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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 and Loss Tangent, Flexural Strength, Arc Resistance, Thermal Stress, Electric Strength, Vertical Flammability Test, Glass Transition Temperature, Decomposition Temperature, Z-Axis CTE (TMA), Time to Delamination (T260, T288, T300), Glass Transition Temperature (DMA), Dimensional Stability, Solderability, Chemical Resistance, Metal Surfaces Cleanability, Pressure Cooker Test.
SAMPLE:	Copper-Clad Laminate
TEST MATERIAL:	TU-901
SPECIFICATION:	IPC-4101E WAM1/134
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	Pass	Pass
Loss Tangent	Pass	Pass
Flexural Strength	--	Pass
Arc Resistance	Pass	Pass
Thermal Stress	Pass	Pass
Electric Strength	Pass	---
Vertical Burning Test	Pass	Pass
Glass Transition Temperature	--	Pass
Decomposition Temperature	--	Pass
Z-Axis CTE (TMA)	--	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 WAM1/134 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	0.82	
Side B Cross-Wise and Length-Wise Average	0.86	
Requirement	≥ 0.70	Pass

Table 2 Peel Strength After Thermal Strength Thick

Side A Cross-Wise and Length-Wise Average	1.08	
Side B Cross-Wise and Length-Wise Average	1.07	
Requirement	≥ 0.70	Pass

Table 3 Peel Strength At Elevated Temperature Thin

Side A Cross-Wise and Length-Wise Average	0.74	
Side B Cross-Wise and Length-Wise Average	0.75	
Requirement	≥ 0.70	Pass

Table 4 Peel Strength At Elevated Temperature Thick

Side A Cross-Wise and Length-Wise Average	0.76	
Side B Cross-Wise and Length-Wise Average	0.78	
Requirement	≥ 0.70	Pass

Table 5 Peel Strength After Process Solutions Thin

Side A Cross-Wise and Length-Wise Average	0.81	
Side B Cross-Wise and Length-Wise Average	0.82	
Requirement	≥ 0.70	Pass

Table 6 Peel Strength After Process Solutions Thick

Side A Cross-Wise and Length-Wise Average	0.89	
Side B Cross-Wise and Length-Wise Average	0.88	
Requirement	≥ 0.70	Pass

Table 7 Peel Strength As Received Low Profile Copper Thin

Side A Cross-Wise and Length-Wise Average	0.81
Side B Cross-Wise and Length-Wise Average	0.84
	No Requirement

Table 8 Peel Strength As Received Low Profile Copper Thick

Side A Cross-Wise and Length-Wise Average	0.87
Side B Cross-Wise and Length-Wise Average	0.89
	No Requirement

Volume & Surface Resistivity

Reference:

IPC-TM-650 Method 2.5.17.1 Volume and Surface Resistivity of Dielectric Materials

IPC-4101E WAM1/134 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	8.15 E+09	
Requirement C-96/35/90		≥ 1.00 E+06	Pass
Surface Resistivity	Average of three specimens	2.73 E+09	
Requirement C-96/35/90		≥ 1.00 E+05	Pass

Table 10 Volume and Surface Resistivity At Elevated Temperature Thin

Volume Resistivity	Average of three specimens	7.44 E+08	
Requirement 125°C		≥ 1.00 E+06	Pass
Surface Resistivity	Average of three specimens	1.43 E+08	
Requirement 125°C		≥ 1.00 E+05	Pass

Table 11 Volume and Surface Resistivity Humidity Conditioning Thick

Volume Resistivity	Average of three specimens	4.3 E+09	
Requirement after moisture		1.00 E+05	Pass
Surface Resistivity	Average of three specimens	2.87 E+08	
Requirement after moisture		≥ 1.00 E+06	Pass

Table 12 Volume and Surface Resistivity At Elevated Temperature Thick

Volume Resistivity	Average of three specimens	6.72 E+08	
Requirement 125°C		≥ 1.00 E+06	Pass

Surface Resistivity	Average of three specimens	3.52 E+07	
Requirement 125°C		≥ 1.00 E+05	Pass

Moisture Absorption

Reference:

IPC-TM-650 Method 2.6.2.1 Water Absorption of Metal Clad Plastic Laminates
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 13 Moisture Absorption Thick

Moisture Absorption	Average of three specimens	0.22	
Requirement		≤ 0.2	Pass

Dielectric Breakdown

Reference:

IPC-TM-650 Method 2.5.6 Dielectric Breakdown
IPC-4101E WAM1/134 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

Permittivity and Loss Tangent

Reference:

IPC-TM-650 Method 2.5.5.9 Permittivity and Loss Tangent, Parallel Plate 1 MHz to 1.5 MHz
IPC-TM-650 Method 2.5.5.15 Permittivity and Loss Tangent by SPDR 1 GHz to 20 GHz
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Boards

Results:

Table 15 Permittivity and Loss Tangent

Permittivity @ 1 MHz	Average of three specimens	3.7	
Requirement Thin		≤ 4.3	Pass
Loss Tangent @ 1 MHz	Average of three specimens	0.002	
Requirement Thin		≤ 0.006	Pass
Permittivity @ 1 MHz	Average of three specimens	3.9	
Requirement Thick		≤ 4.3	Pass
Loss Tangent @ 1 MHz	Average of three specimens	0.004	
Requirement Thick		≤ 0.006	Pass
Permittivity @ 1 GHz	Average of three specimens	3.7	
Requirement Thin		≤ 4.3	Pass
Loss Tangent @ 1 GHz	Average of three specimens	0.0029	
Requirement Thin		≤ 0.006	Pass
Permittivity @ 1 GHz	Average of three specimens	3.97	
Requirement Thick		≤ 4.3	Pass
Loss Tangent @ 1 GHz	Average of three specimens	0.003	
Requirement Thick		≤ 0.006	Pass

Permittivity @ 10 GHz	Average of three specimens	3.52	**Pass**
Requirement Thin		< 4.2	
Loss Tangent @ 10 GHz	Average of three specimens	0.0037	
Requirement Thin		< 0.006	**Pass**
Permittivity @ 10 GHz	Average of three specimens	3.9	
Requirement Thick		≤ 4.2	Pass
Loss Tangent @ 10 GHz	Average of three specimens	0.0043	Pass
Requirement Thick		≤ 0.006	
Permittivity @ 20 GHz	Average of three specimens	3.51	
Requirement Thin		≤ 4.2	Pass
Loss Tangent @ 20 GHz	Average of three specimens	0.0043	
Requirement Thin		≤ 0.006	Pass
Permittivity @ 20 GHz	Average of three specimens	3.89	
Requirement Thick		≤ 4.2	Pass
Loss Tangent @ 20 GHz	Average of three specimens	0.0052	
Requirement Thick		≤ 0.006	Pass

Flexural Strength

Reference:

IPC-TM-650 Method 2.4.4 Flexural Strength of Laminates at Ambient Temperature
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 16 Flexural Strength

Flexural Strength Length Direction	Average of two specimens	448	
Requirement		≥ 345	Pass
Flexural Strength Cross Direction	Average of two specimens	396	
Requirement		≥ 345	Pass

Arc Resistance

Reference:

IPC-TM-650 Method 2.5.1 Arc Resistance of Printed Wiring Material
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 17 Arc Resistance

Arc Resistance Thin	Average of three specimens	183	
Requirement		≥ 60	Pass
Arc Resistance Thick	Average of three specimens	193	
Requirement		≥ 60	Pass

Thermal Stress

Reference:

IPC-TM-650 Method 2.4.13.1 Thermal Stress of Laminates
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

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

Electric Strength

Reference:

IPC-TM-650 Method 2.5.6.2 Electric Strength
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 19 Electric Strength

Electric Strength Thin	Average of three specimens	44	
Requirement		≥ 30	Pass

Flammability Vertical Burning

Reference:

UL94 Section 8 50W (20mm) Vertical Burning Test; V-0, V-1, V-2
IPC-4101E WAM1/134 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
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Boards

Results:

Table 22 Glass Transition Temperature

Glass Transition Temperature	No Requirement / DMA only
Requirement	Test by DMA Only

Decomposition Temperature

Reference:

IPC-TM-650 Method 2.4.24.6 Decomposition Temperature of Laminate Material Using TGA
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 23 Decomposition Temperature

Glass Transition Temperature 5% Weight Loss	447°C	
Requirement	≥ 400	Pass

Z-Axis CTE (TMA)

Reference:

IPC-TM-650 Method 2.4.24.6 Decomposition Temperature of Laminate Material Using TGA
IPC-4101E WAM1/134 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	37	
Requirement	≤ 50	Pass
Z-Axis CTE Alpha 2 Average of two specimens	149	
Requirement	≤ 275	Pass
Z-Axis CTE 50-260 Average of two specimens	1.6	
Requirement	≤ 2.8	Pass

Time to Delamination

Reference:

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

IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 25 Time to Delamination (TMA)

Delamination T260	Average of two specimens	> 60	
	Requirement	≥ 60	Pass
Delamination T288	Average of two specimens	> 60	
	Requirement	≥ 60	Pass
Delamination T300	Average of two specimens	> 30	
	Requirement	≥ 30	Pass

Glass Transition Temperature (DMA)

Reference:

IPC-TM-650 Method 2.4.24.4 Glass Transition Temperature by DMA

IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 26 Glass Transition Temperature (DMA)

Glass Transition Temperature	226°C	
Requirement	≥ 170	Pass

Dimensional Stability

Reference:

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

IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 27 Dimensional Stability Thin

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

Table 28 Dimensional Stability Thick

Dimensional Stability Bake	Average of three specimens		
	Machine direction	-0.05	
	Cross direction	-0.07	
	Requirement	-0.3 to +0.3	Pass
Dimensional Stability Stress	Average of three specimens		
	Machine direction	-0.03	
	Cross direction	-0.06	
	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 WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 29 Solderability

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.
IPC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 30 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:

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

PC-4101E WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 31 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 WAM1/134 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 32 Pressure Cooker Test

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

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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:

Weiting Shen
Weiting Shen
QA Engineer
16 August 2022

Approved by:

Money Wang
QA Manager
16 August 2022

Douglas J. Sober
For IPC
16 August 2022