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Moisture Induced Cracking During Solder Reflow

The surface mount reflow processing step subjects the Plastic Surface Mount Components (PSMC) to high thermal exposure and chemicals from solder fluxes and cleaning fluids during user's board mount assembly. The plastic mold compounds used for device encapsulation are, universally, hygroscopic and absorb moisture at a level determined by storage environment and other factors. Entrapped moisture can vaporize during rapid heating in the solder reflow process generating internal hydrostatic pressure. Additional stress is added due to thermal mismatch, and the Thermal Coefficient of Expansion (TCE) of plastic, metal lead frame, and silicon die. The resultant pressure may be sufficient to cause delamination within the package, or worse, an internal or external crack in the plastic package. Cracks in the plastic package can allow high moisture penetration, inducing transport of ionic contaminants to the die surface and increasing the potential for early device failure.

How the effects of moisture in plastic packages and the critical moisture content result in package damage or failure is a complex function of several variables. Among them are package construction details-materials, design, geometry, die size, encapsulant thickness, encapsulant properties, TCE, and the amount of moisture absorbed. The PSMC moisture sensitivity has, in addition to package cracking, been identified as a contributor to delamination-related package failure artifacts. These package failure artifacts include bond lifting and breaking, wire neckdown, bond cratering, die passivation, and metal breakage.

Because of the importance of the PSMC moisture sensitivity, both device suppliers and device users have ownership and responsibility. The background for present conditions, moisture sensitivity standardized test and handling procedures have been published by two national organizations. Users and suppliers are urged to obtain copies of both documents (listed below) and use them rigorously. Xilinx adheres to both.

- JEDEC STANDARD JESD22-A112. Test Method A112
"Moisture-Induced Stress Sensitivity for Plastic Surface Mounted Devices". Available through Global Engineering Documents Phone: USA and Canada 800-854-7179, International 1-303-792-2181
- IPC Standard IPC-SM-786A
"Procedures for Characterizing and Handling of Moisture/Reflow Sensitive ICs". Available through IPC Phone: 1-708-677-2850

None of the previously stated or following recommendations apply to parts in a socketed application. For board mounted parts careful handling by the supplier and the user is vital. Each

of the above publications has addressed the sensitivity issue and has established six levels of sensitivity (based on the variables identified). A replication of those listings, including the preconditioning and test requirements, and the factory floor life conditions for each level are outlined in Table 6. Xilinx devices are characterized to their proper level as listed. This information is conveyed to the user via special labeling on the Moisture Barrier Bag (MBB).

In Table 1, the level number is entered on the MBB prior to shipment. This establishes the user's factory floor life conditions as listed in the time column. The soak requirement is the test limit used by Xilinx to determine the level number. This time includes manufacturer's exposure time or the time it will take for Xilinx to bag the product after baking.

Table 1: Package Moisture Sensitivity Levels per J-STD-020

Level	Factory Floor Life		Soak Requirements (Preconditioning)			
	Conditions	Time	Time		Conditions	
1	<=30°C / 90% RH	Unlimited	168 hours		85°C / 85% RH	
2	<=30°C / 60% RH	1 year	168 hours		85°C / 60% RH	
			Time (Hours)			
			X +	Y	= Z	
3	<=30°C / 60% RH	168 hours	24	168	192	30°C / 60% RH
4	<=30°C / 60% RH	72 hours	24	72	96	30°C / 60% RH
5	<=30°C / 60% RH	24 / 28 hours	24	24 / 28	48 / 72	30°C / 60% RH
6	<=30°C / 60% RH	6 hours	0	6	6 3	0°C / 60% RH

Notes:

1. X =Default value of semiconductor manufacturer's time between bake and bag. If the semiconductor manufacturer's actual time between bake and bag is different from the default value, use the actual time.
2. Y = Floor life of package after it is removed from dry pack bag.
3. Z = Total soak time for evaluation.

Factory Floor Life

Factory floor life conditions for Xilinx devices are clearly stated on MBB containing moisture sensitive PSMCs. These conditions have been ascertained by following Test Methods outlined in JEDEC JESD22-A112 and are replicated in Table 6. If factory floor conditions are outside the stated environmental conditions (30°C/90% RH for Level 1, and 30°C/60% RH for Levels 2-6) or if time limits have been exceeded, then recovery can be achieved by baking the devices before the reflow step. Identified in the next section are two acceptable bake schedules. Either can be used for recovery to the required factory floor level.

Dry Bake Recommendation and Dry Bag Policy

Xilinx recommends, as do the mentioned publications and other industry studies, that all moisture sensitive PSMCs be baked prior to use in surface mount applications, or comply strictly with requirements as specified on the MBB. Tape and Reeled parts are universally dry packed. Level 1 parts are shipped without the need for, or use of, an MBB.

Two bake schedules have been identified as acceptable and equivalent. The first is 24 hours in air at 125°C, in shipping media capable of handling that temperature. The second bake schedule is for 192 hours in a controlled atmosphere of 40°C, equal to or less than 5% RH. Dry Devices are sealed in special military specification Moisture Barrier Bags (MBB). Enough desiccant pouches are enclosed in the MBB to maintain contents at less than 20% RH for up to 12 months from the date of seal. A reversible Humidity Indicator Card (HIC) is enclosed to

monitor the internal humidity level. The loaded bag is then sealed shut under a partial vacuum with an impulse heat sealer.

Artwork on the bags provides storage, handling and use information. There are areas to mark the seal date, quantity, and moisture sensitivity level and other information. The following paragraphs contain additional information on handling PSMCs.

Handling Parts in Sealed Bags

Inspection

Note the seal date and all other printed or hand entered notations. Review the content information against what was ordered. Thoroughly inspect for holes, tears, or punctures that may expose contents. Xilinx strongly recommends that the MBB remain closed until it reaches the actual work station where the parts will be removed from the factory shipping form.

Storage The sealed MBB should be stored, unopened, in an environment of not more than 90% RH and 40°C. The enclosed HIC is the only verification to show if the parts have been exposed to moisture. Nothing in part appearance can verify moisture levels.

Expiration Date

The seal date is indicated on the MBB. The expiration date is 12 months from the seal date. If the expiration date has been exceeded or HIC shows exposure beyond 20% upon opening the bag bake the devices per the earlier stated bake schedules. The three following options apply after baking:

Use the devices within time limits stated on the MBB.

Reseal the parts completely under a partial vacuum with an impulse sealer (hot bar sealer) in an approved MBB within 12 hours, using fresh desiccant and HIC, and label accordingly. Partial closures using staples, plastic tape, or cloth tape are unacceptable.

Store the out-of-bag devices in a controlled atmosphere at less than 20% RH. A desiccator cabinet with controlled dry air or dry nitrogen is ideal.

Other Conditions

Open the MBB when parts are to be used. Open the bag by cutting across the top as close to the seal as possible. This provides room for possible resealing and adhering to the reseal conditions outlined above. After opening, strictly adhere to factory floor life conditions to ensure that devices are maintained below critical moisture levels.

Bags opened for less than one hour (strongly dependent on environment) may be resealed with the original desiccant. If the bag is not resealed immediately, new desiccant or the old one that has been dried out may be used to reseal, if the factory floor life has not been exceeded. Note that factory floor life is cumulative. Any period of time when MBB is opened must be added to all other opened periods.

Both the desiccant pouches and the HIC are reversible. Restoration to dry condition is accomplished by baking at 125°C for 10-16 hours, depending on oven loading conditions.

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