driver conflicts:

When measuring I/O common semiconductors, care is required to prevent semiconductor output and tester driver output conflicts.

(6) Leakage from electrical facilities:

Make sure that there is no current leakage through the pins or chassis of the curve tracer, oscilloscope, pulse generator, or DC voltage regulator from AC power supplies.

(7) Semiconductor package breakage due to a handler:

When an auto handler is used in the automatic measurement of semiconductors, care is necessary to avoid excessive impact

on the semiconductor package at the very end of the shooting section. There is a special danger of package destruction in ceramic- and glass-packaged ICs.

(8) General precautions:

When measuring, prevent pin misconnection, reverse insertion, and short circuits between pins. When checking board operation, confirm that there are no solder bridges or foreign particle bridges before powering up for the check.

5. Precautions against static electricity

5.1 General precautions against electrostatic discharge (ESD)

Caution is necessary in handling IC devices since they are generally susceptible to destruction through electrostatic discharge. Because the possibility of electrostatic destruction is especially high in the cases listed below, countermeasures after confirmation of the conditions are necessary to prevent destruction.

(1) When the device and the conductor are contacted:

When conductors or devices are charged, a discharge occurs between them. Workers must be grounded as described in section 5.2(2)(b). For metal objects, the danger of device destruction due to sharp discharges is higher. Contact of devices with metal must be avoided as much as possible, but when unavoidable, the metal should be grounded and the charge must be removed from the device.

(2) When the device receives friction:

Packages become charged when subjected to friction, and when lead pins are rubbed, the chip and lead frame are charged. Prevent friction or suppress the amount of charges by changing the material where friction occurs.

(3) When charged tools are brought in proximity to devices:

The device will be charged through electrostatic induction. Tools must be replaced by those of anti-static materials.

(4) When the humidity of the surrounding area drops:

When humidity drops in the device-handling location, devices or tools once charged do not easily return to their original condition. Since static electricity cannot be seen, it is not easy to take perfect countermeasures against the above (1)~(3). When countermeasures are taken, further effectiveness can be expected if humidity is controlled.

5.2 Cautions on handling devices

(1) Working environment:

Static electricity occurs easily when the relative humidity drops. Surface mount devices must be stored in a dry atmosphere to prevent moisture absorption, but it is important to maintain relative humidity at 45 to 75% with humidifiers during handling and the board mounting process.

(2) Work:


At the work site, easily charged insulators (especially chemical fiber and plastic products) must be avoided as much as possible. Anti-static materials such as anti-static control work gowns and air ionizing blowers are recommended.

When handling semiconductor devices, it is necessary to use materials for electrostatic countermeasures or anti-static containers (for example, electrostatic shield packing, anti-static mats, etc.) in storage and transport.

(a) Equipment and facilities

To prevent electrostatic accumulation, thoroughly ground measuring and test equipment, conveyors, work platforms, floor mats, tools, and soldering baths and irons. Cover workbenches and floors with anti-static mats ($10^5\Omega/\square$ to $10^9\Omega/\square$) and ground them.

(b) Workers

 CAUTION
Ground yourself while working. Also, always connect a resistor of $1M\Omega$ or greater in series. Never touch high-voltage areas. (Electrical shock may result.)

Always wear gloves so that devices are not touched by bare hands.

Gloves and work gowns must not be made of easily charged materials such as nylon. Shoes or sandals, with resistance of $1M\Omega$ to $100M\Omega$ are regarded as adequate, but this resistance can change due to dirt, wear, or humidity.

(c) Work methods

Use a soldering iron for semiconductors (12 to 24V low voltage), and ground the iron tip. In handling devices it is desirable to keep the handling frequency and time on one device to a minimum; working quickly can prevent damage.

6. Precautions for device installation

For assembly and installation of semiconductor devices, consider lead forming, cutting, printed board installation, soldering, cleaning, heat sink installation, component placement, and printed board coating. Take care with these handling and installation methods to ensure semiconductor device reliability.

6.1 Lead forming and cutting

Before installing semiconductor devices onto printed boards, it is sometimes necessary to form or cut leads, but if unnecessary force is applied, device destruction or shortened life can result. For example, if relative stress is applied between the device package and its leads, internal connections can break or a gap which damages the hermetic seal and lowers reliability can open between the body and leads. In the worst case, the mold resin or glass will break. Therefore, take care regarding the following points when forming or cutting leads:

(1) When bending leads, hold the leads between the body and the bending point so that the body is not touched and bending is not done by holding the body, to avoid placing stress between the body and leads.

When using a metal pattern to form large quantities, establish a lead fixing mechanism and keep the lead pressing mechanism from adding stress to the device body.

(2) When bending leads at a right angle, bend at a point at least 3 mm from the body. Avoid bending more than 90° . When bending to an angle less than 90° , bend at a point at least 1.5 mm from the body.

(3) Do not bend leads repeatedly.

(4) Do not bend leads in the thick direction.

(5) Devices are sometimes destroyed by excessive stress (pulling, etc.) in the axial direction, so be certain to keep forces within prescribed values.

(6) Be careful of damage to lead line plated surfaces due to bending jigs or tools. There are no particular problems if application to the leads is around 0.5 mm.

6.2 Mounting on printed circuit boards

When mounting semiconductor devices on a printed board, take care not to place excessive stress on leads.

(1) Make spacing of the printed board device installation holes the same as that of the leads to avoid adding excessive stress during or after device insertion.

(2) When inserting devices into printed boards, avoid forcibly

stretching the leads and using excessive force between the body and leads.

(3) Maintain an appropriate gap between the semiconductor device and the printed board. Use of spacer is a good method.

(4) Avoid any assembly that causes stress between the device body and the leads after fixing in the printed board. For example, if after the leads are soldered into the printed board a heat sink is installed on the device, excessive stress will accumulate in the leads due to lead length tolerance scattering or printed board dimension scattering, which invites lead line pull out, package damage, or disconnection. In such cases, solder the leads after fixing the device.

(5) When using an automatic inserter, take care that shock is not added to the device body, especially during insertion. This prevents package or chip cracks due to shock forces.

(6) Board installation is sometimes carried out using IC sockets, but in use in severe environmental conditions, contact faults between the IC pins and IC socket sometimes occur, so avoid using IC sockets as much as possible.

6.3 Soldering

(1) It is not desirable to subject semiconductor devices to high temperatures for a long period of time. For any methods such as solder iron or reflow, soldering must be done as quickly and at the lowest temperature as possible. The semiconductor device solder heat tolerance test standard is 260°C for 10 seconds or 350°C for 3 seconds at a distance of 1 to 1.5 mm from the device body. Be careful not to exceed these conditions when soldering. When the soldering temperature is high and the time is long the device temperature rises, which can lead to degradation or destruction.

If highly acidic or alkaline flux is used in soldering, corrosion of the leads can occur, having negative effects on characteristics, so rosin type flux is recommended. In all cases adequate flux cleaning after soldering is important (see section 6.4).

For soldering irons, use of either a grounded three-terminal iron or a grounded iron tip with a secondary voltage dropped by a transformer to prevent leakage in the tip is considered adequate (Fig. 7.5). The soldering location should be as far as possible from the device body.

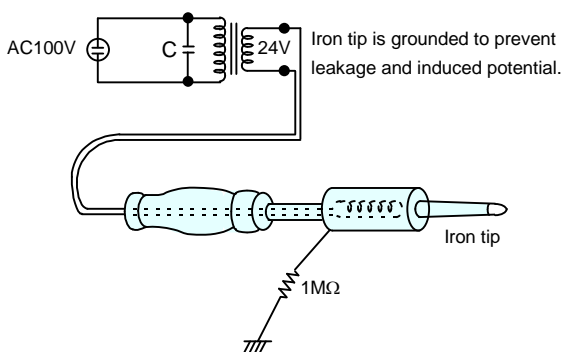


Fig. 7.5 Solder iron tip grounding

(2) Use caution when soldering pin insertion packages in a wave soldering bath. In this method, the package lead pin soldering section is placed on the liquid surface of a flowing solder bath, but if the flowing solder touches the package body, package damage can result, so take care that the solder does not directly contact the package body.

In wave solder bath use, the board can warp due to the temperature difference between the top surface and back side to which the solder heat is added. If soldering is done with the

board in this warped condition, the board will try to return to its original shape when removed from the solder bath, and there is a chance of contact section cracks, or lead or package damage due to excessive stress. For this reason, clamp the board with a metal clasp so that warping does not occur during soldering when using wave solder baths (Fig. 7.6).

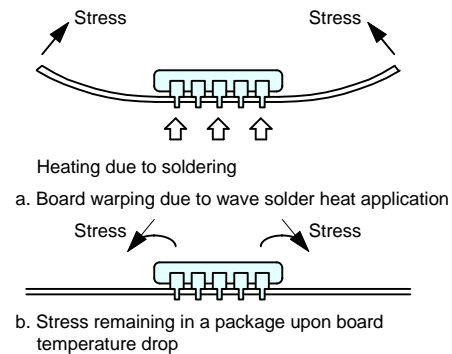


Fig. 7.6 Board warping in a wave solder bath

(3) Refer to section 7 for precautions on soldering surface mount packages.

6.4 Cleaning methods

Flux residue after soldering affects the reliability of components and board wiring, so cleaning is necessary as a rule. Cleaning methods include ultrasonic wave, soaking, spraying, and vapor cleaning. The features of each cleaning method are as follows:

(1) Ultrasonic wave cleaning:

Ultrasonic wave cleaning vibrates a product in a solvent to clean it, which is good for cleaning microscopic gaps, but care is necessary to avoid possible damage to the contact between the board and the device.

(2) Soaking:

A product can be soaked in a warm or cold cleaning solution. The cleaning solution must be very pure.

(3) Spray cleaning:

A solvent under high pressure is sprayed onto a product, when there is little clearance between the component and the board, spraying at an angle increases cleaning effectiveness.

(4) Vapor cleaning:

Solvent stream is used to clean. Since cleaning is possible with solvents containing no impurities, vapor cleaning is most often used in final cleaning processes.

Cleaning is generally carried out combining these processes. A general cleaning process is shown in Figure 7.7.

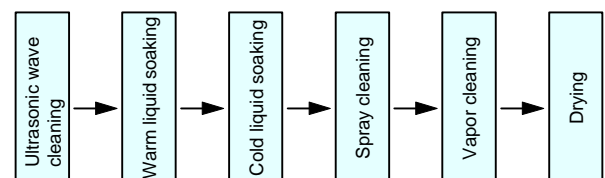


Fig. 7.7 General cleaning process

Be attentive to the following points during cleaning:

(1) Ultrasonic wave cleaning is done under the conditions listed below as an example, but to prevent destruction, care is necessary to prevent device oscillation. Care is also necessary with the applied frequency, power (especially peak power), and time:

- Frequency: 28 to 29kHz (device not oscillating)

- Ultrasonic wave output power. 15W/1 (1 time)
- Time: Less than 30 seconds
- Other: Avoid direct contact between vibration source and device or printed board.

Connecting wires can oscillate and break when ultrasonic cleaning is carried out, especially for ceramic package families such as QFN (LCC) and QFP (ceramic), which are cavity packages.

(2) Since markings will sometimes disappear after cleaning for long periods, apply after confirmation in actual use conditions.

(3) Consideration of public environmental and safety standards is necessary when solvents are used.

(4) The standards in Table 7.2, which follow the MIL standards, are recommended for the desired degree of purity after cleaning printed boards.

Table 7.2 Degree of printed board purity after cleaning

Printed board purity after cleaning	Item	Standard
	Amount of CI residue	Less than 1 $\mu\text{g}/\text{cm}^2$
Resistive value of extract solvent (after extraction)	$2 \times 10^6 \Omega \cdot \text{cm}$ or greater	

- Notes: 1. Board area: Both surfaces of printed board + installed components
 2. Extract solution: Isopropyl alcohol (75 vol%) + H₂O (25 vol%) before extraction (Extract solution resistance value $6 \times 10^6 \Omega \cdot \text{cm}$ or greater).
 3. Extraction method: Clean both board surfaces with 10 ml / 2.54×2.54 cm² (for at least 1 minute).
 4. Determine solvent resistance value measurement with conductivity meter. Confirm details of MIL standards by referring to MIL-P-28809A.

6.5 Mounting on heat sinks

Heat sinks are generally used with power devices to lower the junction temperature by radiating heat externally. The following precautions are necessary when using heat sinks attached to semiconductor devices for effective heat radiation and for preventing loss of reliability.

(1) Silicon grease selection:

A thin layer of silicon grease is generally applied evenly over the contact surface between the device and the heat sink to maximize heat conduction. However, some devices will absorb the silicon grease and become swollen.

Therefore, select only products such as Shinetsu Chemical G746 or the equivalent, which contain a non-penetrating resin and oil base. (This applies only to epoxy packages, not metal or ceramic packages.) Avoid high-viscosity or non-homogeneous greases because forces that develop as the package is tightened to the heat sink may cause package cracking. Avoid application of excessive amounts of grease for the same reason.

(2) Tightening torque:

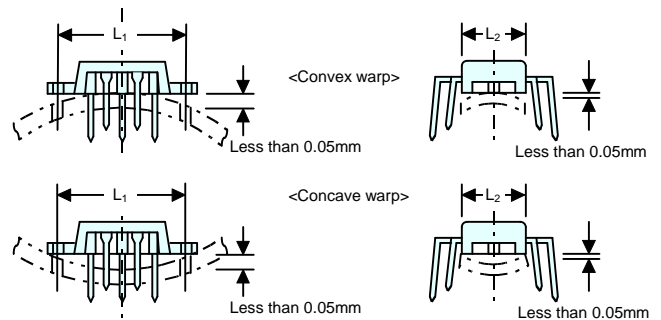
Insufficient tightening torque invites an increase in heat resistance, and excessive torque invites such failures as warping of the device, die destruction, and connector lead breakage. Please use the tightening torque value 0.39~0.59N·m (4~6 kg·cm).

(3) Heat sink flatness:

When attaching devices to heat sinks, inappropriate heat sinks will hinder heat radiation. In addition, adding

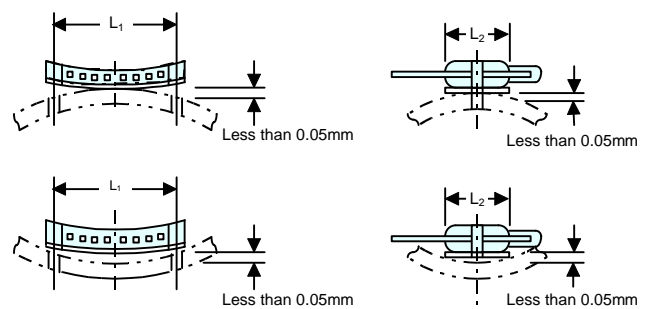
unnecessary stress will cause characteristic degradation or resin cracks. Observe the following points regarding heat sinks:

1) To avoid a heat sink causing convex or concave warping, keep the warp between screw holes less than 0.05 mm (Fig. 7.8 and 7.9). Also, twist to a maximum of 0.05 mm.



L₁: Screw hole gap (24 ± 0.22mm), L₂: Resin width (10.7mm)

Fig. 7.8 Heat sink warping: QIL and DIL packages



L₁: Screw hole gap (24 ± 0.3mm), L₂: Header width (8.4mm)

Fig. 7.9 Heat sink warping: SIL package

2) For aluminum, copper, and iron boards, make sure there is no press tension, and always bevel the screw holes.

3) A contact surface with a device must be ground flat (▽▽finishing).

4) Prevent and remove any shaved particles between the IC header and the heat sink.

5) Make sure the screw hole gaps match those of the device. If they are too wide or too narrow, resin cracks can result.

(4) Avoid direct soldering on the device heat sink side:

Direct soldering on the device heat sink side can cause destruction or a shorter life span by adding heat in excess of the junction temperature guarantee value.

(5) Avoid adding mechanical stress to packages:

When metal tools (drivers or jigs) are used to tighten plastic packages, cracks in packages, internal mechanical stress, speeding of device contact section fatigue, and destruction or broken connection faults occur. Therefore, sufficient caution is required.

(6) Do not attach a heat sink to a device after lead soldering:

If heat sinks are attached to devices after soldering leads into printed boards, excessive stress accumulates in the leads due to the lead length, or printed board and heat sink dimension dispersion occurs. Consequently, leads pull out, package destruction occurs, and broken connections can result. Attach heat sinks to the device before soldering leads.

(7) Avoid processing or transforming the tab or package.

If cutting or forming is done to the tab or package, an increase in thermal resistance is encouraged and abnormal stress is applied inside the device, which promotes failures.

(8) Note which screws are to be used:

The screws that attach the heat sink to the device are generally classified into small screws and tapping screws. Observe the following precautions when using these types of screws:

- 1) Use small bind and truss screws that have heads which meet JIS-B1101 standards.
- 2) Avoid using countersink screws, which add abnormal stress to devices (Fig. 7.10).

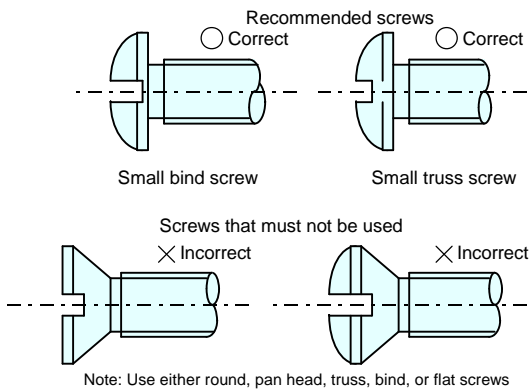


Fig. 7.10 Classification of recommended screws and those that must not be used.

- 3) Even when using tapping screws, ensure the tightening torque noted previously.

- 4) Avoid using tapping screws that are thicker than the device attachment hole diameter. Tapping the device attachment holes or heat sinks can promote failures.

- (9) Heat sink screw hole diameters:

Note the following points.

- 1) Hole diameter too large: Do not make the heat sink hole diameter or beveling larger than the head diameter of the screw. The tightening torque will deform copper boards and plastic packages, especially for devices using copper boards as flange material.

- 2) Hole diameter too small: When using tapping screws, the tightening torque becomes large and the recommended torque is exceeded, or the desired contact resistance becomes unobtainable.

- (10) Other precautions and recommended conditions for heat sink attachment:

- 1) When attaching one heat sink to two or more devices, the heat resistance of each device rises.
- 2) Heat sinks must have an appropriate shape and size. Use forced cooling as necessary.

6.6 Part arrangements

Semiconductor device reliability and characteristics vary according to environmental conditions. Therefore, semiconductor device positioning within the system based on temperature and heat dissipation conditions must be carefully researched to promote high reliability.

- (1) Heat radiation sources such as large resistors near semiconductor devices will add heat directly to the heat sinks or the devices; abnormal heat will lower reliability. Give consideration to ventilation during positioning.

- (2) Dust easily accumulates inside of equipment near high-voltage circuits and in lower corners. Insulation degradation or malfunction will sometimes occur in semiconductor devices that are mounted in such places, due to dust affixation. Countermeasures include coating the printed boards and semiconductor devices with a water repellent resin.

Board coating is very effective in achieving and raising system reliability. When boards are not coated, the life span of the system and semiconductor device is shortened. Some

examples are: malfunction caused by short circuit between the board wiring and semiconductor pins due to conductive foreign matter (soldering or plating scraps), noise generation due to dust accumulation and moisture absorption, trouble due to a large current leakage, and trouble due to metal migration (Ag migration) in environments that allow condensation. Board coating is extremely important under harsh conditions such as high humidity, condensation, and dust accumulation to ensure reliability over long maintenance-free periods. When using coating materials with surface mount package semiconductors, stress arising from resin hardening, contraction stress, or the heat expansion coefficient difference with the board can cause device breakage, cracks, or disconnections in solder sections between the leads and the boards. Therefore, sufficient consideration must be given when selecting the coating material and coating structure. See section 7, "Handling surface mount packages."

7. Handling surface mount packages

This section explains cautions and installation conditions for surface mount packages.

7.1 Cautions for handling

When surface mount devices are soldered to a printed board, the solder must be first put on the devices, so they have a structure not susceptible to heat stress during installation. Observe the following precautions when using installation methods that heat the entire package.

- (1) Package moisture absorption:

When epoxy resin used in plastic packages is stored in high humidity areas, moisture absorption is unavoidable. If a large amount of water is absorbed, it quickly turns into steam during solder installation, which causes resin/lead frame surface separation and, in some cases, package cracking. Therefore, store surface mount packages in a dry atmosphere.

For products requiring moisture absorption control, anti-moisture packaging is used for shipping and storage. To avoid reabsorption after opening anti-moisture packaging, store under the designated environmental conditions and complete installation within permissible storage time.

For storage after opening, insert silica gel free of absorbed moisture (for which blue color indication can be confirmed), reseal and store.

To remove moisture absorbed during shipping, storage, or handling for 16 to 24 hours at 125°C is recommended before solder installation. Baking is necessary in the following cases:

- 1) When a blue color indicator placed in a desiccant (silica gel) cannot be seen through the desiccant pouch.
- 2) When more than one week has elapsed since opening (except for storage under conditions noted above).
- 3) When baking with an attached label is requested. (Baking of one part of products containing ultra-thin packages or very large chips is sometimes necessary.)

Normal shipping magazines, trays, tape and reels are not heat resistant. Therefore, devices must be transferred to heat resistant containers before baking. Heat resistant magazines and trays are partially developed. Trays marked "Heatproof" can be baked. However, avoid baking items still in their anti-moisture packaging pouch. To prevent tray warping, place trays on a flat board, bake, and cool slowly.

- (2) Moisture resistivity countermeasures:

Compared to normal plastic package DIP products, surface mount product mold resin is thinner and the distance between the external leads and the internal chip is shorter, therefore

consideration of moisture resistivity is necessary. One example of a countermeasure is resin coating for outdoor instruments or those for which moisture resistivity is especially important. For coating material, there are polyurethane-based and silicon-based resins, but stress arising from resin hardening, contraction stress, or a difference in heat expansion coefficients vis-à-vis the board can cause device breakage and cracks or disconnections in solder sections between the leads and the boards. Therefore, sufficient consideration must be given when selecting a coating material and coating structure.

(3) Precautions for taped products:

For chip components and ICs (SOPs, etc.) that are taped, the cover tape and carrier tape peeling charge becomes higher the faster the peeling speed. To prevent electrostatic destruction, avoid high-speed peeling and friction when possible. Recommended peeling speed is under 10 mm/sec.

(4) Installation precautions:

When the relative humidity drops, static electricity charges more easily. Surface mount packages must be stored in a dry atmosphere to prevent moisture absorption, however, to prevent charging. Relative humidity of 45% to 75% is desirable during handling and installation.

7.2 Reflow soldering

A fixed amount of solder paste is applied with a screen print method (for example) to a pattern on a printed board forming the prescribed shape of the lead pin solder junctions, then the package is placed on it. The package is temporarily fixed by the solder paste surface tension. Afterwards, when the solder is remelted (during reflow), the package leads and printed board pattern section conform to each other due to a selfalignment effect through melted solder surface tension. The values for the junction section pattern of a printed board lead vary according to the solder paste materials used and the reflow conditions; however, they should be designed for 1.1 to 1.3 times the solder lead pin width.

7.3 Recommended conditions for each installation method

The most-often used methods for surface mounting devices are the infrared reflow, vapor phase reflow, and flow solder methods. As the entire package is heated in all of these methods, significant heat stress is added to packages, and control of surface temperature and solder junction temperature is necessary to maintain reliability. In the case of the reflow method, Hitachi's recommended installation conditions are stated as the package surface temperature.

In case of the flow solder method Hitachi's recommended installation conditions are stated as the solder temperature and dipping times.

Description of Fig. 7.11 is as follows:

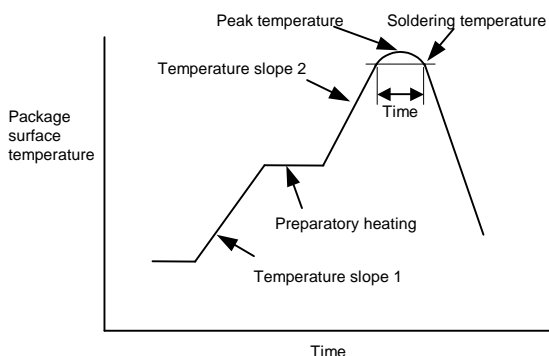


Fig. 7.11 Recommended conditions

(1) Temperature slope 1:

When the temperature rises quickly, the surface mount device package part (top, insides, back) temperatures become unequal, and packages warp due to material heat expansion coefficient differences, which sometimes results in chip damage. Therefore, care is necessary concerning the upper limit of the temperature increase speed. The lower limit is set by reflow equipment operating efficiency.

(2) Preparatory heating:

To promote solder junction stability and alleviate heat shock, the component and board temperatures should be adjusted to less than the solder melting temperature. This is generally established as close to the surface mount device rated temperature.

(3) Temperature slope 2:

The increase speed upper limit is the same as in number 1 above. The lower limit is determined by the need to stay within the prescribed peak temperature, and the time is indicated in (4), below.

(4) Peak temperature and time:

Care must be taken to keep package damage to a minimum. As the peak temperature directly affects the package strength decrease (due to resin temperature characteristics) and steam pressure within the package, the lowest possible temperature is desired. As the steam pressure rises with time, treatment should be completed as quickly as possible. The conditions reported by Hitachi are common points between the allowable range and the possible range for solder junctions; however, because they are upper limits and not average values, do not exceed upper limit values when establishing conditions (as indicated by the dotted line in Figure 7.11).

The recommended conditions for each installation method are shown in Figures 7.12 and 7.13.

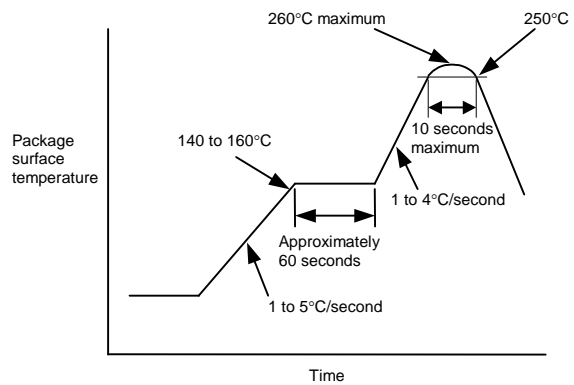


Fig. 7.12 Recommended conditions for infrared reflow and air reflow

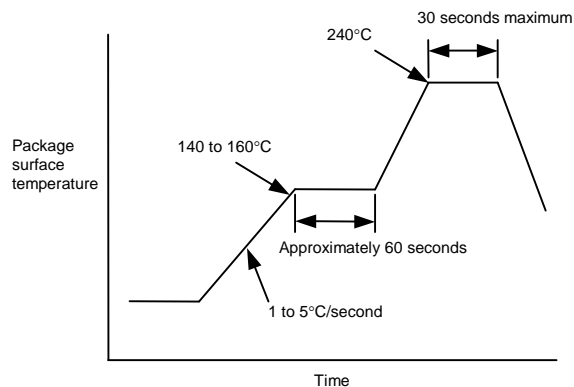


Fig. 7.13 Recommended conditions for vapor phase

8. Package storing and transporting

General cautions concerning storage and shipping of devices, but some points require additional care. Below is an explanation including general items.

8.1 Packaging precautions

Recent semiconductor devices have high quality and reliability, but there are many factors in device destruction (electrostatic or mechanical destruction, or by humid gas) related to user handling, installation, or use conditions. First, cautions concerning device destruction occurring with storage cases and packing are listed.

(1) Storage cases:

Pay heed to the following storage case precautions.

(a) Since semiconductor makers use device storage cases with materials and construction to maintain initial quality even under the worst environmental conditions, use storage cases designated by the maker whenever possible.

(b) When maker-designated storage cases cannot be used, store in cases that:

- Do not cause chemical reactions or generate harmful gases
- Are constructed to prevent device destruction due to vibration or shock
- Have case parts that contact the device pins made of conductive or non-charging material (surface painted with a charge preventing agent)

(c) When removing from storage cases devices susceptible to electrostatic destruction such as high frequency or MOS devices, use finger sheathes or anti-static gloves after discharging static electricity from the worker and clothing through a high resistance (about $1\text{M}\Omega$) to ground.

(2) Packaging:

Semiconductor devices contained in storage cases must be packaged to avoid external influences such as shock, rain, or contamination.

(a) Keep shock, vibration, and humidity to a minimum. Consider the mechanical strength, vibration tolerance, and moisture resistivity of the shipping method. Generally, storage cases are tightly wrapped in polyfoam or vinyl, placed in a cardboard box filled with packing material for vibration tolerance, and then closed tightly with tape or string. For some shipping circumstances stricter packaging is required.

(b) Indicators such as those in Fig. 7.14 should be put on the external cardboard box.

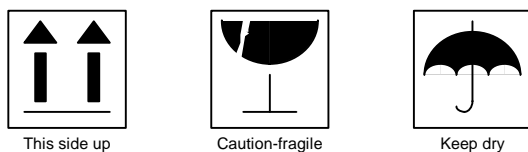


Fig. 7.14 External indicators

(c) When relatively bad environments are foreseen such as in sea shipping, vacuum packing or hermetic containers are necessary.

(d) Transparent plastic magazine surfaces are treated for charge prevention, but because degradation occurs with time, avoid storing for more than six months, and avoid re-using plastic magazines.

8.2 Storage methods for semiconductor devices

When storing semiconductor devices, environmental control is necessary for temperature, humidity, ultraviolet rays, harmful gases such as hydrogen sulfide, radiation such as x-rays, static electricity, and strong electromagnetic fields.

(1) Storage environment:

(a) Humidity range

Normal values of temperature and humidity are desirable in a semiconductor device storage location; avoid extremes. Temperatures of $5\sim 35^\circ\text{C}$ and $45\sim 75\%$ relative humidity are desirable condition. In areas that become very dry in winter a humidifier must be used. If tap water is used in the humidifier, chlorine might rust device leads, so use boiled or distilled water.

(b) Cleanliness

Avoid places that are dusty or where corrosive gases are generated.

(c) Stable temperature

Avoid environments where there are sudden temperature changes, since moisture condensation can occur in devices. Choose darker places with no direct sunlight or strong lighting.

(d) Other

Choose a location free from radiation, static electricity, and strong electromagnetic fields.

(2) Storage form:

(a) Care is required so that weight is not applied to semiconductor devices in storage. Weight can be applied unexpectedly, especially in stacking. Avoid placing heavy objects on devices (Fig. 7.15).

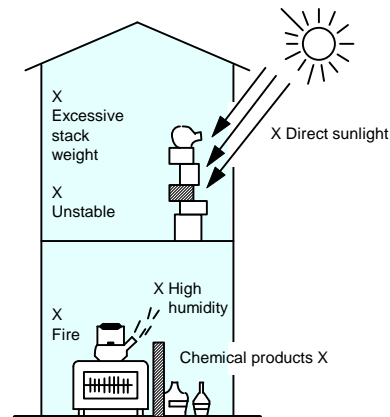


Fig. 7.15 Bad storage locations

(b) Store semiconductor device external terminals in an unprocessed condition to avoid lead oxidation during storage; oxidation will cause solderability failure (Fig. 7.16).

(c) Choose containers that do not charge easily for storing semiconductor devices.

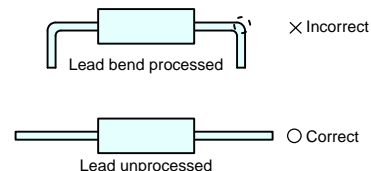


Fig. 7.16 Storage form

(3) Long-term storage:

When storing semiconductor devices for long periods (one year or more), there is a chance of lead pin solderability deterioration, rusting, or electrical characteristic faults; the precautions below are especially necessary.

(a) See storage environment above, 8.2(1), for proper storage conditions.

(b) When long-term storage (one year or more) is foreseen, use vacuum packing or hermetic containers with silica gel placed inside.

(c) When an unexpectedly long period has elapsed (one to eight years) in normal storage, inspection for solderability and lead rusting before use is necessary.

(d) When left in very bad environments or when more than one year has elapsed in normal storage, inspection is necessary for solderability, lead rusting, and electrical characteristics (for surface mount packages see section 7). Additionally, use tape automated bonding (TAB) products within three months.

(4) Chip and wafer storage:

Semiconductor chips and wafers require stricter storage than packaged products. Fig. 7.17 shows an example chip storage container. Absolutely avoid leaving or storing chips or wafers directly exposed to air.

(a) Store chips and wafers in a proper container and do not open or close more than necessary. Normal chip storage containers have a hermetic construction and protect chips and wafers from temperature, humidity, harmful gases, and from vibration and shock during shipment or movement.

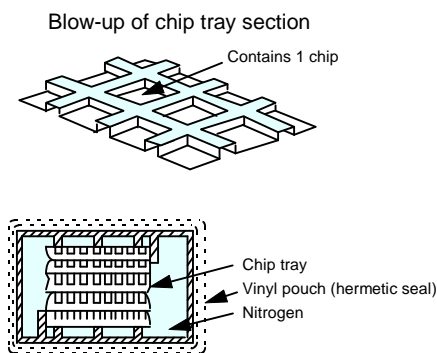


Fig. 7.17 Chip storage containers

(b) Avoid leaving containers open, to prevent chip and wafer temperature and humidity changes, or oxidation or corrosion due to gas, dust, or chemicals.

(c) Store in an environment of 5~30°C, 45~75% RH, away from the effects of volatile chemicals.

(d) When taking chips from or placing them into storage containers, handle gently with vacuum tweezers or collets to avoid scratching chip surfaces.

(e) After storage, five days is the standard maximum time from opening a chip or wafer container until assembly. However, during periods between work such as nights, devices must be placed in dry nitrogen. After package opening, keep in dry nitrogen (lower than the -30°C dew point) up to 20 days; for packages in an unopened condition, keep less than 3 months.

8.3 Precautions in transporting

When shipping semiconductor devices, units, or subsystems that include them, heed the precautions common to other electronic components as well as the following:

(1) Handle the external cardboard box gently, as shocks or dropping can cause device destruction.

(2) Handle the internal box especially gently. If dropped, stoppers in the magazines may come out, causing products to be thrown out and leads to be bent or damaged, or causing hermetic leakage faults in ceramic packages.

(3) Keep the package dry. Be careful to prevent it from getting wet during shipment in rain or snow.

(4) Ship in containers and jigs that do not produce static electricity or charging due to vibration during shipping. Use of anti-static containers or aluminum foil is effective.

(5) Prevent electrostatic destruction from workers or clothing by grounding through a large resistance during handling. A resistance value of 1 MΩ is used to prevent the danger of generating an electrical shock between the body and the ground.

(6) Move printed boards with semiconductor devices installed using methods that prevent static electricity charging, and short pins to the same potential. Also, when moving printed boards with a belt conveyor, use anti-static controls to prevent the conveyor rubber from charging.

(7) Keep mechanical vibration and shock to the absolute minimum when shipping semiconductor devices or printed boards.