



MICROTEK™
L A B O R A T O R I E S

The Hot New Ticket UltraThin (UT) Coatings

Presenters: Debora Obitz and Russ Shepherd

Microtek Laboratories

705 Digital Drive, Suite S, Linthicum, MD 21090

(714) 999-1616

Russ@thetestlab.com or Debora@thetestlab.com



UltraThin (UT) Coatings

- Agenda
 - How IPC defines an UltraThin (UT) conformal coating
 - How it is different than the legacy coatings
 - How to classify a UT conformal coating
 - How the coating is helping to update IPC-CC-830 testing
 - IPC (IPC-CC-830B, Am 1 vs Military (MIL-I-46058C, Am 7)
 - Qualification of the UT coatings
 - Method inconsistencies that a gage R&R discovered
 - New IPC board to be designed

UT Coatings

- Historically coatings are classified by chemistry in both the IPC (IPC-CC-830) and Military (MIL-I-46058) Specifications
 - AR (Acrylic)
 - UR (Urethane)
 - ER (Epoxy)
 - SR (Silicone)
 - XY (Paraxylene)
- UT coatings are to use/apply in thickness ranges below 12 micrometers which is the defining characteristic of the UT coating



UT Coatings

- UT coatings are to be identified by their primary chemistry in combination with loose thickness in the future IPC revision
 - Loose thickness means that there is no requirement specified (as the legacy coatings have) for these coatings only that they do not exceed 12 microns
 - They will be classified as UT-IN (Inorganic) or UT-OR (Organic) which also differs from the legacy



Testing UT Coatings

- UT coatings are tested in accordance with IPC-CC-830B, Amendment 1 and MIL-I-46058C, Amendment 7
- A little history of the coating specifications
 - The IPC-CC-830B was mirrored to the 46058 over 10 years ago in preparation of discussion at that time to cancel the MIL-I-46058C (Amendment 7)
 - The military specification has not been revised since 1993 and was declared inactive for new designs – this however does not mean that new coatings cannot be qualified and placed on the QPL (which is the active Qualified Products List maintained by DLA Land and Maritime)...they can!

Testing

- IPC vs. Military Testing
 - These two specifications are similar in testing but have some tests that do not overlap and are slightly different in how the tests are performed.
 - We will discuss the tests of the IPC-CC-830 based on Qualification testing, **Table 1**.
 - How they relate to the military specification
 - The differences between the two – different test substrates for electrical testing
 - How they relate to UT coatings
 - List the outstanding tests between each

Testing

- The following slides are based on the IPC-CC-830 testing
 - They will identify
 - Test requirements
 - Test substrates
 - Test parameters
 - How the testing relates to the military
 - UT requirements assessment

Materials

- Materials
 - Paragraph 3.3.1
 - The conformal coating shall be free of deleterious (harmful) substances
 - The MSDS sheets provided by the manufacturer will show that there are no harmful substances contained within the conformal coating
 - This testing is similar to military testing
- The UT requirement will be similar to the legacy coatings

Shelf Life

- Shelf Life
 - Paragraph 3.3.2
 - The conformal coating shall be stored for a minimum of 6 months at room temperature
 - The coating at a minimum will be tested for Appearance, Insulation Resistance (IR), and Dielectric Withstanding Voltage (DWV) – each will be discussed later in this presentation
 - This is to assess that the coating maintains physical and electrical properties
 - This testing is similar to military testing
- The UT coating requirements are in the process of being defined

Cure

- Cure
 - Paragraph 3.3.3
 - When applied and cured per the manufacturer the coating shall exhibit all desired properties (hardness, clarity, etc.)
 - The coating shall be cured to full hardness in the time and temperature recommended by the manufacturer.
 - They will also specify the optimum coating procedure (spray, dip, etc.)
 - This testing is similar to military testing
- The UT requirement will be similar to the legacy coatings

Fourier Transform Infrared Spectroscopy (FTIR)

- Fourier Transform Infrared Spectroscopy (FTIR)
 - Paragraph 3.4.1
 - IPC-TM-650, method 2.3.39, or equivalent
 - FTIR spectra shall be compared to those obtained during initial qualification inspection.
 - Tin panel conformally coated
 - The initial spectra will be retained for retention testing
 - The retention testing spectra will be compared to the initial spectra of the initial qualification of the conformal coating material



Fourier Transform Infrared Spectroscopy (FTIR)

- Absorption peaks completely missing or additional peaks signify change in chemistry present within the coating product.
- Change in chemistry as detected by FTIR may or may not constitute a product change - paragraph 4.4 defines product change.
- FTIR testing is not required for military testing
- The UT requirement will be similar to the legacy coatings

Viscosity

- Viscosity
 - ASTM D1084 Standard Test Methods for the Viscosity of Adhesives using the Brookfield Method
 - The viscosity test is conducted on the raw uncured coating and the following shall be defined by the manufacturer:
 - Range of viscosity
 - Test conditions.
 - Spindle
 - Revolutions per minute (rpms)



Viscosity



- This test determines the viscosity range for quality and optimum conformal coating application.
- Viscosity is not required for military testing
- The UT requirement will be similar to the legacy coatings

Appearance

- Appearance
 - Paragraph 3.5.2
 - The coating is inspected in both the uncured and cured state.
 - The test is conducted on all specimens
 - The uncured conformal coating materials shall be free of deleterious substances, bubbles, pinholes, whitish spots, blistering, wrinkling, cracking, and peeling.
 - The cured conformal coating shall be smooth, homogeneous, transparent or translucent, and tack-free when observed at ambient conditions.



Appearance

- The test vehicles' conformal coating shall have no bubbles, pinholes, blisters, cracking, crazing, peeling, wrinkles, mealing or evidence of reversion, or cause a corrosion.
- The coatings are examined under normal lighting
- This testing is similar to military testing with the exception that fluorescence is combined with the visual assessment
- The UT requirement will be specialized as these coatings cannot be assessed easily with 1.75x (10x) magnifications

Fluorescence

- Fluorescence
 - Paragraph 3.5.3
 - Conformal coatings shall be fluorescent except type XY
 - Testing is conducted on glass samples
 - The coatings, except XY, are examined under black light
 - The black light aids in determining complete coverage and reveals some of the defects stated in the previous visual assessment section
 - This testing is conducted the same as military testing; however, black light is not conducted on types SR and XY
- With the addition of the UT coatings the requirement may change to simply state if the coating fluoresces

Fungus Resistance

- Fungus Resistance
 - Paragraph 3.5.4
 - IPC-TM-650, 2.6.1.1
 - This test is conducted to determine if the coating can support biological (fungus) growth.
 - Testing is conducted on glass specimens
 - Five spores are used for testing (*Aspergillus niger*, *Chaetomium globosum*, *Gliocladium virans*, *Aureobasidium pullulans*, *Penicillium funiculosum*)
 - These spores have been chosen since they have a know history to attack and degrade coatings
 - Testing is performed under aseptic/sterile conditions

Fungus Resistance

- Long term test – up to two weeks incubation followed by four weeks of specimen under test
- Results are based on a growth rating assessment
- 0 = no growth
- 1 = up to 10% growth
- 2 = 10 – 30% growth
- 3 = 30 to 60% growth
- 4 = over 60% growth
- Similar to military testing since the method was generated after the ASTM G21 (military method)
- The UT requirement will be similar to the legacy coatings



Flexibility

- Flexibility
 - Paragraph 3.5.5
 - IPC-TM-650, method 2.4.5.1
 - The test determines evidence of crazing or cracking of the conformal coating on a flexible sample
 - Tin panels are used for testing
 - The tin panel is flexed 180 degrees over a 0.12" mandrel
 - They are then inspected for cracking and crazing of the coating
 - Identical to military testing
- The UT requirement will be similar to the legacy coatings

Flammability

- Flammability
 - Paragraph 3.5.6
 - UL 94 HB
 - Coating shall meet UL 94 HB
 - Five 5" x ½" bare laminate specimens
 - No burning rate exceeding 40 mm (1.75") per minute over 75 mm (2.95") for specimens with a thickness 3.0 – 13 mm (0.118 – 0.512")
 - No burning rate exceeding 75 mm (2.95") per minute over 75 mm (2.95") for specimens with a thickness less than 3.0 mm (0.118")

Flammability

- Cease to burn before the 100 mm (3.937")
- Rated either non-burning or self extinguishing
- Identical to military testing
- The UT requirement will be similar to the legacy coatings

Dielectric Withstanding Voltage

- Dielectric Withstanding Voltage (DWV)
 - Paragraph 3.6.1
 - IPC-TM-650, method 2.5.7.1
 - There shall be no disruptive discharge evidence by flashover (surface), sparkover (air), or breakdown (puncture).
 - The leakage rate shall not exceed 10 microamperes
 - Testing is conducted on five IPC-B-25A boards, pattern D
 - 1,500VAC was applied for one minute
 - One electrode was attached 1,3, and 5 and the other was attached to the 2 and 4



Dielectric Withstanding Voltage

- Identical to military testing
- During an in depth gage R&R it was found that this test methods need to be revised
 - IPC and military use different test vehicles
 - IPC uses the D-pattern 12.5 mil space/traces
 - Military uses a Y-pattern with 30 mil space/traces
 - At 1500 VAC it was found that even the legacy coupons could not meet the 10 microampere requirement – many have a concern that the requirement should be 10 milliamps
 - Testing is undergoing further investigation to insure that the correct requirements will be in place for the future C revision²⁴

Dielectric Withstanding Voltage

- How did the UT coating fare based on the gage R&R testing
 - Some repeatedly exceeded a minimum of 700VAC
 - Some could achieve the 1500VAC but could not endure this voltage for the one minute duration
 - The majority (just like some of the legacy) exceeded the 10 microampere requirement
- The UT requirement for DWV is unknown at this time and will be discussed in Rosemont, IL at the end of this month

Moisture and Insulation Resistance (MIR)

- Moisture and Insulation Resistance (MIR)
 - Paragraph 3.7.1
 - IPC-TM-650, method 2.6.3.4
 - The minimum insulation resistance shall be 500 M Ω for Class Type ER and 5000 M Ω for all other types during humidity, after humidity, and one to two hours at reference conditions, and after 24 hours at reference conditions.
 - Appearance and DWV shall be tested after 24 hour
 - Testing conducted on five IPC-B-25A boards



Moisture and Insulation Resistance (MIR)

- Similar to military testing but with a few differences
 - To the IPC-CC-830 parameters of 26/65°C cyclic for 6 2/3 days
 - cycles are constant with no static between steps
 - Military 46058 is 25/65°C – 2 cycles followed by an 8 hour 25°C static for 10 cycles (10 days)
 - Measurements are taken during step 5 for both (hot cycle) of 65°C during the first, fourth, seventh, and tenth cycles
 - The IPC resistance results are defined by minimum insulation resistance whereas the military results are defined by averages of the measurement
 - Military test specimens are four y-patterns

Moisture and Insulation Resistance (MIR)

- During the gage R&R it was discovered that the requirement of the IPC document was adopted from the military 46058
 - Test vehicle differences makes it hard for certain legacy coating to meet the current 5000 requirement
 - No thought was given to the differences in the trace/space when adopting the military requirement into the 830
 - The requirement may go back to the original 500 M Ω
- The UT requirement will be similar to the legacy coatings for DWV but not for appearance

Thermal Shock

- Thermal Shock
 - Paragraph 3.7.2
 - IPC-TM-650, method 2.6.7.1
 - Appearance and DWV shall be tested after 24 hour
 - Testing conducted on five IPC-B-25A boards
 - -65°C/125°C
 - 15 minute dwells at temperature extremes
 - Immediate transfer between temperatures
 - 100 cycles
 - Appearance and DWV shall be tested after 24 hour

Thermal Shock

- Similar to military testing with temperature
 - -65°C/125°C
 - 30 minute dwells at temperature extremes
 - Immediate transfer between temperatures
 - 50 cycles
- The UT requirement will be similar to the legacy coatings for DWV but not for appearance



Temperature and Humidity Aging (Hydrolytic Stability)

- Temperature and Humidity Aging (Hydrolytic Stability)
 - Paragraph 3.7.3
 - IPC-TM-650, method 2.6.11.1
 - No evidence of softening, chalking, blistering, surface tack, cracking, loss of adhesion or reversion to the liquid state
 - Clarity must allow viewing of the identification markings and color codes used for identifying components



Temperature and Humidity Aging (Hydrolytic Stability)

- The test is conducted on five y-patterns
 - Two resistors (one with markings and one with bar codes) soldered to the holes of the test patterns
 - One is held at lab ambient conditions as a control
 - Four are placed in test parameters of 85°C and 90-98%RH
 - Test is run for 120 days – at 28, 56, 84 days the specimens are returned to lab ambient conditions 25°C with 50%RH for 2 hours and visually assessed
 - After 120 days all specimens are held at lab ambient conditions and compared to the control
- Identical to military testing

Temperature and Humidity Aging (Hydrolytic Stability)

- Although the tests are identical at the IPC meetings it has been decided to revisit the clarity requirement
 - Testing has proven that although the coating discolors there is no issues with electrical properties
 - This requirement is going to be revisited and if accepted the test method will be revised to incorporate an insulation resistance measurement after testing
- The UT requirement will be similar to the legacy coatings however as previously stated it will need to be determined how to assess coating coverage



Thickness

- Thickness
 - Paragraph 4.6.4
 - The requirements are specified for legacy coatings
 - This is not specified in the Qualification table
- The UT range is to be specified by the manufacturers
- The manufacturers have been tasked with how to measure/assess thickness – suggestions for testing are to use a durometer
- For any and all tests it has been suggested to state the thickness of the coating material for each test

Thickness

- Thickness
 - Paragraph 4.6.4
 - The requirements are specified for legacy coatings
 - The thickness is to be assessed using a micrometer on the glass specimens
 - This is not specified in the Qualification table
- The UT range is to be specified by the manufacturers
 - The range must be below 12 micrometers



Thickness



- The manufacturers have been tasked with how to measure/assess thickness
 - suggestions for testing are to use a durometer
- For any and all tests it has been suggested to state the thickness of the coating material for each test – this will not be limited to UT coatings

Test Vehicle Design

- The IPC Committee is designing a new test vehicle to replace the IPC-B-25A
 - The test vehicle will merge the 1,3 and 5 and the 2 and 4 of the D-pattern
 - This will make the pattern a two point
 - Easier for automated systems (AutoSIR)
 - More in line with the y-pattern used by the military
 - The new board will likely be designated IPC-B-53

Military Testing

- Outstanding military testing
 - Q resonance
 - This test is not in the 830 for several reasons
 - It is not repeatable on a day to day basis
 - The test is designed to be conducted on different days
 - Since this test was proven non-repeatable this test was not incorporated into the 830
 - The UT coatings can be tested per the military 46058 but if they pass will not be placed on QPL



Review

- UT coatings can be tested to both the IPC-CC-830 and military specifications
- UT coatings will be classified as UT-IN (inorganic) or UT-OR (organic)
 - Follow in the footsteps of legacy coatings
- UT coating must be less than 12 micrometers
- Manufacturers will specify the range



Review

- Manufacturers will specify how to determine thickness
 - Thickness of the coating will be recorded for each test for future IPC revision
- Some requirement may need to be revised for UT coatings
 - MIR, DWV, Appearance
- A new test vehicle is being designed

Thank You!

