ROGERS CORPORATION

CLTE-AT™ Series Laminates Data Sheet

Excellent Dimensional Stability with High Degree of Phase Stability vs. Temperature

CLTE-AT™ laminates represent the commercial version of the CLTE™ product line. CLTE-AT laminates use the common building blocks developed with CLTE-XT™ laminates, but with some changes to make the product more affordable. This results in a higher dielectric constant (3.00) and a slightly different thickness than the CLTE-XT laminates. To maintain its lower cost base, CLTE-AT laminates have less options for copper style and panel sizes.

CLTE-AT micro dispersed ceramic PTFE composites utilize a woven fiberglass reinforcement to provide the highest degree of dimensional stability, critical in multi-layer designs. CLTE-AT laminates are in a "League of their Own" for registration when utilizing thin substrates (i.e. 0.005" and 0.010").

CLTE-AT laminates have "Best-in-Class" Insertion Loss (S21) and Loss Tangent (0.0013) in the commercial marketplace and second only to CLTE-XT laminates. During Development, Rogers focused not only in reducing Loss Tangent, but, also in reducing Conductive Losses.

The impact of copper foil roughness on conductor loss is due to increase in transmission line resistance as a result of skin effect. Rogers' CLTE-AT laminates were designed to provide a quality peel strength without having to resort to the utilization of the lossier, rougher coppers prevalent in competitive products to achieve acceptable copper adhesion.

CLTE-AT laminates have Low CTE xyz and Very Low TCEr for applications that require Electrical Phase Stability, Dk Stability, and Mechanical Stability well over a -55 to 150°C Operating Temperature. CLTE-AT laminates continue the competitive advantages of CLTE laminates (dimensional stability, low absorption of moisture and processing chemicals, ease of processability). The higher thermal conductivity of CLTE-AT laminates improve heat transfer relative to alternative materials and enable better power handling.

Applications include sensitive filter applications, collision avoidance radar, adaptive cruise control, temperature stable antennas and other microwave and RF applications.

Features:

- Ceramic/PTFE Microwave Composite
- Mechanically more robust and more dimensionally stable than alternatives
- Lowest Insertion Loss in Commercial Class
- Very Low Loss Tangent (0.0013)
- Electrical Phase Stability vs. Temperature
- High Thermal Conductivity
- Tight Dielectric Constant (±0.04) and Thickness Tolerance

Benefits:

- Excellent Thermal Stability of Dk and Df
- Phase Stability across temperature
- High Degree of Dimensional Stability required for complex, multilayer boards
- Excellent CTE in X,Y and Z

Typical Applications:

- Automotive Radar & Adaptive Cruise Control Applications
- Microwave/RF Applications
- Phase/Temperature Sensitive Antennas
- Phase Sensitive Electronic Applications
- RF and Microwave Filters

Typical Properties

Property	Units	Value	Test Method
1. Electrical Properties			
Dielectric Constant (may vary by thickness)			
@1 MHz	-	3.00	IPC TM-650 2.5.5.3
@ 10 GHz	-	3.00	IPC TM-650 2.5.5.5
Dissipation Factor			
@ 1 MHz	-	0.0013	IPC TM-650 2.5.5.3
@ 10 GHz	-	0.0013	IPC TM-650 2.5.5.5
Temperature Coefficient of Dielectric	-		
TCεr @ 10 GHz (-40-150°C)	ppm/ºC	-10	IPC TM-650 2.5.5.5
Volume Resistivity			
C96/35/90	MΩ-cm	$4.25x10^8$	IPC TM-650 2.5.17.1
E24/125	MΩ-cm		IPC TM-650 2.5.17.1
Surface Resistivity			
C96/35/90	MΩ	$2.02x10^8$	IPC TM-650 2.5.17.1
E24/125	MΩ		IPC TM-650 2.5.17.1
Electrical Strength	Volts/mil (kV/mm)		IPC TM-650 2.5.6.2
Dielectric Breakdown	kV	58	IPC TM-650 2.5.6
Arc Resistance	sec	250	IPC TM-650 2.5.1
2. Thermal Properties			
Decomposition Temperature (Td)			
Initial	°C	487	IPC TM-650 2.4.24.6
5%	°C	529	IPC TM-650 2.4.24.6
T260	min	>60	IPC TM-650 2.4.24.1
T288	min	>60	IPC TM-650 2.4.24.1
T300	min	>60	IPC TM-650 2.4.24.1
Thermal Expansion, CTE (x,y) 50-150ºC	ppm/ºC	8, 8	IPC TM-650 2.4.41
Thermal Expansion, CTE (z) 50-150ºC	ppm/ºC	20	IPC TM-650 2.4.24
% z-axis Expansion (50-260ºC)	%		IPC TM-650 2.4.24
3. Mechanical Properties			
Peel Strength to Copper (1 oz/35 micron)			
After Thermal Stress	lb/in (N/mm)	7 (1.3)	IPC TM-650 2.4.8
At Elevated Temperatures (150º)	lb/in (N/mm)	9 (1.6)	IPC TM-650 2.4.8.2
After Process Solutions	lb/in (N/mm)	7 (1.2)	IPC TM-650 2.4.8
Young's Modulus	kpsi (MPa)	260 (1790)	IPC TM-650 2.4.18.3
Flexural Strength (Machine/Cross)	kpsi (MPa)	14.6/7.8 (101/54)	IPC TM-650 2.4.4
Tensile Strength (Machine/Cross)	kpsi (MPa)	7.0/4.4 (48/30)	IPC TM-650 2.4.18.3
Compressive Modulus	kpsi (MPa)	244	ASTM-D-3410
Poisson's Ratio	-	0.17	ASTM D-3039
4. Physical Properties			
Water Absorption	%	0.03	IPC TM-650 2.6.2.1
Density, ambient 23ºC	g/cm^3	2.06	ASTM D792 Method A
Thermal Conductivity	W/mK	0.64	ASTM E1461
Flammability	class	V-0	UL-94
NASA Outgassing, 125ºC, $\leq 10^{-6}$ torr			
Total Mass Loss	%	0,04	NASA SP-R-0022A
Collected Volatiles	%	0.00	NASA SP-R-0022A
Water Vapor Recovered	%	0.00	NASA SP-R-0022A

Laminates thicker than 0.060" are tested via IPC-TM 650 2.5.5.3 due to test fixture limits of the 2.5.5.5 Test Method Test Biasing of the IPC-TM 650 2.5.5.3 results in a 3.02 ±0.04 nominal for Quality Control.

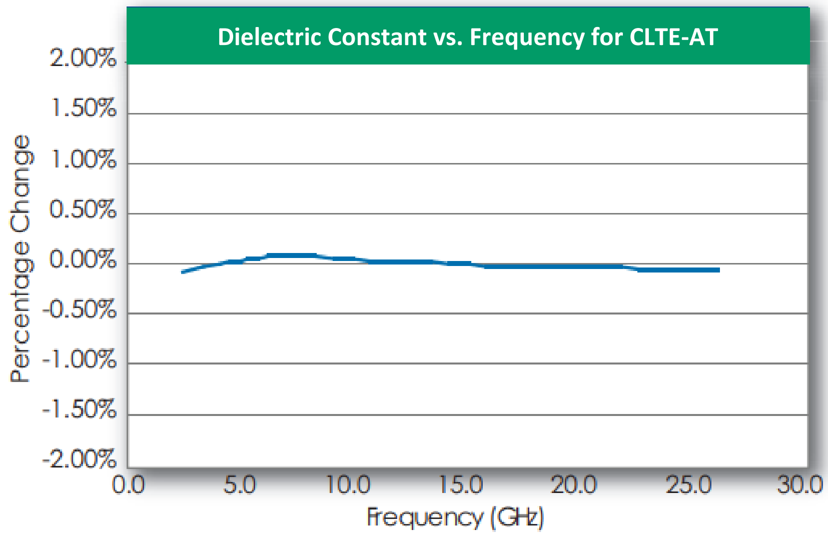

Figure 1

Demonstrates the stability of dielectric constant across frequency. This information was correlated from data generated by using a free space and circular resonator cavity. This characteristic demonstrates the inherent robustness of Rogers' laminates across frequency, thus simplifying the final design process when working across EM spectrum. The stability of the dielectric constant of CLTE-AT laminates over frequency ensures easy design transition and scalability of design.

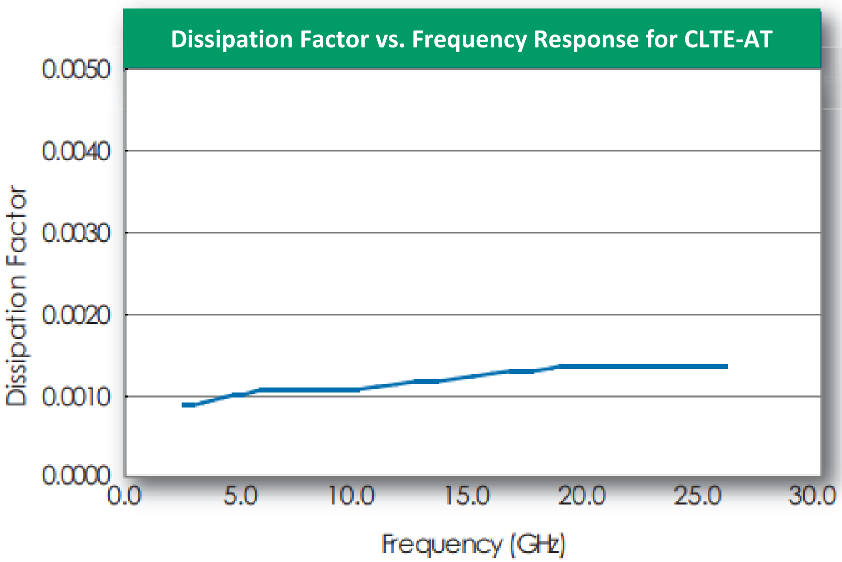

Figure 2

Demonstrates the stability of dissipation factor across frequency. This characteristic demonstrates the inherent robustness of Rogers' laminates across frequency, providing a stable platform for high frequency applications where signal integrity is critical to the overall performance of the application.

Resonant cavity methods yielded slightly lower dissipation factor results than IPC 650-TM 2.5.5.5. Df across 1.8 GHz to 25.6 GHz averaged 0.0011 in the Z-Axis. Dielectric loss best correlates with Z-Axis (Efield perpendicular to the board) as the signal propagation down the length of the board maintains the E-Field perpendicular to the plane of the board (right hand rule), such as a microstrip or stripline design.

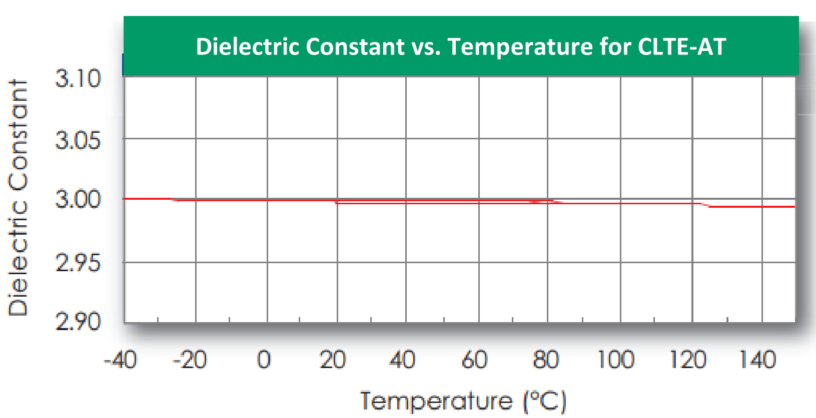

Figure 3

Dk/Temperature curve shows the unique thermal stability properties of CLTE-AT materials when thermocycled over temperature. Even over a wider temperature variation, the material retains its ultra-stable dielectric constant characteristics. This feature is critical to phase sensitive devices, and phase fed apertures that must perform over a wide temperature range.

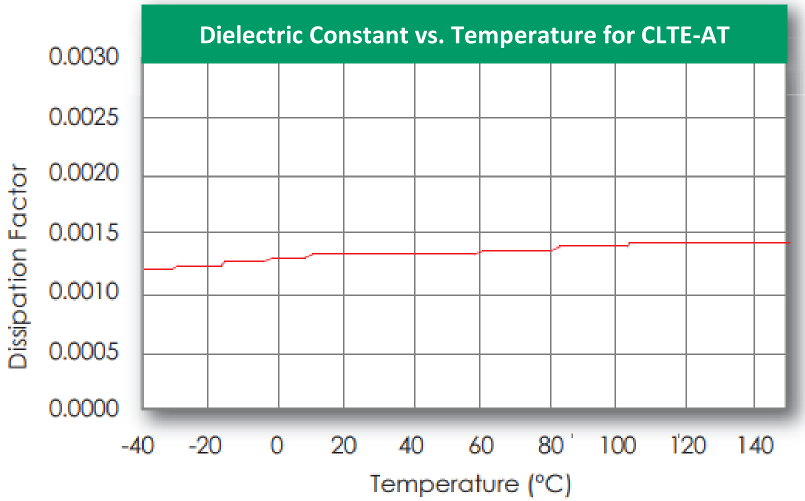

Figure 4

This Df/Temperature curve shows the unique thermal stability properties of CLTE-AT materials when thermocycled over temperature.

Material Availability

Grade	Available Thicknesses	Standard Panel Sizes	Available Cladding
CLTE-AT	0.005" (0.13mm) ±0.0005" 0.010" (0.25mm) ±0.0007" 0.020" (0.51mm) ±0.0015" 0.030" (0.76mm) ±0.0020" 0.060" (1.52mm) ±0.0030"	12"x18" (305mm X 457mm) 24"x18" (610mm X 457mm)	½ oz. (18µm), 1 oz. (35µm) electrodeposited copper Foil ½ oz. (18µm), 1 oz. (35µm) Reverse Treat electro-deposited copper Foil

Multilayer Lamination Recommendations

Following the use of conventional imaging and etching processes, successful fabrication of multilayer circuit assemblies using the CLTE Series prepregs (designated CLTE-P™) with the CLTE-AT series laminates can be achieved through use of the following recommendations.

Prepreg Material (CLTE-P prepreg)

The prepreg material consists of woven fiberglass fabric coated with a proprietary resin formulation that is matched in Dk to the CLTE-XT and CLTE laminates. As received, the thickness of prepreg is ≈.0032". After lamination, the thickness is compressed to ≈.0024".

Surface Preparation

Substrate surface - No additional surface treatment, either mechanical or chemical, should be necessary to achieve good adhesion. However, this recommendation is based upon laboratory conditions where multilayer lamination was performed immediately after etching of the copper surface. For panels which have a long wait time between etching and lamination, a sodium etch (or plasma etch process appropriate for PTFE) of the CLTE-XT laminate surface will provide optimal results.

Copper surfaces - Microetch and dry the inner layer copper surfaces immediately prior to lay-up and lamination. Standard FR-4 black oxide processes may not provide optimal results due to the high lamination temperatures required to bond CLTE-P material. Brown or red oxide treatments may improve the bond to large copper plane areas.

Lamination

CLTE-P prepreg requires a lamination temperature of 565°F/296°C to allow sufficient flow of resin. It is not recommended for bonding layers involving more than ½ ounce copper. Press cycle optimization should be done on each design to insure adequate fill/flow. Starting point guidelines are listed below. Contact your Rogers' representative with specific questions.

Equipment - A press which has heat and cool cycles in the same opening is recommended. This ensures that constant pressure can be maintained throughout both the heat-up and cool-down cycle.

Temperature - CLTE-P prepreg requires a lamination temperature of 550°F/572°F (288-300°C) to allow sufficient flow of the resin. The lamination temperature should be measured at the bond line using a thermocouple located in the edge of the product panel. Because of the high temperatures required for lamination, noncombustible peripheral materials, such as separator sheets and press padding material, should be used. Epoxy separator sheets are not recommended, as they may char or burn. Paper and certain rubber press padding materials are also not recommended for similar reasons.

Pressure (400 psi actual) - A pressure of 400 psi is recommended to remove any entrapped air and force the flow of the prepreg into the exposed "tooth" present on the surface of the laminate. This pressure must be maintained throughout the full extent of the heating and cooling cycles.

Heat up and cool down rate - Since CLTE-P is a thermoplastic material, precise control of heat up and cool down rates is not critical.

Time at laminating temperature (45 minutes) - Good adhesion will be achieved by maintaining the recommended laminating temperature for a period of 45 minutes.

The information in this data sheet is intended to assist you in designing with Rogers' circuit materials. It is not intended to and does not create any warranties express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown on this data sheet will be achieved by a user for a particular purpose. The user should determine the suitability of Rogers' circuit materials for each application.

These commodities, technology and software are exported from the United States in accordance with the Export Administration regulations. Diversion contrary to U.S. law prohibited.

The Rogers' logo, Helping power, protect, connect our world, CLTE, CLTE-AT, CLTE-XT and CLTE-P are trademarks of Rogers Corporation or one of its subsidiaries.