Multilayer Board Thermal Robustness

Proposed New Test Method for Evaluating the Thermal Robustness of Multilayer Boards

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- Background
- Test Capability Goals
- Proposed Test Method
- Future Work

Background

Several large OEMs (IBM, HP, CISCO, etc.) have been working together as a group to develop a new test method for evaluating the thermal robustness of multilayer boards, both for initial qualification and occasional on-going process/material monitoring. The new method is similar to the new "Laminate Material Temperature of Decomposition" test method (IPC TM-650, 2.4.24.6) included as a parameter for the more thermally robust laminate material classifications listed in the new IPC-4101B, Specification for Base Materials for Rigid and Multilayer Printed Boards.

Multilayer Board Test Capability Goals

* Improper press lamination (cycle time too short, peak temperature not reached in center of stack-up/press opening, resin starvation)

* Dry weave or excessive voids between fibers within a glass reinforcement bundle

* Delamination

* Localized “tail” and “eyebrow” type cracks in the annular pad area of blind vias

* Poor quality prepreg in prepreg layers within multilayer boards (ex: foreign material)

Proposed New MLB Material Integrity Test Method

See attachment (file: TM-2.4.TBD_T240-MLB.doc).

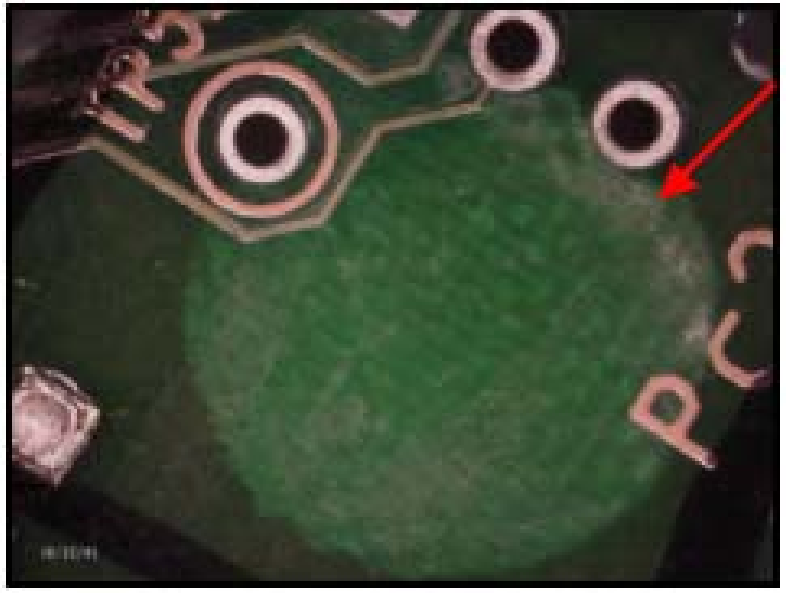

Fig 1

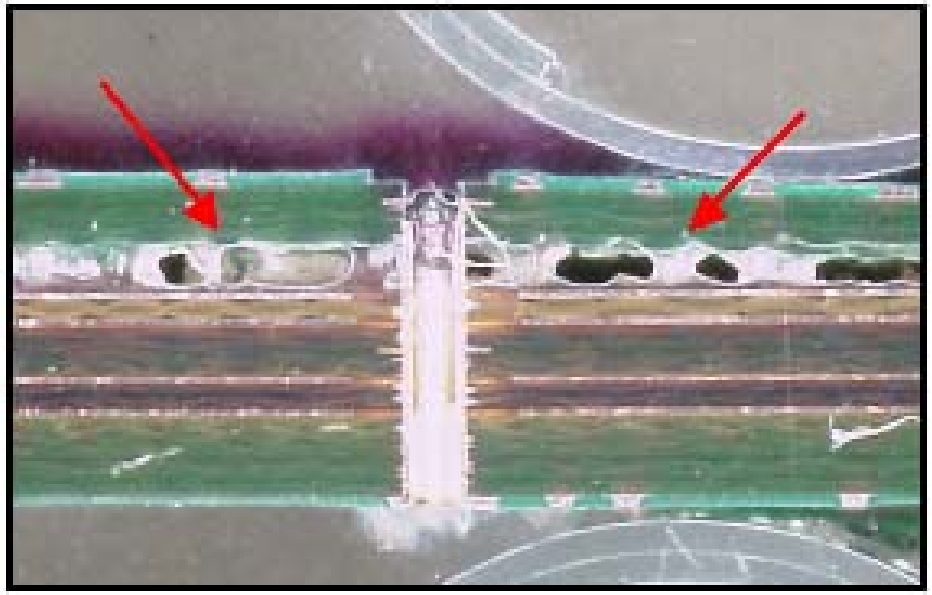

Fig 2

Multilayer Board Thermal Robustness

Future Work:

Similar to T260 testing, test facilities should use the same "bumps" and starting points for determining test failure. A standard test board / test coupon containing the worst case design features should be used for evaluating this new "MLB Laminate Integrity" test method using a variety of laminate materials. After developing a product history and a well populated database, this new MLB test method could lead to the specification of a minimum requirement for acceptance.

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Future Work, Cont.:

Participants in this effort are needed to provide "good" multilayer boards and "bad" multilayer boards for a given preheat profile and peak solder reflow temperature. These will be used to evaluate the sensitivity of the new test method using a range of test parameters. Both the IPC and iNEMI are considering forming subcommittees that may take on this project of developing a new multilayer board “material integrity” test method capable of becoming an industry standard.

Test Method 2.4.?-A
Title: Delamination Resistance of Multilayer Boards
Stage: Proposed Test Method
Date: August 3, 2006
Originating Subcommittee: IPC TBD

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1 Scope

This test method determines the time to delamination and/or loss of laminate integrity of multilayer printed wiring boards through the use of a thermomechanical analyzer (TMA), such as may occur during longer pre-heat times before higher temperature lead-free assembly reflow processing. This test method can be used both for product qualification (acceptability based upon customer pass/fail criteria) and for on-going process monitoring. Use of this test method for composites other than FR-4 laminate materials may not yield comparative results.

2 Applicable Documents

IPC-TM-650 Method 2.4.24, Glass Transition Temperature and Z-Axis Thermal Expansion by TMA
IPC-TM-650 Method 2.4.24.1, Time to Delamination (TMA Method)

3 Test Samples

3.1 Sample Size
Samples shall be cut to approximately 6.35 mm x 6.35 mm [0.25 inches x 0.25 inches] in size. Samples shall be cut using appropriate procedures and equipment to minimize mechanical stress and/or thermal shock.

3.2 Sample Construction / Sample Selection
Samples for testing should be selected from representative areas of the multilayer production or test board, including where there is a transition from relatively high internal copper density areas to relatively low copper density areas, and should include a few plated through holes with no plane layer connections.

3.3 Surface Preparation
All edges of the sample shall be finished smooth and burr-free by sanding or equivalent (to allow the sample to rest completely flat on the sample pan). Use care to minimize the introduction of mechanical stress or heat to the sample prior to testing.

3.4 Sample Quantity
Minimum of 3 samples per board (center, edge, transition area), and minimum of 1 board per production lot.

4 Equipment/Apparatus or Material

4.1 Drying Chamber
Air circulating oven capable of maintaining 105 +/- 2.0 degrees C [221 +/- 3.6 degrees F]

4.2 Cutting Equipment
Diamond blade or wheel, sanding equipment, or equivalent, to provide a sample of the size and edge quality specified.

4.2 Desiccator
Dessication chamber capable of maintaining an atmosphere less than 30 percent relative humidity (RH) at 23 degrees C [73 degrees F].

4.4 Tester
Thermal Mechanical Analyzer (TMA) capable of measuring dimensional changes to within +/- 0.0025 mm [0.0001 inches] over the specified temperature range.

Deleted: 4.6
Deleted: 2.1 IPCIPC-TM-650, Method 2.3.40 Thermal Stability2.2 American Society for Testing and Materials (ASTM)ASTM D-3850 Standard Test Method for Rapid Thermal Degradation of Solid Electrical Insulating Materials by Thermogravimetric Analysis
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Deleted: The accuracy of the initial weight measurement shall be within +/- 0.01mg. If two specimens of the same material are tested, one with a large surface area and one with a small surface area, and both of the same mass; the specimen with the smaller surface area will normally lose weight at a slower rate.
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5 Procedure

5.1 Test Sample Preparation

The test samples should be baked at 105 °C +/- 2 °C [221.0 °F +/- 3.6 °F] for 4 hours and placed in a desiccator for cooling to room temperature (equilibration) prior to testing. In standard lab conditions, the TMA test should be started within 15 minutes of removing test sample from the desiccator because samples may absorb moisture.

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5.2 Equipment Startup and Calibration

Follow the manufacturer's recommendations.

5.3 Testing

5.3.1 Remove sample from the desiccator and place it on the stage of the TMA, taking care that the sample is centered and resting flat on the stage.
5.3.2 Firmly attach the thermocouple for monitoring the sample temperature to the top of the sample.
5.3.3 Lower the TMA's probe on to the sample, and apply a force of 0.005 Newtons (5 grams). Then lower the furnace into place around the stage.
5.3.4 Start the sample thickness monitoring from an initial temperature no higher than 35 °C [95 °F].
5.3.5 Maintain the temperature ramp rate at 5.0 °C +/- 1.0 °C per minute. Boards with overall thickness less than 2.0 mm may be tested using a temperature ramp rate of 10.0 °C +/- 1.0 °C per minute.
5.3.6 When the temperature of the sample reaches the specified isothermal temperature, hold at that temperature for the specified number of minutes, or until failure, whichever occurs first.

*** For ROUND ROBIN testing will test using three different temperature ramp rates: 5/10 C, 10/15 C, and 20/25 C (ref. 5.3.5).

5.4 Recommended Isothermal Temperatures & Qualification Criteria

5.4.1 Eutectic Tin-Lead (SnPb):
Isothermal Temperature = 240 °C
Qualification Criteria = 2.0 minutes minimum without loss of laminate integrity
5.4.2 SnAgCu Alloy (Lead-Free):
Isothermal Temperature = 260 °C
Qualification = 5.0 minutes minimum without loss of laminate integrity

6 Evaluation

The time to delamination or loss of laminate integrity is determined as the time from the onset of the isotherm to failure. Delamination includes cracks within the resin, separation between plies, between epoxy and glass fiber reinforcement, and between glass fibers. Failure is any event or deviation of the data plot where the thickness is shown to have irreversibly changed. In cases where an irreversible thickness change occurs before the isotherm is reached, the temperature at the time of failure shall be recorded.

This test method should detect insufficient adhesion between copper layer and epoxy, between resin and glass reinforcement, and weak resin-resin bonding. Any permanent change in the extent of crazing and/or measling within the laminate material may be considered a failure by some customers, and should be confirmed by 40x stereoscope. Observations of "tail cracks" and "eyebrow" type localized delamination (example: cracks in annular pad area of blind vias) should also be documented in addition to observations of any permanent increase in the extent of crazing and measling. A standard test board / test coupon containing the worst case design features may be used for this testing, using consistent "bumps" and starting points for determining test failure.

7 Report

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7.1 Report the Time to Delamination as determined by an irreversible change in thickness. Also report the time at which any other event took place which was not determined to be irreversible.
7.2 Report whether the testing being reported is for process monitoring, or for determining product acceptability.
7.3 Report the isothermal temperature used, and minimum hold time if testing to determine product acceptability.
7.4 Document the severity and extent of other laminate integrity issues observed (crazing, measling, resin cracking, separation between plies, etc.) including those found while crossectioning failed samples to determine the extent of delamination.
7.5 Report the multilayer board identification and/or description of the sample, including the overall board or sample thickness, laminate material used and the laminate material Tg.
7.6 Report the temperature ramp rate if other than 5.0 ^{o}C per minute.
7.7 Report the room temperature and relative humidity under which the testing was conducted.