LEAD-FREE ASSEMBLY COMPATIBLE PWB FABRICATION AND ASSEMBLY PROCESSING GUIDELINES.

TECHNICAL BULLETIN

As the industry has moved to lead-free assembly processing, the performance demands on the "lead free compatible" PWB have significantly increased. The typical increase in assembly temperatures from tin-lead to lead-free alloys is 50^{o}C and represents a new set of challenges in the PWB fabrication and assembly processing. The increase in assembly temperatures magnifies the impact of residual moisture (vapor pressure) and Coefficient of Thermal Expansion (CTE) mismatches within the construction of the PWB. The following suggestions are provided to identify opportunities to optimize the fabrication and assembly processes to reduce the impact.

RESIDUAL MOISTURE IN THE PWB

The vapor pressure of water is 225 PSI at 200^{o}C. The vapor pressure increases to 575 PSI at a 250^{o}C temperature. This results in a 2.5x increase in stresses present at the laminate interfaces (resin – glass, resin - resin, resin – oxide, and resin – copper).

COEFFICIENT OF THERMAL EXPANSION (CTE) MISMATCHES IN THE PWB STACKUP

All laminates experience some degree of CTE mismatch. The CTE mismatches stem from the use of two fundamentally different materials; the relatively low CTE glass reinforcement fibers and the moderate CTE polymer matrix. The CTE mismatch can be minimized by optimizing the laminate construction through changes in the glass fabric weave style and in the matrix resin content. Such changes will directly impact the in-plane CTE values. Typical 200^{o}C X-Y CTE values for some common glass styles are included below.

Glass Style	X-axis CTE (ppm/^{o}C)	Y-axis CTE (ppm/^{o}C)
106	22.2	22.2
1080	16.9	19.4
2113	15.3	15.9
2116	14.7	14.9
1652	14.1	14.1
7628	12.1	15.9

SUGGESTIONS TO REDUCT THE IMPACT OF RESIDUAL MOISTURE AND XY CTE MISMATCHES DURING PWB FABRICATION AND LEAD-FREE ASSEMBLY.

PWB FABRICATION PROCESSING

PART NUMBER CONSTRUCTION STACKUP

Whenever possible, utilize prepreg glass styles with similar CTE performance in adjacent dielectrics to reduce laminate stresses during higher lead free assembly temperatures.

MATERIAL STORAGE

Prepreg storage parameters (upon receipt and during use) must be strictly followed to minimize any moisture absorption. Prepreg storage conditions cannot exceed 68^{o}F and 50%RH. These storage conditions also apply to the lay-up processes during the building of the lamination books.

OXIDE & OXIDE REPLACEMENT PROCESS OPTIMIZATION

Compatibility with this process is critical. The oxide or oxide replacement process bond strength and time to delamination performance must be validated with the prepreg material through the PWB lamination process. If coated layers cannot be immediately processed through lay-up and lamination after oxide or oxide replacement application, then they should be stored in temperature/humidity controlled conditions (68^{o}F max, 50% RH maximum). To assure no re-oxidization of coated layers that may compromise the oxide to prepreg bonding, do not exceed the oxide suppliers recommended hold times. Layers should be baked immediately prior to layup @ 100^{o}C for 30 minutes in racks to remove any absorbed moisture, regardless of whether or not a conveyorized turbine dryer is used to remove surface moisture from the oxide or oxide replacement coating and etched core. Higher temperature bakes may adversely impact the chemical composition of some reduced oxides or oxide replacements. Consult the oxide or oxide replacement supplier if bake temperatures in excess of 105^{o}C are being considered.

LAMINATION BOOK LAYUP

Prepreg in the buildup/buildup area must be stored at controlled conditions (68^{o}F maximum, 50% RH maximum). Prepreg materials that cannot be maintained at controlled conditions should be stored in a desiccator prior to, during, and after use in the lay-up area.

LAMINATION CYCLE ADJUSTMENTS

Lamination books should be subjected to a minimum 20-minute “pre-vac” cycle in vacuum lamination presses. This involves closing the press door and pulling vacuum on the book with the platens open and the lamination book on “lifters” to prevent heat transfer into to package.

Approximately 15-30 minutes after the center of the book reaches curing temperature (depending on the resin system being used), the lamination pressure should be reduced from full pressure down to 50 PSI for the remainder of the cycle. Reducing pressure to 50 PSI will provide a degree of mechanical stress relief.

PRE-SOLDERMASK

Due to the conversion to lead free final finishes (tin, silver, nickel/gold, and OSP), the bake prior to hot air solder coating has been eliminated in the PWB fabrication process flow. Therefore, panels should be baked prior to the application of soldermask to limit any absorbed moisture through the wet chemistry processes from drilling through outerlayer etching. Panels should be baked at 150^{o}C for 4 hours minimum to remove residual moisture absorption.

PWB PACKAGING REQUIREMENTS

Base materials pick up moisture over time. Moisture picked up around the periphery of the boards or around the tooling holes that have not been plated or on the exposed areas turns to steam during solder reflow. The vapor pressure of water can range from 300 PSI for lower temperature eutectic solder (63% Tin, 37% Lead) assembly to over 700 PSI at 260 Degrees C for Lead-Free solder assembly. This higher vapor pressure can cause delamination.

It is very important that the printed circuit boards are dry when they reach the assembly operations. Isola recommends that printed circuit boards should be dry packed in sealed shipping bags with desiccant bags and a humidity indicator card (HIC).

MOISTURE PROOF DRY PACKING

While there is increased sensitivity to lead free assembly, Isola recommends that customers pack the printed circuit boards in moisture proof bags regardless of the assembly temperatures as a best practice. Sufficient amount of desiccant bags and a Humidity indicator card should be packed with the board.

ASSEMBLY PROCESSING

HANDLING OF CLOSED DRY PACKS AT ASSEMBLY

- The user must ensure that the package is not exposed to moisture during storage, board assembly and rework.
- The shipments should be inspected for any tears or punctures of any kind.
- The check for conformance of the order can be done with the label on the bag.
- The bag should remain closed until the contents are needed.

STORING DRY PACKED PRODUCTS

If the boards are to be stored in the dry pack bag, the bag (including the desiccant and humidity indicator card (HIC)) should be resealed with a hot bar barrier sealer within 2 hours upon opening the dry packs. The integrity of the seal is important to the storage life of the devices. If the bag is left open longer, the desiccant bags should be replaced with new (or re-dried) desiccant.

- If the bag is not resealed, the boards should be placed in a dry storage cabinet at 25 ± 5°C and < 10% RH to keep them dry.

DETERMINING THE NEED FOR BAKING

Baking prior to solder reflow is required if:

- The HIC is> 10% when read at 23 ± 5°C, or
- Floor life time has been exceeded, or
- Storage condition of < 10% RH has not been met.
- If the Boards have been exposed to a maximum temperature of 30 Deg C and a maximum 60 % Relative Humidity for more than 168 hours.

Since Baking Temperatures and duration is a function of floor conditions, storage conditions, surface finishes and board thickness, Isola recommends that the baking process should be based on the assembler's experience. Guidelines appear in the Table below.

Please note that the baking does not necessarily guarantee assembly performance. The best practice is to avoid exposure to moisture.

PRE ASSEMBLY

A pre-bake may be necessary to remove any residual moisture that may have been absorbed by the boards during the time between completion of the PWB fabrication process and exposure to lead free assembly profiles. This is particularly true if the completed PWB/s have been exposed to or stored in uncontrolled temperature/humidity conditions. Depending on the final finish on the boards, the following bake temperatures and times are recommended to remove any absorbed moisture.

NOTE: More aggressive bake cycles than those listed in the Table below may be necessary if the boards have been exposed to environments with high temperature/humidity conditions. Further, exposure to uncontrolled temperature/humidity conditions for prolonged periods can also result in the requirement for more aggressive bake cycles. Consult with the supplier of the final finish to make sure that a more aggressive bake does not compromise final finish solderability. More aggressive bakes that consist of a lower temperature for longer duration may be required to preserve solderability while ensuring complete moisture removal.

Final Finish	Temperature	Time	Comments
Tin	125°C	4 Hours	Higher temperature may reduce solderability
Silver	150°C	4 Hours	Silver may tarnish, but solderability should not be affected
Nickel/Gold	150°C	4 Hours	No issues with extended bake on Nickel/Gold finish
Organic Coating	105°C	2 Hours	Extended bake cycles may negatively impact multiple heat cycle assembly processes

ASSEMBLY OVEN PROFILING

To avoid excessive over temperature conditions during processing through the assembly reflow process; the assembly profile should be optimized depending on the board thickness, area, and copper distribution.

As board thickness changes, the assembly profile may need to be adjusted by changing the line speed or the reflow oven zone temperatures in order to ensure that all assemblies see the same temperature profile regardless of board thickness. Typically ramp rates should be targeted around 1-2 °C per second with minimum dwell times above 125°C to the targeted peak reflow temperature.

It is critical to control and monitor the temperature gradient across the board areas during assembly. Unequal copper distribution and / or differential component mass can result in "laminate hot spots" or areas of excessive temperature across the board, which may result in delamination. To reduce the development of detrimental temperature gradients and excessive heat transfer that can produce excessive stresses during the assembly process, designs with copper planes areas at the outer surface or near the outer surface at the N-1 layer may require optimization of the assembly profile to increase the ramp rates to limit the dwell times from 125°C to peak reflow temperature.

FIRST ARTICLE QUALIFICATION

Due to the variation in board designs, copper distribution, board thickness, board dimensions, and component type and placement, a First Article Qualification should be completed to verify the lead free assembly process. The results of the First Article Qualification should be provided to the PWB fabricator so that common design features and board construction options can be documented and implemented on similar, future, board / assembly designs.

DISCLAIMER

Isola provides these suggestions to assist the user when making the necessary adjustments needed for building and assembling lead free compatible PWBs. These suggestions are not a guarantee by Isola that the PWBs will survive lead free assembly and we strongly recommend that a First Article process is used to validate the compatibility with lead free assembly any product.