M/A-COM Technology Solutions

Moisture Effects on the Soldering of Plastic Encapsulated Devices

Rev. V5

Introduction

Improper packaging, storage, and handling of plastic encapsulated devices (PED's) can trap moisture within the devices and lead to damage during reflow soldering to printed circuit boards. As part of reliability qualification and testing, M/A-COM tests and classifies all semiconductor devices for moisture sensitivity to assure long term reliability. This application note briefly describes the moisture-induced soldering failure mechanism and test procedures, and moisture sensitivities of M/A-COM's plastic packaged semiconductors.

Moisture Induced Soldering Failures

Moisture inside a plastic package turns to vapor and tries to expand when the package is exposed to rapid high temperatures during soldering. The internal vapor pressure can cause separation of the plastic encapsulant from the semiconductor chip or lead frame, internal and external cracks, and damage to thin films and wire bonds. In severe cases, soldering may cause an integrated circuit to bulge and then explode with an audible pop. Compared to through-hole devices, surface mount devices (SMD's) have thinner plastic capsules and come into more intimate contact with high temperatures. Therefore, measures to limit and reduce the ingress of moisture during handling and storage of SMD's are generally more critical for SMD's than for through-hole devices. To reduce the effects of moisture-induced stress during soldering, M/A-COM recommends bake-out of some of its most moisture sensitive devices before reflow soldering according to standard industry procedures.

Moisture Test Methods

M/A-COM tests its PED's according to the procedures outlined by the standards organization JEDEC. We will briefly summarize the procedures here, but we recommend that the reader consult IPC/JEDEC J-STD-020, J-STD-033 and JESD22-A113 for detailed explanation of test procedures and failure criteria. For information on surface mounting consult application note M538 or S2083.

As recommended by JEDEC, we start with a sample of known good parts and subject the parts to a 24-hour bake-out at 125°C to remove all moisture. Next we place the parts in a moist, warm environment for a prescribed period of time, as outlined in Table 1 under "soak requirements". Within four hours of removing them from the soak, we then subject the parts to three cycles of convection reflow with the temperature profile recommended by JEDEC. The tin-lead eutectic solder profile includes a preheat to 150°C, followed by 60 - 150 seconds above 180°C with a maximum temperature of 240°C, followed by a ramp-down back to room temperature. The lead-free/RoHS solder profile includes a preheat to 200°C, followed by 60 - 150 seconds above 217°C with a maximum temperature of 260°C. Please consult JEDEC for the complete profile.

After the convection reflow procedure, we examine the devices for failures. JEDEC defines moisture-induced solder stress failures as any external cracks visible with a 40X optical microscope, DC electrical or functional failures, and most internal cracks, especially those that intersect a bond wire or ball/wedge bond. M/A-COM also examines the devices for any delaminating associated with moisture sensitivity.

M/A-COM performs these tests on any devices with different package type, mold compound, or die pad area relative to devices that we have already tested.

Moisture Absorption and Floor Life

After bake-out for removal of moisture, all PED's eventually reach a condition of humidity equilibrium between the inside and outside of the package. JEDEC defines the time at which the moisture inside the package reaches a level likely to induce failure as the "floor life". The rate of moisture absorption depends upon ambient temperature and humidity conditions, so JEDEC defines the floor life under specific ambient conditions. Devices stored beyond the floor life require a bake-out before reflow soldering to avoid possible damage. M/A-COM includes moisture sensitivity labels with all PED's that have a limited floor life and might need bake-out.

Moisture Sensitivity Ratings

Devices with sensitivity to moisture-induced solder stress should be shipped and stored in sealed, dry containers with a desiccant. As explained above, sensitive devices require a bake-out to remove moisture prior to reflow soldering if stored in typical ambient conditions beyond the floor life, or damage could result.

Based on the floor life, JEDEC outlines six levels of moisture sensitivity as shown in ***Table 1***. Level 1 devices are considered not sensitive to moisture, and have an unlimited floor life. These devices do not require dry pack shipping, and do not require bake-out prior to reflow soldering. Devices above level 2 are considered moisture sensitive, and require dry pack shipping and bake out. Level 6 devices are considered extremely moisture sensitive. The JEDEC guidelines specify that the user should reduce or eliminate reflow heating by mounting these PED's on sockets or by performing a bake-out on the devices immediately before reflow soldering.

Visit www.macomtech.com for additional data sheets and product information.

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Level	Description	Floor Life		Soak Requirements	
		Time	*	Hours	*
1	Not Sensitive	Unlim-ited	1	168	3
2	Sensitive. Requires dry pack	1 year	2	168	4
2A	Sensitive. Requires dry pack	4 weeks	2	696	5
3	Sensitive. Requires dry pack	168 hours	2	192	5
4	Sensitive. Requires dry pack	72 hours	2	96	5
5	Sensitive. Requires dry pack	48 hours	2	72	5
5A	Sensitive. Requires dry pack	24 hours	2	48	5
6	Extremely Sensitive. Dry pack. Socket mount or bake-out before reflow solder-ing	See Label	2	See Label	5

*Conditions

1. ≤ 30°C / 85 percent relative humidity
2. ≤ 30°C / 60 percent relative humidity
3. 85°C / 85 percent relative humidity
4. 85°C / 60 percent relative humidity
5. 30°C / 60 percent relative humidity

(See test for definition of floor life.)

Table 1: JEDEC Defined Moisture Sensitivity Level

Moisture Sensitivity Ratings of M/A-COM Devices

All PED's shown within the M/A-COM catalog meet moisture sensitivity classification level 1, unless otherwise indicated on the data sheet. At the time of writing of this application note (November 2000), only devices in plastic ball grid array (pBGA) packages, do not meet level 1 specifications. M/A-COM rates these devices at or above moisture sensitivity level 3, indicating that the parts have a floor life of 168 hours or less.

Conclusion

Moisture trapped inside plastic encapsulated devices (PED's) can damage them during soldering, as the moisture vaporizes and tries to expand. M/A-COM tests its PED's for moisture sensitivity according to the procedures outlined by the standards organization JEDEC. With one exception at the time of wiring of this application note, you can store any of M/A-COM PED's at room temperature and 85 percent relative humidity for an unlimited time without experiencing solder damage from moisture absorption. The exception in devices packaged in the pBGA's package, most of which we rate at a moisture sensitivity level (MSL) of 3. M/A-COM recommends that users of pBGA's observe the JEDEC-recommended cautions. If a user has stored these devices beyond the floor life at or above recommended temperature relative humidity, JEDEC guidelines recommend a bake-out before reflow soldering.

Additional Notes:

1. See M/A-COM's web site, www.macom.com, or contact your local field sales representative, factory applications engineer, or product manager for assistance with moisture sensitivity and plastic encapsulated semiconductor components. For information on surface mounting consult application note M538 or S2083.
2. For more information on JEDEC procedures for moisture sensitivity, see IPC/JEDEC J-STD-020, J-STD-033 and JESD22-A113, available at www.jedec.org

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