DuPont™ Pyralux® APR

ALL-POLYIMIDE WITH EMBEDDED RESISTOR FOIL, FLEXIBLE LAMINATE

Technical Data Sheet

Product Description

DuPont™ Pyralux® APR double-sided, copper-clad resistor laminate is an all-polyimide composite of polyimide film bonded to copper foil, similiar to Pyralux® AP, but including Ticer Technologies TCR® thin film copper resistor foil as one or both of the clad foils. This material system is ideal for multi-layer flex, rigid flex and rigid PCB applications which require reliable embedded resistor technology, advanced material performance, temperature resistance, high reliability, and robust processing. Offered in a wide range of dielectric thicknesses and resistance levels, Pyralux® APR provides designers, fabricators, and assemblers a versatile option for a wide variety of circuit constructions. Attributes include:

- Excellent resistive layer tolerance and electrical performance
- Excellent dielectric thickness tolerance
- Embedded capacitance and resistance in a single laminate
- Thin, rugged Cu-clad laminate with superior handling and processing
- High Cu-polyimide resistor foil adhesion strength
- Low CTE for flex and rigid multi-layer PCBs
- Excellent thermal resistance, up to 180C (356F) M.O.T.
- UL 94V-0, UL Registered, File E124294
- Compatible with PWB industry processes, IPC 4204/11 certified

Packaging

Pyralux® APR copper clad resistor laminate is supplied in the following standard sheet sizes:

24″ x 36″ (610 mm x 914 mm)
24″ x 18″ (610 mm x 457 mm)
24″ x 12″ (610 mm x 305 mm)
12″ x 18″ (305 mm x 457 mm)

Other sizes are available by special order. All Pyralux® APR packaging materials are 100% recyclable.

Pyralux® APR Processing

Pyralux® APR resistor foil copper clad handling and processing requirements are similar to standard 2 mil Pyralux® AP clads. Resistor formation requires a 2 or 3 step etch process, depending on the resistor material type selected **(Table 2)**. Common etchant chemistries are used. Recommended processing information is available. The clads are typically compatible with conventional circuit fabrication processes including oxide treatment and wet chemical plated-through-hole desmearing. Fabricated circuits can be cover coated and laminated together to form multilayers or bonded to heat sinks using polyimide, acrylic, or epoxy adhesives.

Table 1: List of typical constructions

Representative Pyralux® APR Product Offerings*				
Product Code Examples	Resistivity (Ohms/square)	Dielectric Thickness (mil)	ED Copper Thickness (oz/ft2)	ED Copper Thickness (oz/ft2)
APR 02502535NC	025 = 25	025 = 1.0 mil	35µm = 1 oz/ft2	NC = NiCr
APR 02502518NC	25	.5	0.5 oz	NC = NiCr
APR 02505035NC	25	2.0	1.0	NC = NiCr
APR 10002535NC	100	1.0	1.0	NC = NiCr
APR 10002518NC	100	1.0	0.5	NC = NiCr
APR 10005035NC	100	2.0	1.0	NC = NiCr
*Additional balanced/unbalanced copper constructions, dielectrics (>2 mil), and copper foils are available through your DuPont Representative				
Additional Ticer Technologies TCR® foil types are available (eg. 250 Ohm/square NiCrAlSi, etc.), one or both sides.				
Ohms/square range includes 10, 25, 50, 100, 250.				

Safe Handling

Anyone handling DuPont™ Pyralux® APR should wash their hands with soap before eating, smoking, or using restroom facilities. Although DuPont is not aware of anyone developing contact dermatitis when using Pyralux® APR products, some individuals may be more sensitive than others. Gloves, finger cots, and finger pads should be changed daily.

Pyralux® APR is fully cured when delivered. However, lamination areas should be well ventilated with a fresh air supply to avoid build-up from trace quantities of residual solvent (typical of polyimides) that may volatilize during press lamination. When drilling or routing parts made with Pyralux® APR, provide adequate vacuum around the drill to minimize worker exposure to generated dust.

As with all thin, copper-clad laminates, sharp edges present a potential hazard during handling. All personnel involved in handling Pyralux® APR clads should use suitable gloves to minimize potential cuts.

Quality and Traceability

Pyralux® APR resistor foil copper clads are manufactured under a quality system registered to ISO9002 by Underwriters Laboratories. The clads are certified to IPC-4204/11. Material and manufacturing records, which include archived samples of finished product, are maintained by DuPont. Each manufactured lot is identified for reference and traceability. The packaging label serves as the primary tracking mechanism in the event of customer inquiry and includes the product name, batch number, size, and quantity.

Storage and Warranty

Pyralux® flexible laminates should be stored in the original packaging at temperatures of 4-29°C (40-85°F) and below 70% humidity. The product should not be frozen and should be kept dry, clean and well protected. Subject to compliance with the foregoing handling and storage recommendations, DuPont's warranties for these products as provided in the DuPont Standard Conditions of Sale shall remain in effect for a period of one year following the date of shipment.

Pyralux® APR – Embedded Resistor and Foil Properties

Performance leading Ticer Technologies TCR® thin film resistor foil is combined with the unsurpassed reliability of all-polyimide Pyralux® AP construction to provide designers with unique options of embedded resistors in high performance flex or rigid PCB applications. Benefits include:

- Lighter and more rugged Rigid Flex and Rigid PCBs
- Optimized designs for minimal PCB X-Y-Z axis sizes
- Excellent resistor formation and smaller tighter lines
- Reliable resistor formation using common PCB chemistries and processes
- Small and predictable resistance shifts
- Thin dielectric also provides embedded planar capacitance capability
- High processing yields in thin laminate constructions
- Excellent high operating temperature and thermal resistance
- Excellent high voltage and power capability
- Reduced solder joints, rework, and PTH processing

Ticer Technologies TCR® foil Information (Data is courtesy of Ticer Technologies)

Figure A – Ticer Technologies TCR® Thin Film Resistor Foil

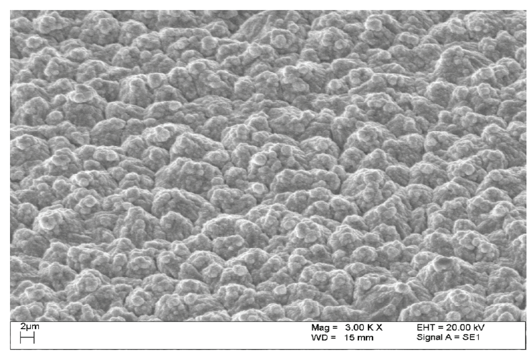


Figure B – Resistive alloy layer on copper made side

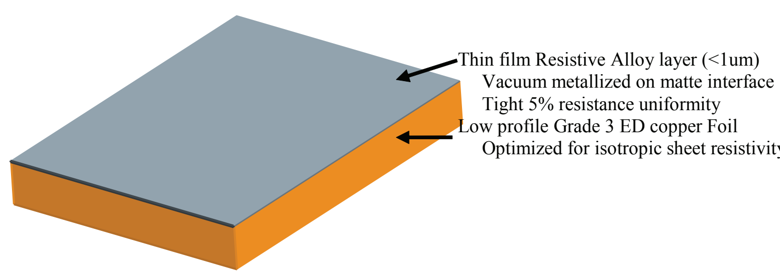


Figure C – Formed Embedded Resistor

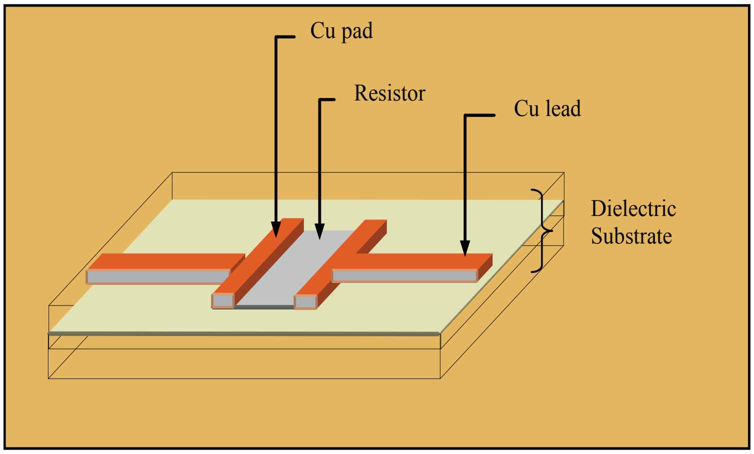


Table 2: Ticer Technologies TCR® Foil Properties

Resistive Alloy	NiCr	NiCrAlSi
Sheet Resistance (Ohms/sq.)	25, 50, 100	25, 50, 100, 250
Material Tolerance (%)	+/- 5	+/- 5
Temperature Coefficient of Resistance (max ppm/C)	110	-20
Base Copper Foil thickness (um)	18, 35	18, 35
Recommended Etch Solution 1st Etch 2nd Etch 3rd Etch	 Cupric Chloride Ammoniacal N/A	 Ammoniacal* Acidic Permanganate Ammoniacal* *Cupric Chloride alternatively
Resistor Tolerances (%) Feature size 10 mil or greater Laser Trimmed	 +/- 10 +/- 1.0	 +/- 10 +/- 1.0
Minimum Feature Sizes* "In trace" resistors Trace width Trace spacing Termination overlap Resistor "keep out" * Power and resistance heating must also be considered.	 5 mils Fabricator capability Fabricator capability 2.5 mils 10 mils	 5 mils Fabricator capability Fabricator capability 2.5 mils 10 mils
Resistor Patterns	Fractional to high multiple squares. Serpentine and Others	Fractional to high multiple squares. Serpentine and Others
Maximum recommended power dissipation at 40C (watts/sqin) OPS = ohm/sq.	25 OPS: 250 50 OPS: 200 100 OPS: 150	25 OPS: 250 50 OPS: 200 100 OPS: 150 250 OPS: 75
Note: Embedded resistors should be applied in rigid portions of PCBs and should not be placed in areas where dynamic flex will occur. Locating embedded resistors in flex-to-install locations is possible, but should be thoroughly tested and confirmed. Resistance values may be altered.		

Figure D – Power Density by Resistor Type and Area

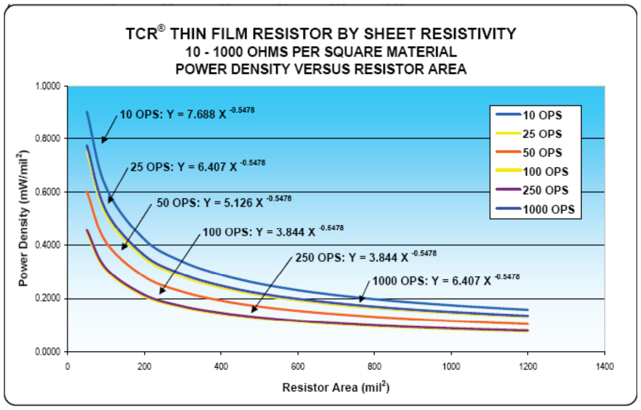


Figure E – Typical Resistance Shift after Embedded Lamination
(Average of 120 data points with different size embedded resistors, non-optimized.)

25 OPS NiCr, 0.5 oz		
	Rs/OPS	1S VAR/%
FR4	24.4	3.2
Pyralux AP	24.7	2.6
Resistance shift after embedded		
1st FR4 lamination cycle		-4.8%
2nd FR4 lamination cycle		0.7%

25 OPS NiCrAlSi, 0.5 oz		
	Rs/OPS	1S VAR/%
FR4	25.2	4.7
Pyralux AP	27.7	3.4
Resistance shift after embedded		
1st FR4 lamination cycle		-2.7%
2nd FR4 lamination cycle		0.7%

100 OPS NiCr, 0.5 oz		
	Rs/OPS	1S VAR/%
FR4	98.8	3.4
Pyralux AP	92.4	4.2
Resistance shift after embedded		
1st FR4 lamination cycle		0.5%
2nd FR4 lamination cycle		1.6%

100 OPS NiCrAlSi, 0.5 oz		
	Rs/OPS	1S VAR/%
FR4	95.9	3.8
Pyralux AP	100.0	2.5
Resistance shift after embedded		
1st FR4 lamination cycle		-0.5%
2nd FR4 lamination cycle		0%

Properties common to both DuPont™ Pyralux® AP and APR Families

Table 3: Representative DuPont™ Pyralux® AP properties

Laminate Property	IPC TM-650 (* or other)	AP-9111 1 mil dielectric	AP-9121 2 mil dielectric	AP-9131–9161 3–6 mil dielectric
Adhesion to Cu (Peel Strength)	Method 2.4.9			
As fabricated, N/mm (lb/in)		1.6 (9)	>1.8 (10)	>1.8 (10)
After solder, N/mm (lb/in)		1.6 (9)	>1.8 (10)	>1.8 (10)
Solder Float at 288°C (550°F)	Method 2.4.13	Pass	Pass	Pass
Dimensional Stability	Method 2.2.4			
Method B, %		–.04 to –.08	–.04 to –.08	–.03 to –.06
Method C, %		–.05 to –.08	–.04 to –.07	–.03 to –.06
Dielectric Thickness Tolerance, %	Method 4.6.2	±10	±10	±10
UL Flammability Rating	*UL-94	V-0	V-0	V-0
Dielectric Constant*, 1 MHz	Method 2.5.5.3	3.4	3.4	3.4
Dissipation Factor*, 1 MHz	Method 2.5.5.3	0.003	0.002	0.002
Dielectric Strength, kV/mil	ASTM-D-149	6-7	6–7	6-7
Volume Resistivity, ohm-cm	Method 2.5.17.1	E16	E17	E17
Surface Resistance, ohms	Method 2.5.17.1	>E16	>E16	>E16
Moisture & Insulation Res., ohms	Method 2.6.3.2	E11	E11	E11
Moisture Absorption, %	Method 2.6.2	0.8	0.8	0.8
Tensile Strength, MPa (kpsi)	Method 2.4.19	>345 (>50)	>345 (>50)	>345 (>50)
Elongation, %	Method 2.4.19	>50	>50	>50
Inititation Tear Strength, g	Method 2.4.16	700–1000	900–1200	900–1200
Propagation Tear Strength, g	Method 2.4.17.1	>10	>20	>20
Chemical Resistance, min. %	Method 2.3.2	Pass, >95%	Pass, >95%	Pass, >95%
Solderability	*IPC-S-804, M. 1	Pass	Pass	Pass
Flexural Endurance, min. cycles	Method 2.4.3	6000	6000	6000
Glass Transition (Tg), C	—	220	220	220
Modulus, kpsi	—	700	700	700
In-Plane CTE (ppm/C) T<Tg	—	25	25	25
In-Plane CTE (ppm/C) T>Tg	—	40 (est.)	40 (est.)	40 (est.)

Product Family Highlights and Data

DuPont™ Pyralux® AP adhesiveless laminate was developed for high reliability flexible and rigid circuit applications requiring thin dielectric profiles and the superior performance provided by its all-polyimide construction. All-polyimide constructions enable designers, fabricators, and assemblers to achieve higher density, premium performance circuitry. The high material modulus provides excellent handling characteristics in a thin adhesiveless laminate. Pyralux® AP supports advanced circuit designs through its polyimide chemistry strengths:

- Thin adhesiveless polyimide core dielectric with excellent thickness uniformity for consistent electrical performance
- 12µm to 150µm (0.5-6.0mil) thick dielectric availability
- 12µm, 18µm, 24µm cores provide thin embedded planar capacitance
- 3mil-6 mil provide controlled impedance with high yield **(Figure 8)**
- Excellent adhesion of copper, resistor and dielectric
- Excellent long-term thermal exposureperformance **(Figure 1)**
- Superior thermal resistance for high temperature applications and assembly processes
- UL 94V-0, UL Registered, File E124294
- Low thermal expansion coefficient is compatible with Cu and provides higher rigid-flex fabrication yields
- Consistent dimensional stability
- Superior mechanical and electrical properties
- Compatibility with severe environment applications
- Compatibility with most circuit processing and handling systems

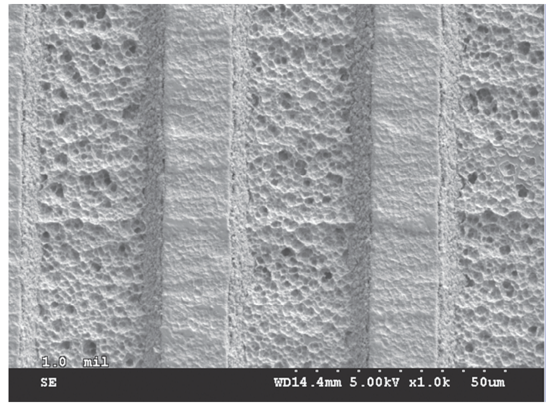


Figure 1. 150°C (302°F) Continuous Temperature

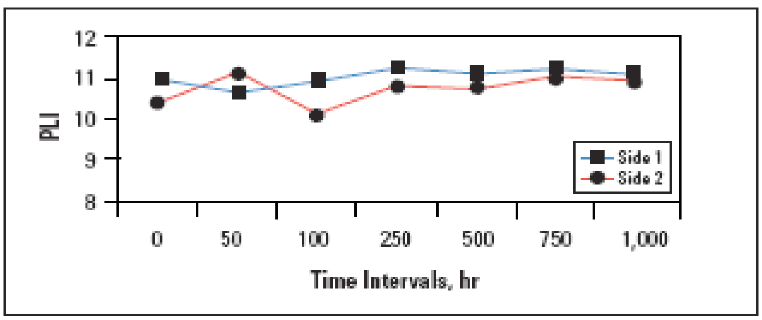
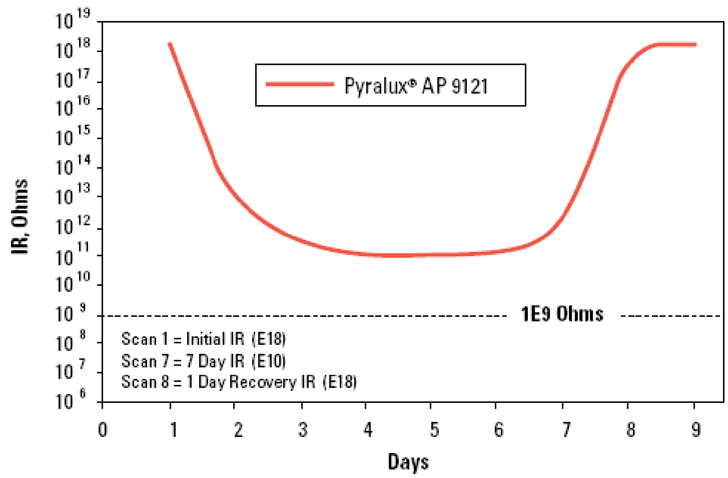


Table 4: 288°C (550°F) Solder Float Performance

Pyralux® AP Solder Float Resistance	Conditions	Results
Thermal Stress, Solder Shock	10 layer circuit similar to 50884C 100 mil centers, 288°C (550°F) 10-second dwell time	Pass No blisters, delamination, solder wicking

Test Method: IPC-TM-650, 2.4.13

Figure 2. Moisture and Insulation Resistance

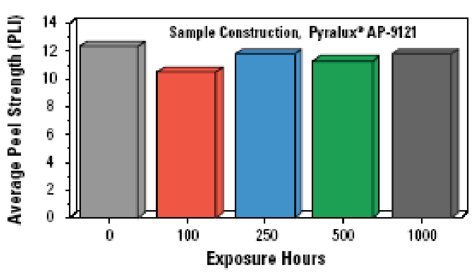


Test Method: IPC-TM-650, 2.6.3.2
168 hours at 25°C –>65°C, 95% RH

Notes: Scans 8 and 9 represent ambient recover. Testing at DuPont Labs, RTP, NC

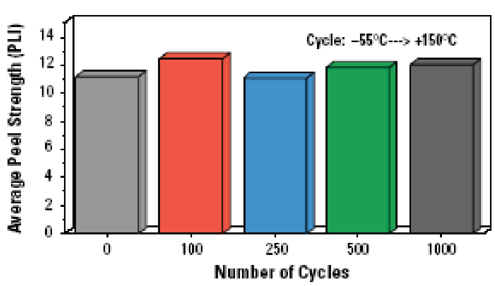
2 mil Pyralux® AP—Environmental Performance

Figure 3. Thermal Aging, 150°C (302°F)



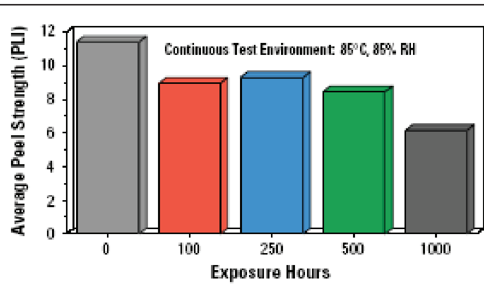
Peel Test Method: IPC-TM-650, 2.4.9
Note: Values represent average MD and TD results.

Figure 4. Thermal Cycling



Peel Test Method: IPC-TM-650, 2.4.9
Note: Values represent average MD and TD results.

Figure 5. Temperature/Humidity Exposure



Peel Test Method: IPC-TM-650, 2.4.9
Note: Values represent average MD and TD results.

Figure 6. Dielectric Constant vs. Frequency

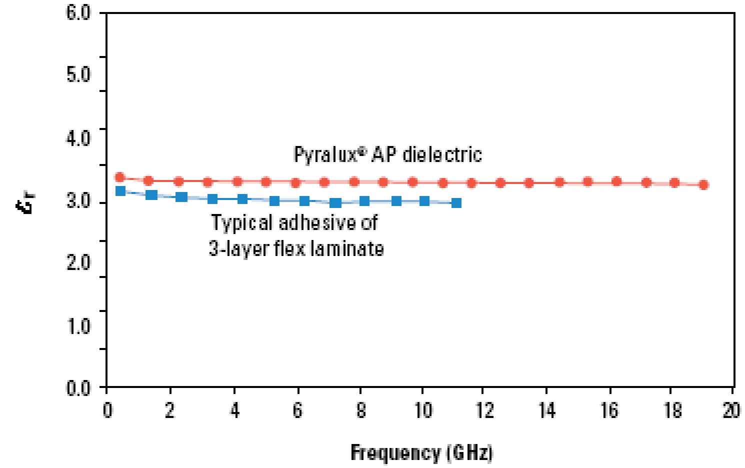
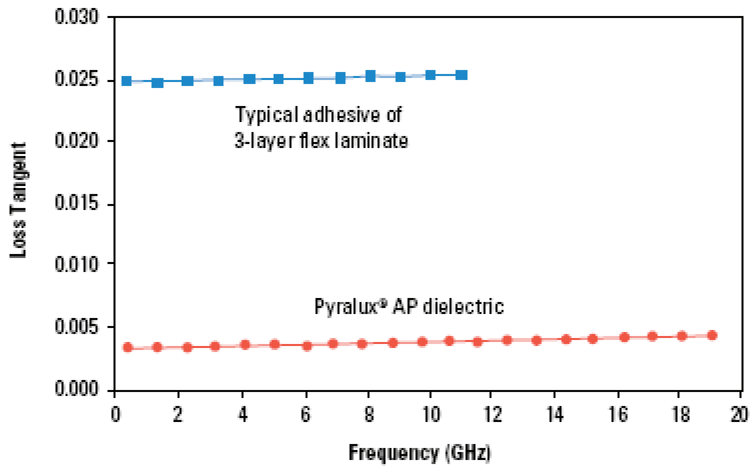


Figure 7. Loss Tangent vs. Frequency



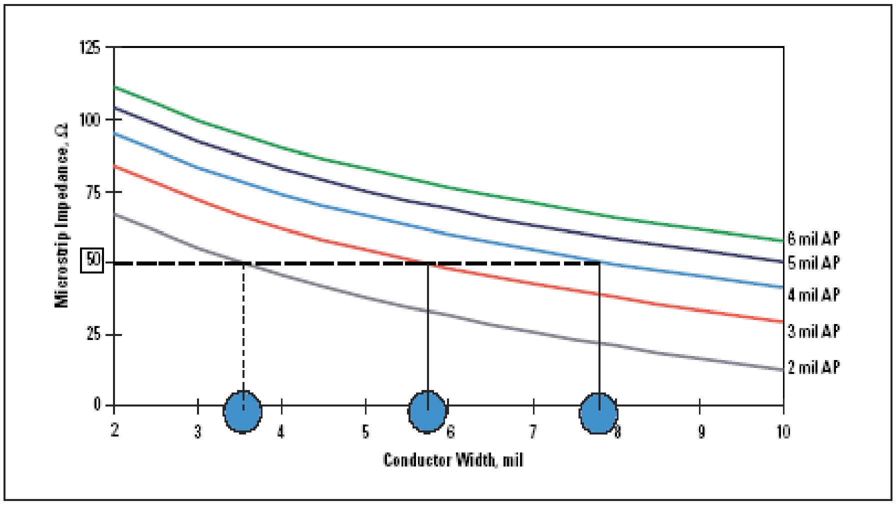
Notes: The Typical Adhesive Value is for the adhesive alone. When the Adhesive is used in conjunction with Kapton® H film for typical 3-layer copper clads, the Loss Tangent will be measurably lower—typically about 0.020.

Earlier data suggests that the Typical Adhesive value drifts up noticeably after 12 GHz.

The Pyralux® AP dielectric values are typical for constructions 1 through 6 mils of dielectric. A new 3-mil bondply made specifically for use with AP has equivalent Loss Tangent Values.

Figure 8 illustrates the fabrication benefits of thick DuPont™ Pyralux® AP core (vs. standard 2 mil) in a nominal 50 impedance microstrip circuit. Copper traces with 2x greater line/space resolution can be used to achieve identical electrical performance while greatly reducing fabrication yield loss from fine line imaging.

Figure 8. Yield Benefits of Pyralux® AP Laminate in Controlled Impedance Microstrip Design



For more information on DuPont™ Pyralux® Flexible Circuit Materials , please contact your local representative, or visit our website for additional regional contacts:

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