



台灣聯合科技股份有限公司

Taiwan Union Technology

TEST REPORT

CLIENT: IPC Validation Services
3000 Lakeside Drive
Suite 105N
Bannockburn, IL 60015 USA
Attention: Mr. Randy Cherry
+1-847-597-5606

TEST ITEMS: Peel Strength, Volume Resistivity, Surface Resistivity, Moisture Absorption, Dielectric Breakdown, Permittivity @ 1 MHz, Loss Tangent @ 1 MHz, Flexural Strength, Arc Resistance, Thermal Stress, Electric Strength, Flammability, Glass Transition Temperature, Decomposition Temperature, CTE (TMA), Time to Delamination (T260, T288, T300), Dimensional Stability, Solderability, Chemical Resistance, Metal Surfaces Cleanability, Pressure Cooker Test.

SAMPLE: Copper-Clad Laminate

TEST MATERIAL: TU-84P NF

SPECIFICATION: IPC-4101E WAM1/130

TEST RESULTS: The specimens were tested by the indicated test methods within this report.
The actual detailed test results are enclosed.

DATE OF REPORT: 16 August 2022



SUMMARIZED TEST RESULTS:

| Test Item | Thin | Thick |
|------------------------------|-------------|-------------|
| Peel Strength | Pass | Pass |
| Volume Resistivity | Pass | Pass |
| Surface Resistivity | Pass | Pass |
| Moisture Absorption | -- | Pass |
| Dielectric Breakdown | -- | Pass |
| Permittivity @ 1MHz | Pass | Pass |
| Loss Tangent @ 1MHz | Pass | Pass |
| Flexural Strength | -- | Pass |
| Arc Resistance | Pass | Pass |
| Surface Resistivity | Pass | Pass |
| Thermal Stress | Pass | Pass |
| Electric Strength | Pass | Pass |
| Flammability | Pass | Pass |
| Glass Transition Temperature | -- | Pass |
| Decomposition Temperature | -- | Pass |
| Z-Axis CTE | -- | Pass |
| Time to Delamination | -- | Pass |
| Dimensional Stability | Pass | Pass |
| Solderability | -- | Pass |
| Chemical Resistance | Report Only | Report Only |
| Metal Surface Cleanability | -- | Report Only |
| Pressure Cooker Test | -- | Report Only |

Peel Strength

Reference:

IPC-TM-650 Method 2.4.8 Peel Strength of Metal Clad Laminates

IPC-TM-650 Method 3.4.8.3 Peel Strength of Metal Clad Laminates at Elevated Temperature

IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 1 Peel Strength After Thermal Strength Thin

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.88 | |
| Side B Cross-Wise and Length-Wise Average | 0.88 | |
| Requirement | ≥ 0.80 | Pass |

Table 2 Peel Strength After Thermal Strength Thick

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 1.15 | |
| Side B Cross-Wise and Length-Wise Average | 1.13 | |
| Requirement | ≥ 1.05 | Pass |

Table 3 Peel Strength At Elevated Temperature Thin

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.87 | |
| Side B Cross-Wise and Length-Wise Average | 0.89 | |
| Requirement | ≥ 0.70 | Pass |

Table 4 Peel Strength At Elevated Temperature Thick

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.97 | |
| Side B Cross-Wise and Length-Wise Average | 0.99 | |
| Requirement | ≥ 0.70 | Pass |



Table 5 Peel Strength After Process Solutions Thin

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.85 | |
| Side B Cross-Wise and Length-Wise Average | 0.82 | |
| Requirement | ≥ 0.55 | Pass |

Table 6 Peel Strength After Process Solutions Thick

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.95 | |
| Side B Cross-Wise and Length-Wise Average | 0.97 | |
| Requirement | ≥ 0.80 | Pass |

Table 7 Peel Strength As Received Low Profile Copper Thin

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.96 | |
| Side B Cross-Wise and Length-Wise Average | 0.96 | |
| Requirement | ≥ 0.70 | Pass |

Table 8 Peel Strength As Received Low Profile Copper Thick

| | | |
|---|-------------|------|
| Side A Cross-Wise and Length-Wise Average | 0.97 | |
| Side B Cross-Wise and Length-Wise Average | 0.95 | |
| Requirement | ≥ 0.70 | Pass |

Volume & Surface Resistivity

Reference:

IPC-TM-650 Method 2.5.17.1 Volume and Surface Resistivity of Dielectric Materials
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer
Printed Board

Results:

Table 9 Volume and Surface Resistivity Humidity Conditioning Thin

| | | | |
|------------------------|----------------------------|--------------------------|------|
| Volume Resistivity | Average of three specimens | 4.35 E+08 | |
| Requirement C-96/35/90 | | $\geq 1.00 \text{ E}+06$ | Pass |
| Surface Resistivity | Average of three specimens | 3.51 E+07 | |
| Requirement C-96/35/90 | | $\geq 1.00 \text{ E}+04$ | Pass |

Table 10 Volume and Surface Resistivity At Elevated Temperature Thin

| | | | |
|---------------------|----------------------------|--------------------------|------|
| Volume Resistivity | Average of three specimens | 2.29 E+07 | |
| Requirement 125°C | | $\geq 1.00 \text{ E}+03$ | Pass |
| Surface Resistivity | Average of three specimens | 5.29 E+07 | |
| Requirement 125°C | | $\geq 1.00 \text{ E}+03$ | Pass |

Table 11 Volume and Surface Resistivity Humidity Conditioning Thick

| | | | |
|----------------------------|----------------------------|--------------------------|------|
| Volume Resistivity | Average of three specimens | 4.30 E+08 | |
| Requirement after moisture | | 1.00 E+04 | Pass |
| Surface Resistivity | Average of three specimens | 3.59 E+07 | |
| Requirement after moisture | | $\geq 1.00 \text{ E}+04$ | Pass |

Table 12 Volume and Surface Resistivity At Elevated Temperature Thick

| | | | |
|--------------------|----------------------------|--------------------------|------|
| Volume Resistivity | Average of three specimens | 2.75 E+07 | |
| Requirement 125°C | | $\geq 1.00 \text{ E}+03$ | Pass |



| | | | |
|---------------------|----------------------------|--------------------------|------|
| Surface Resistivity | Average of three specimens | 3.54 E+07 | |
| Requirement 125°C | | $\geq 1.00 \text{ E}+03$ | Pass |

Moisture Absorption

Reference:

IPC-TM-650 Method 2.6.2.1 Water Absorption of Metal Clad Plastic Laminates

IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 13 Moisture Absorption Thick

| | | | |
|---------------------|----------------------------|------------|------|
| Moisture Absorption | Average of three specimens | 0.12 | |
| Requirement | | ≤ 0.5 | Pass |

Dielectric Breakdown

Reference:

IPC-TM-650 Method 2.5.6 Dielectric Breakdown

IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 14 Dielectric Breakdown

| | | | |
|----------------------|---------------------------|-----------|------|
| Dielectric Breakdown | Average of four specimens | 44+ | |
| Requirement | | ≥ 40 | Pass |



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Permittivity and Loss Tangent @ 1 MHz



Reference:

IPC-TM-650 Method 2.5.5.9 Permittivity and Loss Tangent, Parallel Plate 1 MHz to 1.5 MHz
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 15 Permittivity and Loss Tangent

| | | | |
|---|----------------------------|-----------------------|------|
| Permittivity @ 1 MHz Requirement Thin | Average of three specimens | 4.15 ≤ 5.4 | Pass |
| Loss Tangent @ 1 MHz Requirement Thin | Average of three specimens | 0.002 ≤ 0.001 | Pass |
| Permittivity @ 1 MHz Requirement Thick | Average of three specimens | 5.15 ≤ 5.4 | Pass |
| Loss Tangent @ 1 MHz Requirement Thick | Average of three specimens | 0.003 ≤ 0.035 | Pass |

Flexural Strength



Reference:

IPC-TM-650 Method 2.4.4 Flexural Strength of Laminates at Ambient Temperature
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer
Printed Board

Results:

Table 16 Flexural Strength

| | | | |
|--|--------------------------|--------------|------|
| Flexural Strength Length Direction Requirement | Average of two specimens | 455 ≥ 415 | Pass |
| Flexural Strength Cross Direction Requirement | Average of two specimens | 385 ≥ 345 | Pass |

Arc Resistance

Reference:

IPC-TM-650 Method 2.5.1 Arc Resistance of Printed Wiring Material
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 17 Arc Resistance

| | | | |
|----------------------------------|----------------------------|-------------|------|
| Arc Resistance Thin Requirement | Average of three specimens | 135 ≥ 60 | Pass |
| Arc Resistance Thick Requirement | Average of three specimens | 181 ≥ 60 | Pass |



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Thermal Stress

Reference:

IPC-TM-650 Method 2.4.13.1 Thermal Stress of Laminates

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Results:

Table 18 Thermal Stress

| | | |
|---------------------------------------|--|------|
| Thermal Stress Thin Etched A Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thin Etched B Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thick Etched A Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thick Etched B Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thin Un-Etched A Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thin Un-Etched B Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thick Un-Etched A Side | No obvious blister, delamination or damage | Pass |
| Thermal Stress Thick Un-Etched B Side | No obvious blister, delamination or damage | Pass |

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Electric Strength

Reference:

IPC-TM-650 Method 2.5.6.2 Electric Strength

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Results:

Table 19 Electric Strength

| | | | |
|------------------------------------|----------------------------|-----------|------|
| Electric Strength Thin Requirement | Average of three specimens | 68 | |
| | | ≥ 30 | Pass |

Flammability Vertical Burning

Reference:

UL94 Section 8 50W (20mm) Vertical Burning Test; V-0, V-1, V-2

IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 20 Vertical Burning Test Thin

The specimens were tested by the methods given above.

The flammability Classification Condition A of specimens is V-0

The flammability Classification Condition A of specimens is V-0

The specimens pass.

Table 21 Vertical Burning Test Thick

The specimens were tested by the methods given above.

The flammability Classification Condition A of specimens is V-0

The flammability Classification Condition B of specimens is V-0

The specimens pass.

Glass Transition Temperature

Reference:

IPC-TM-650 Method 2.4.25 Glass Transition Temperature and Cure Factor by DSC

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Results:

Table 22 Glass Transition Temperature



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Glass Transition Temperature

182°C



Decomposition Temperature

Reference:

IPC-TM-650 Method 2.4.24.6 Decomposition Temperature of Laminate Material Using TGA
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 23 Decomposition Temperature

| | | |
|---|-------|------|
| Glass Transition Temperature 5% Weight Loss | 349°C | |
| Requirement | ≥ 340 | Pass |

Z-Axis CTE (TMA)

Reference:

IPC-TM-650 Method 2.4.24.6 Decomposition Temperature of Laminate Material Using TGA
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 24 Z-Axis CTE (TMA)

| | | | |
|--------------------|--------------------------|------|------|
| Z-Axis CTE Alpha 1 | Average of two specimens | 42 | |
| | | ≤ 60 | Pass |



| | | | |
|--------------------|--------------------------|-------|------|
| Z-Axis CTE Alpha 2 | Average of two specimens | 235 | |
| | | ≤ 300 | Pass |
| Z-Axis CTE 50-260 | Average of two specimens | 2.1 | |
| | | ≤ 3.0 | Pass |

Time to Delamination

Reference:

IPC-TM-650 Method 2.4.24.1 Time to Delamination (TMA Method)

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Results:

Table 25 Time to Delamination (TMA)

| | | | |
|-------------------|--------------------------|------|------|
| Delamination T260 | Average of two specimens | > 60 | |
| | Requirement | ≥ 30 | Pass |
| Delamination T288 | Average of two specimens | > 45 | |
| | Requirement | ≥ 15 | Pass |
| Delamination T300 | Average of two specimens | > 4 | |
| | Requirement | ≥ 2 | Pass |

Dimensional Stability

Reference:

IPC-TM-650 Method 2.4.39 Dimensional Stability, Glass Reinforced Thin Laminates



Results:

Table 26 Dimensional Stability Thin

| | | | |
|------------------------------|----------------------------|--------------|------|
| Dimensional Stability Bake | Average of three specimens | | |
| | Machine direction | -0.02 | |
| | Cross direction | -0.06 | |
| | Requirement | -0.3 to +0.3 | Pass |
| Dimensional Stability Stress | Average of three specimens | | |
| | Machine direction | -0.01 | |
| | Cross direction | -0.01 | |
| | Requirement | -0.3 to +0.3 | Pass |

Table 27 Dimensional Stability Thick

| | | | |
|------------------------------|----------------------------|--------------|------|
| Dimensional Stability Bake | Average of three specimens | | |
| | Machine direction | -0.03 | |
| | Cross direction | -0.06 | |
| | Requirement | -0.3 to +0.3 | Pass |
| Dimensional Stability Stress | Average of three specimens | | |
| | Machine direction | -0.02 | |
| | Cross direction | -0.05 | |
| | Requirement | -0.3 to +0.3 | Pass |

Solderability (Edge Dip Test)

Reference:

IPC-J-STD-003C; Method 4.2.1 Edge Dip Test

IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board



Results:

Table 28 Solderability (TMA)

| | | |
|---------------------|---------------------------------------|------|
| Solderability Thin | Sample surface exhibited good wetting | Pass |
| Solderability Thick | Sample surface exhibited good wetting | Pass |

Chemical Resistance

Reference:

IPC-TM-650 Method 2.3.4.2 Chemical Resistance of Laminates, Prepreg and Coated Foil Products by Solvent Exposure.

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Results:

Table 29 Chemical Resistance

| | | | |
|---------------------------|--------------------------|-----------|------|
| Chemical Resistance Thin | Three specimens | | |
| Requirement | Appearance after bake | No change | Pass |
| Requirement | Appearance after solvent | No change | Pass |
| Chemical Resistance Thick | Three specimens | | |
| Requirement | Appearance after bake | No change | Pass |
| Requirement | Appearance after solvent | No change | Pass |

Metal Surface Cleanability

Reference:



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IPC-TM-650 Method 2.3.1.1 Chemical Cleaning of Metal-Clad Laminate



Results:

Table 30 Metal Surface Cleanability

| | | |
|----------------------------|--|------|
| Metal Surface Cleanability | Three specimens | |
| Requirement | The metal cladding on the test specimen shall be cleaned to a uniform matte finish. Deionized or distilled water poured on the surface does not bead or form puddles. | Pass |

Pressure Cooker Test

Reference:

IPC-TM-650 Method 2.6.16 Pressure Vessel Method for Glass Epoxy Laminate Integrity
IPC-4101E WAM1/130 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 31 Pressure Cooker Test

| | | |
|----------------------|--|------|
| Pressure Cooker Test | Five specimens | |
| Requirement | The samples shall have no measles, blisters or surface erosion | Pass |

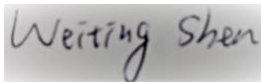
CERTIFICATE OF CONFORMANCE

The TAWIAN UNION TECHNOLOGY CORPORATION (TUC) certifies that the test equipment used complies with the requirements of correlation criterion and that data contained in this report is accurate within the tolerance limitation of the equipment.

The report is invalid without the signature of the reviewer and the approver.

Reviewed by:

Approved by:



Weiting Shen

QA Engineer

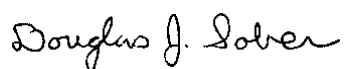
16 August 2022



Money Wang

QA Manager

16 August 2022



For IPC

16 August 2022