



## Commercial Version of CLTE-XT

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

CLTE-AT represents the commercial version of the CLTE product line. CLTE-AT uses the common building blocks developed CLTE-XT, 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. To maintain its lower cost base, CLTE-AT has less options for copper style and panel sizes.

CLTE-AT is a micro dispersed ceramic PTFE composite utilizing a woven fiberglass reinforcement to provide the highest degree of dimensional stability, critical in multi-layer designs. CLTE-AT is in a “League of its Own” for registration when utilizing thin substrates (i.e. 0.005” and 0.010”).

CLTE-AT has “Best-in-Class” Insertion Loss (S21) and Loss Tangent (0.0013) in the commercial marketplace and second only to CLTE-XT. During Development, Arlon focused not only 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. Arlon’s CLTE-AT was 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 has Low CTE<sub>xyz</sub> 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 continues the competitive advantages of CLTE (dimensional stability, low absorption of moisture and processing chemicals, ease of processability). The higher thermal conductivity of CLTE-AT improves heat transfer relative to alternative materials and enables 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 ( $\pm 0.04$ ) and Thickness Tolerance

#### Benefits:

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

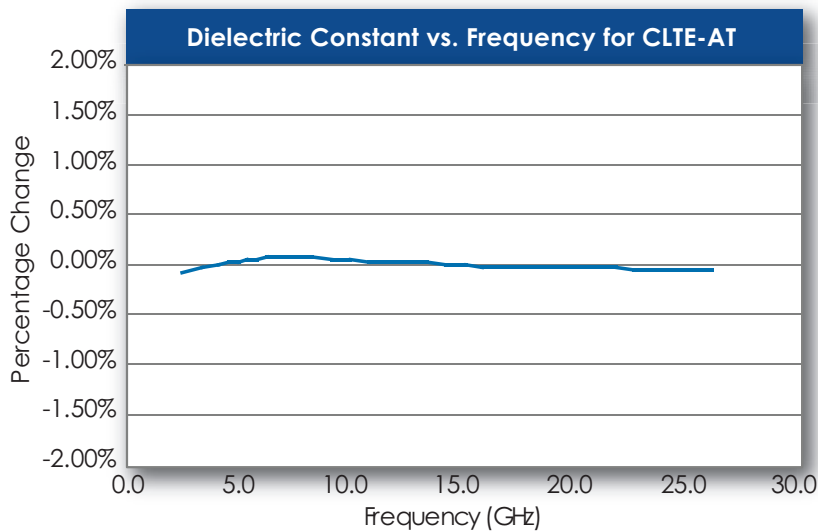
#### Typical Applications:

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

## Typical Properties:

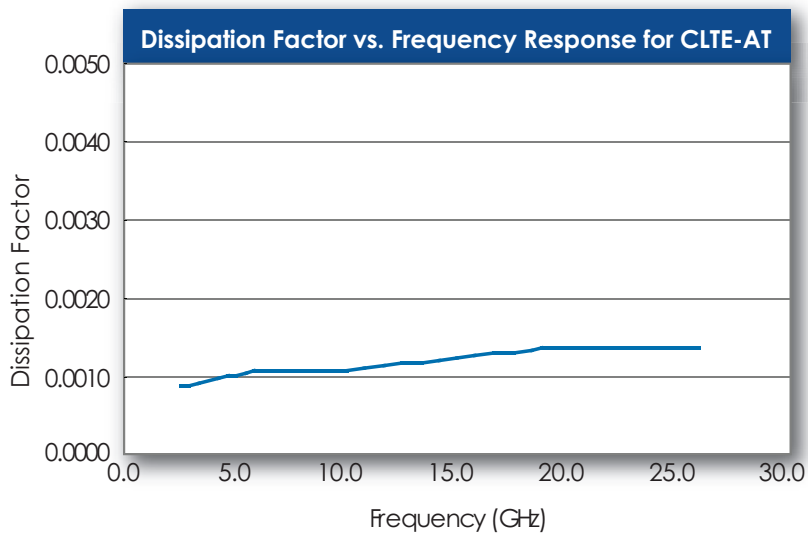
Property	Units	Value	Test Method
<b>1. Electrical Properties</b>			
Dielectric Constant (may vary by thickness)			
@1 MHz	-	3.00	IPC TM-650 2.5.5.3
@ 10 GHz	-	3.00	IPC TM-650 2.5.5.5
Dissipation Factor			
@ 1 MHz	-	0.0013	IPC TM-650 2.5.5.3
@ 10 GHz	-	0.0013	IPC TM-650 2.5.5.5
Temperature Coefficient of Dielectric	-		
TC <sub>εr</sub> @ 10 GHz (-40-150°C)	ppm/°C	-10	IPC TM-650 2.5.5.5
Volume Resistivity			
C96/35/90	MΩ-cm	4.25x10 <sup>8</sup>	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 <sup>8</sup>	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
<b>2. Thermal Properties</b>			
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) 50-150°C	ppm/°C	8, 8	IPC TM-650 2.4.41
Thermal Expansion, CTE (z) 50-150°C	ppm/°C	20	IPC TM-650 2.4.24
% z-axis Expansion (50-260°C)	%		IPC TM-650 2.4.24
<b>3. Mechanical Properties</b>			
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 (150°)	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
<b>4. Physical Properties</b>			
Water Absorption	%	0.03	IPC TM-650 2.6.2.1
Density, ambient 23°C	g/cm <sup>3</sup>	2.06	ASTM D792 Method A
Thermal Conductivity	W/mK	0.64	ASTM E1461
Flammability	class	V-0	UL-94
NASA Outgassing, 125°C, ≤10 <sup>-6</sup> 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 Arlon Laminates across Frequency, thus simplifying the final design process when working across EM spectrum. The stability of the Dielectric Constant of CLTE-AT 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 Arlon 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.*

## Material Availability:

CLTE-AT laminates are built on 0.005" and 0.010" building blocks. CLTE-AT is supplied with 1/2 and 1 ounce electrodeposited copper or reverse treat copper on both sides. When ordering CLTE-AT products, please specify thickness, cladding, panel size and any other special considerations. Available master sheet sizes include 36" x 48", Typical panel sizes include: 12" x 18", 16" x 18" and 18" x 24". Many non-traditional panel sizes are actually cut from the typical panels sizes listed above and charged at the typical panel size price. Please work with Sales Engineering so that Arlon can optimize panel size to minimize scrap and total costs in the supply chain.

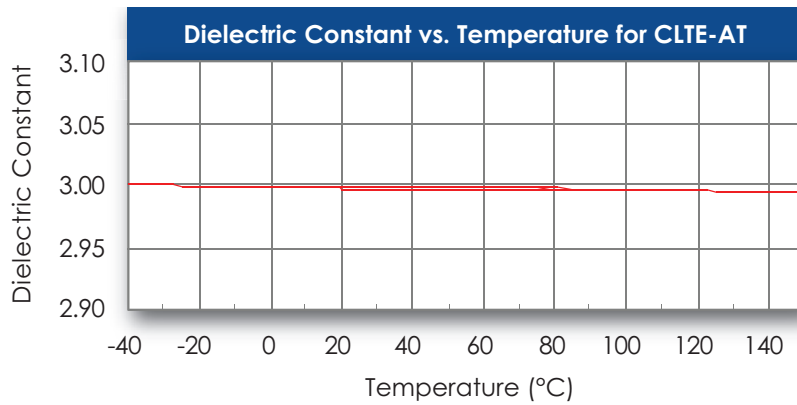


Figure 3

*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.*

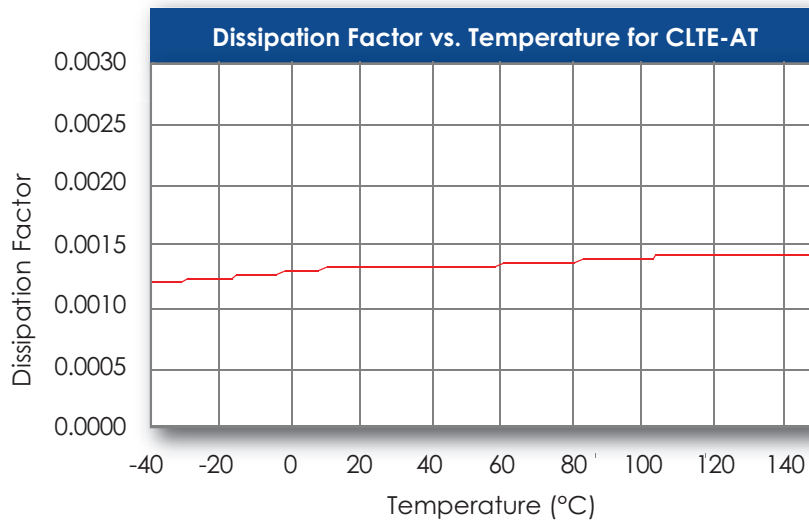


Figure 4

*THIS DF/TEMPERATURE CURVE shows the unique thermal stability properties of CLTE-AT materials when thermocycled over temperature.*

## Multilayer Lamination Recommendations

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

### Prepreg Material (CLTE-P)

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 pre-preg is  $\approx .0032"$ . After lamination, the thickness is compressed to  $\approx .0024"$ .

### 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. Brown or red oxide treatments may improve the bond to large copper plane areas.

### Lamination

CLTE-P requires a lamination temperature of  $565^{\circ}\text{F}/296^{\circ}\text{C}$  to allow sufficient flow of resin. It is not recommended for bonding layers involving more than  $\frac{1}{2}$  ounce copper. Press cycle optimization should be done on each design to insure adequate fill/flow. Starting point guidelines are listed below. Contact your Arlon 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 requires a lamination temperature of  $550^{\circ}\text{F}/288^{\circ}\text{C}$  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.