TACONIC

Finding a better way

TLY Family of Low Loss Laminates

TLY laminates are manufactured with very lightweight woven fiberglass and are much more dimensionally stable than chopped fiber reinforced PTFE composites. The woven matrix in the TLY material yields a more mechanically stable laminate that is suitable for high volume manufacturing. The low dissipation factor enables successful deployment for automotive radar applications designed at 77 GHz as well as other antennas in millimeter wave frequencies.

Comparative OEM testing at 77 GHz of lightly reinforced TLY-5 vs. its closest chopped fiber reinforced competitor has shown “drop in”/ equivalent insertion losses/dielectric properties. The primary benefit is much higher manufacturing yields.

The dielectric constant range is 2.17 to 2.40. For most thicknesses, the dielectric constant can be specified anywhere within this range with a tolerance of +/- .02. In the low dielectric constant range, the dissipation factor is approximately 0.0009 at 10 GHz.

Typical applications include satellite communications, automotive radar, filters, couplers, avionics and phased array antennas.

Newer lightweight fiberglass TLY products have been introduced for better laser hole quality (TLY5-L-0040). TLY products with enhanced flexibility have been designed for fabrication of antennas that have some curvature (TLY-3F).

Taconic is a world leader in RF laminates and high speed digital materials, offering a wide range of high frequency laminates and prepregs. These advanced materials are used in the fabrication of antennas, multilayer RF and high speed digital boards.

Benefits & Applications:

- **Dimensionally Stable**
- **Lowest Df**
- **High Peel Strength**
- **Low Moisture Absorption**
- **Uniform, Consistent Dk**
- **Laser Ablatable**

- **Automotive Radar**
- **Satellite/Cellular Communications**
- **Power Amplifiers**
- **LNBs, LNAs, LNCs**
- **Aerospace**
- **Ka, E and W band Applications**

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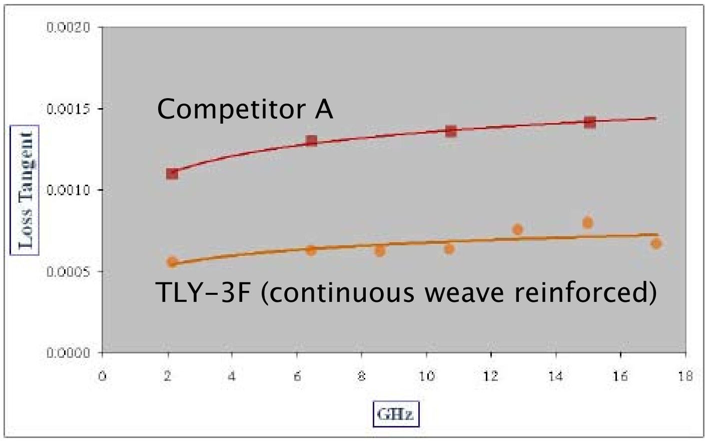
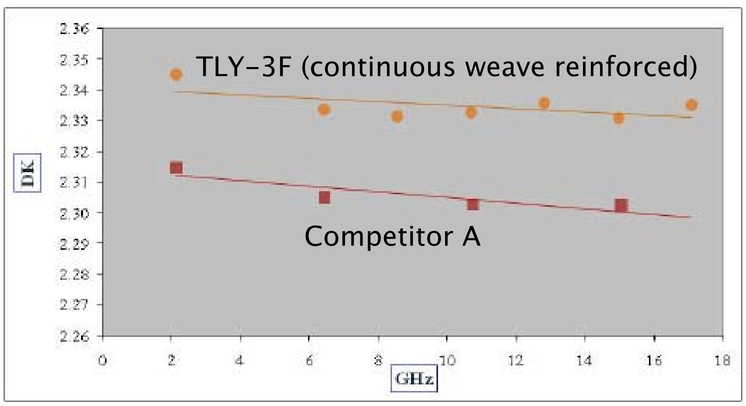
Flexible Laminates





TLY-3F is a new highly flexible laminate designed for applications that require laminates with some bend radius. TLY-3F is much more flexible than standard TLY fiberglass reinforced substrates. The flexibility of TLY-3F is comparable to chopped fiber reinforced PTFE laminates yet it has a loss tangent that is lower than traditional chopped fiber reinforced laminates.

The fiberglass reinforced TLY-3F has been engineered to provide the dimensional stability typical of the standard fiberglass reinforced TLY Series yet offers the mechanical flexibility of chopped fiber reinforced laminates.

TLY-3F has also been designed for improved laser via formation relative to traditional TLY glass reinforced laminates.

The suggestion that chopped fiber reinforced 2.2 laminates is truly random is optimistic and perhaps misleading. Visual observation of a 5 mil chopped fiber 2.2 laminate shows a non homogeneous appearance with dark and light colored areas (Figure A). To determine the uniformity of the chopped fiber reinforcement, X-Ray Fluorescence was used. The chemical composition of fiberglass is dominated by silicon oxide (SiO_2), followed by CaO_2, Al_2O3, MgO and B_2O_3. XRF is more sensitive to the heavier elements than carbon or fluorine. For this reason, XRF was used to trace the relative compositions of the heavy Si and Ca in the light and dark regions. The first observation was that the dark and light regions had different densities (surface analysis not shown). The intensity of the scattering is proportional to the concentration of light vs. heavy elements. A more detailed analysis would be necessary to yield quantitative information on the difference in densities between the two regions. It is well known that the Dk of PTFE is dependent on the amount of air that is compressed out of a PTFE composite during high temperature densification. Figure B shows an overlap of the XRF scattering intensities for the light and dark colored regions (subsurface bulk anaylsis). The dark region shows 2.35 times the amount of silicon and 1.34 times the amount of calcium in the dark regions. Silicon oxide (silica) has a Dk of 3.28 and is appreciably higher than the 2.1 Dk of PTFE. The non uniform distribution of the silicon and calcium suggests that the manufacturing process is prone to producing non homogeneous dielectric materials. It is unknown at this time which material is more homogeneous - chopped fiber or continuous weave reinforced 2.2 Dk PTFE composites. Though it must be stated that the domain sizes of the light and dark regions are very large and visible to the naked eye on the chopped fiber laminate and certainly on par with woven fiberglass PTFE laminates (TLY-5). Truly random chopped fiber reinforced laminates would have equal x, y and z CTE values. The large domain sizes of light and dark colored areas with different Si and Ca concentrations would suggest that there are probably different domains within the laminate of fluctuating CTE values.

	TENSILE PROPERTIES		
Sample	Peak Load	Peak Elongation	Modulus (1% strain)
	(lbs)	(%)	(lbs/in²)
TLY-5-0080 (MD)	119.35	3.34	964,572
TLY-5-0080 (CD)	61.67	3.33	548,723
Chopped Fiber Reinforced (MD)	34.34	5.00	202,664
Chopped Fiber Reinforced (CD)	30.80	5.42	200,143

Fiberglass reinforced TLY has a much higher modulus than chopped glass fiber reinforced equivalents. Because the chopped fiber reinforced equivalents have no continuous fiberglass, it is more prone to stretching during manufacturing. Depending on the machine or cross direction, TLY-5 has a modulus 3 to 5 times higher than the chopped fiber equivalent. This is a direct result of the continuous fiberglass reinforcement. The fiberglass reinforcement also directly influences the elongation properties of TLY. The high modulus fiberglass stretches very little before breaking, resulting in typical elongations of 3 to 4%. Chopped fiber equivalents typically elongate closer to 6%. The more stable structure of TLY lends itself to high volume manufacturing and larger panel fabrication. The chopped fiber reinforced equivalent is generally manufactured in a smaller panel size. For stripline applications involving some requirement for registration from layer to layer and machining tolerances, TLY has demonstrated higher manufacturing yields than the chopped fiber equivalent.

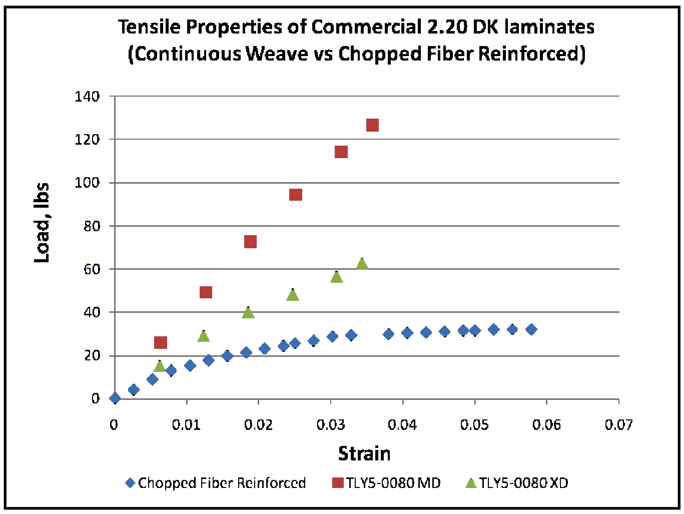
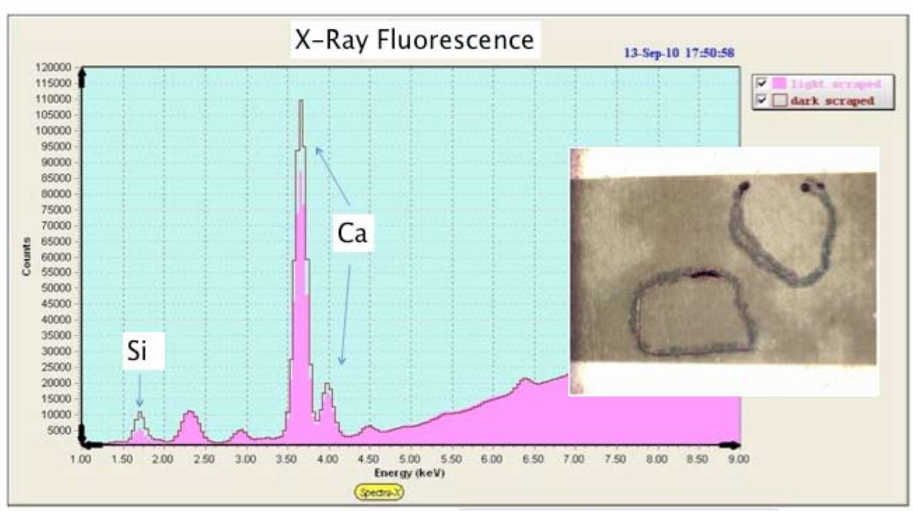


Figure A



	Silicon	Calcium
	Relative Concentrations	
Dark Area	2.35	1.34
Light Area	1	1

Fiberglass Chemical Composition	
Element	wt%
SiO2	52-56
CaO2	16-25
Al2O3	12 to 16
MgO	0-5
B2O3	5 to 10

Figure B

Laser Ablation

CO_2 laser ablation of PTFE substrates is dependent on the reinforcement used. For low Dk 2.2 laminates, the options include chopped fiber reinforced fiberglass and continuous weave woven reinforced fiberglass. The chopped fiber reinforced laminates are sometimes referred to as "non reinforced" or "random weave". This is incorrect. The chopped fiber reinforced laminates are lightly reinforced and there is a degree of anisotropy otherwise the x, y, and z axis coefficients of thermal expansion would be equal and they are not. Regardless, the chopped fiber filled low Dk laminates and the continuous weave reinforced laminates both are laser ablated with some level of defects. The defects correspond to the different power levels required to laser ablate an inorganic glass and an organic PTFE. Acceptable laser ablation of continuous weave fiberglass is related to the fiberglass style. Continuous weave fiberglass is available with various filament sizes used to create fiberglass bundles and various densities of fiberglass bundles. Common square weave fiberglass is manufactured by taking bundles of fiberglass in the machine direction (warp) and interspersing fiberglass perpendicular to the warp direction to create "fill" yarns. It is true that if warp and fill yarns are chosen with large diameter filaments and many filaments are used to create heavy bundles, CO_2 laser ablation can be rough. The largest defects occur when the warp and fill yarns overlap creating a high concentration of fiberglass in one spot. The uneven laser power required to laser ablate a glass rich area versus a PTFE rich area is very different, necessitating a high enough power to laser ablate the glass. This power level usually results in the PTFE melting back away from an ablated hole or cavity edge.

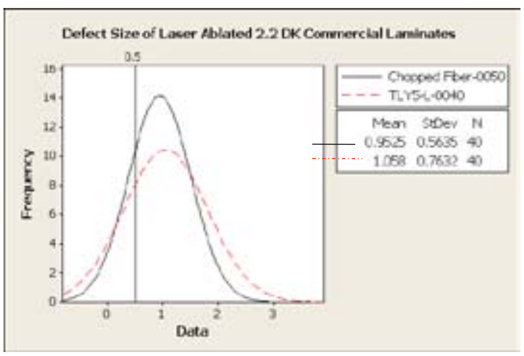
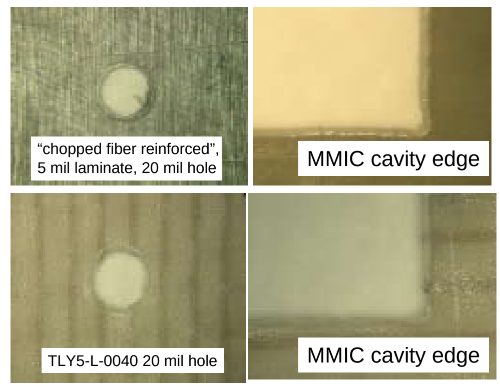


Figure C



Laser ablation of continuous weave fiberglass (TLY-L) and chopped fiber PTFE laminates can yield similar results. Figure C shows CO_2 laser ablated 20 mil holes as well as laser ablated cavity edges for a (5 mil DT) chopped fiber reinforced laminate and a (4 mil DT) continuous weave 2.2 Dk laminate. The same CO_2 laser conditions were used. The mean size of the defects are roughly the same (~1 mil) with the chopped fiber reinforced laminate having a somewhat tighter standard deviation.

DT= dielectric thickness

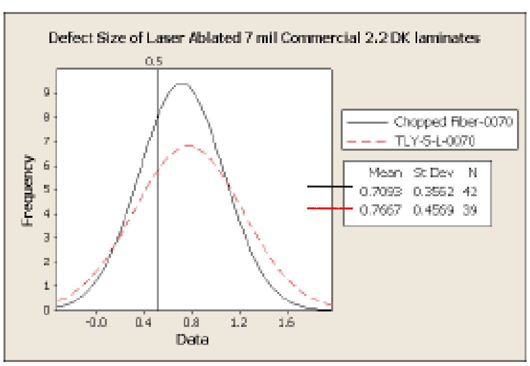


Figure D

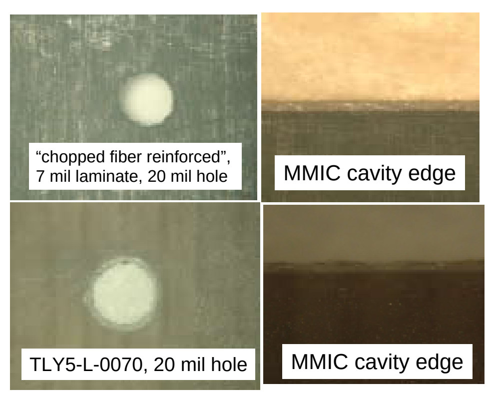
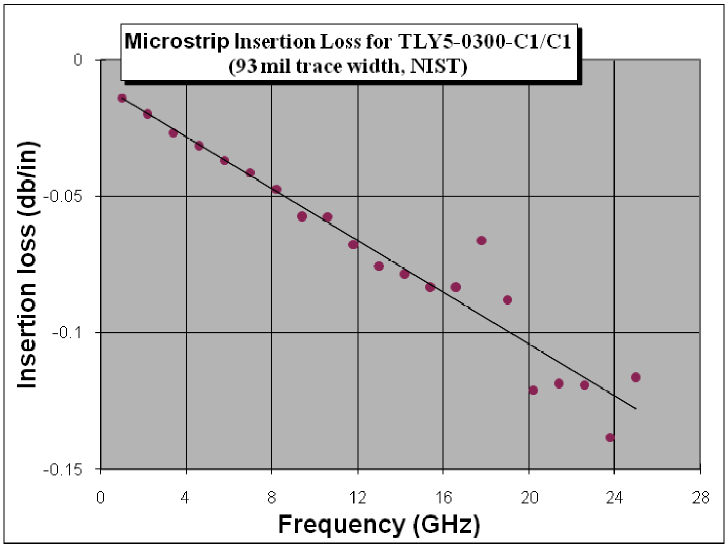


Figure D shows CO_2 laser ablated 20 mil holes as well as laser ablated cavity edges for a (7 mil DT) chopped fiber reinforced laminate and a (7 mil DT) continuous weave 2.2 Dk laminate. Note that the 7 mil laminates have a reduced mean defect size as the thinner 4 - 5 mil laminates. This suggests that as the laminates increase in thickness, single discontinuities in fiberglass-rich or PTFE-rich regions have less of an influence on the laser ablation of a thicker laminate with a varying composition from top to bottom of the laminate. It is acknowledged that chopped fiber reinforced laminates will laser ablate better than woven fiberglass based laminates when heavier weave styles are used. However, woven fiberglass using lightweight fiberglass will laser ablate on par with its chopped fiber equivalent.

TLY Typical Values					
Property	Test Method	Unit	Value	Unit	Value
Dk @ 10 GHz	IPC-650 2.5.5.5		2.20		2.20
Df @ 10 GHz	IPC-650 2.5.5.5		0.0009		0.0009
Moisture Absorption	IPC-650 2.6.2.1	%	0.02	%	0.02
Dielectric Breakdown	IPC-650 2.5.6	kV	>45	kV	>45
Dielectric Strength	ASTM D149	V/mil	2,693	V/mm	106,023
Volume Resistivity	IPC-650 2.5.17.1 (after elevated temp.)	Mohms/cm	10^{10}	Mohms/cm	10^{10}
Volume Resistivity	IPC-650 2.5.17.1 (after humidity)	Mohms/cm	10^{10}	Mohms/cm	10^{9}
Surface Resistivity	IPC-650 2.5.17.1 (after elevated temp.)	Mohms	10^{8}	Mohms	10^{8}
Surface Resistivity	IPC-650 2.5.17.1 (after humidity)	Mohms	10^{8}	Mohms	10^{8}
Flex Strength (MD)	IPC-650 2.4.4	psi	14,057	N/mm^2	96.91
Flex Strength (CD)	IPC-650 2.4.4	psi	12,955	N/mm^2	89.32
Peel Strength (1/2 oz. ED copper)	IPC-650 2.4.8	lbs./inch	11	N/mm	1.96
Peel Strength (1 oz. CL1 copper)	IPC-650 2.4.8	lbs./inch	16	N/mm	2.86
Peel Strength (1 oz. CV1 copper)	IPC-650 2.4.8	lbs./inch	17	N/mm	3.04
Peel Strength	IPC-650 2.4.8 (at elevated temp.)	lbs./inch	13	N/mm	2.32
Young's Modulus (MD)	ASTM D 3039/IPC-650 2.4.19	psi	1.4×10^{6}	N/mm^2	9.65×10^{3}
Poisson's Ratio (MD)	ASTM D 3039/IPC-650 2.4.19		0.21		0.21
Thermal Conductivity	ASTM F 433	W/M*K	0.22	W/M*K	0.22
Dimensional Stability (MD, 10 mil)	IPC-650 2.4.39 (avg. after bake & thermal stress)	mils/inch	-0.038	mm/M	-0.038
Dimensional Stability (CD, 10 mil)	IPC-650 2.4.39 (avg. after bake & thermal stress)	mils/inch	-0.031	mm/M	-0.031
Density (Specific Gravity)	ASTM D 792	g/cm^3	2.19	g/cm^3	2.19
CTE (x) (25 - 260°C)	ASTM D 3386 (TMA)	ppm/°C	26	ppm/°C	26
CTE (y) (25 - 260°C)	ASTM D 3386 (TMA)	ppm/°C	15	ppm/°C	15
CTE (z) (25 - 260°C)	ASTM D 3386 (TMA)	ppm/°C	217	ppm/°C	217
NASA Outgassing (% TML)			0.01		0.01
NASA Outgassing (% CVCM)			0.01		0.01
NASA Outgassing (% WVR)			0.00		0.00
UL-94 Flammability Rating	UL-94		V-0		V-0

All reported values are typical and should not be used for specification purposes. In all instances, the user shall determine suitability in any given application.



Designation	Dk
TLY-5A	2.17
TLY-5A-L	2.17
TLY-5	2.20
TLY-5-L	2.20
TLY-3	2.33
TLY-3F	2.33

Typical Thicknesses[1] Inches	mm
0.0035	0.09
0.0050	0.13
0.0075	0.19
0.0100	0.25
0.0200	0.51
0.0300	0.76
0.0600	1.52

Available Sheet Sizes[2] Inches	mm
12 x 18	304 x 457
16 x 18	406 x 457
18 x 24	457 x 610
16 x 36	406 x 914
24 x 36	610 x 914
18 x 48	457 x 1220

[1]Other thicknesses may be available. Please call for information.
[2]Our standard sheet size is 36" x 48" (914 mm x 1220 mm). Please contact our customer service department for availability of other sizes.

Available Copper Cladding						
Designation	Weight	Copper Thickness		R_{MS} Treated Side		Description
RH*	½ oz / ft²	~0.0007"	~18 µm	16 µin	0.4 µm	Rolled annealed
R1	1 oz / ft²	~0.0014"	~35 µm	11 µin	0.3 µm	Rolled annealed
CLH	½ oz / ft²	~0.0007"	~18 µm	13 µin	0.3 µm	Reverse treated/Electrodeposited
CL1	1 oz / ft²	~0.0014"	~35 µm	13 µin	0.3 µm	Reverse treated/Electrodeposited
CEH	½ oz / ft²	~0.0007"	~18 µm	19 µin	0.5 µm	High ductility/Very low profile/ Electrodeposited
CE1	1 oz / ft²	~0.0014"	~35 µm	19 µin	0.5 µm	High ductility/Very low profile/ Electrodeposited
CVH (CH)	½ oz / ft²	~0.0007"	~18 µm	27 µin	0.7 µm	Very low profile/Electrodeposited
CV1 (C1)	1 oz / ft²	~0.0014"	~35 µm	25 µin	0.6 µm	Very low profile/Electrodeposited

Ohmega Ply®, Ticer® and other resistive films are available upon request. Heavy metal claddings (aluminum, brass & copper) may also be available upon request. Please contact Taconic for availability.
*TLY part #s under 15 mils in thickness laminated with rolled copper cladding are available on a case by case basis as agreed between customer and supplier.

An example of our part number is: TLY-0050-CVH/CVH - 18" x 24" (457 mm x 610 mm)

RoHS WEEE Compliant

rev. 4/12