DuPont™ Pyralux® AP All-Polyimide Flexible Laminate

A Family of High-Performance Adhesiveless Laminates for Flexible Printed Circuit Applications

Product Description

Pyralux® AP double-sided, copper-clad laminate is an all-polyimide composite of polyimide film bonded to copper foil. This material system is ideal for multilayer flex and rigid flex applications which require advanced material performance, temperature resistance, and high reliability.

Offered in a full range of dielectric thicknesses, Pyralux® AP provides designers, fabricators, and assemblers a versatile option for a wide variety of flexible circuit constructions.

- Low CTE for rigid flex multilayers
- Excellent thermal resistance
- Thin Cu-clads with superior handling
- Unique thick-core product for controlled impedance
- Excellent dielectric thickness tolerance/electrical performance
- High Cu-polyimide adhesion strength
- Full compatibility with PWB industry processes, IPC 4204/11 certified
- UL 94V-0, UL 796, 180°C (356°F) max. operating temperature

Table 1
Pyralux® AP Product Offerings*

Product Code	Dielectric Thickness, mil	Copper Thickness, µm (oz/ft²)
AP 7163E**	1.0	9 (.25)
AP 7164E**	1.0	12 (.33)
AP 8515R	1.0	18 (0.5)
AP 9111R	1.0	35 (1.0)
AP 9212R	1.0	70 (2.0)
AP 7156E**	2.0	9 (.25)
AP 7125E**	2.0	12 (.33)
AP 8525R	2.0	18 (0.5)
AP 9121R	2.0	35 (1.0)
AP 9222R	2.0	70 (2.0)
AP 8535R	3.0	18 (0.5)
AP 9131R	3.0	35 (1.0)
AP 9232R	3.0	70 (2.0)
AP 8545R	4.0	18 (0.5)
AP 9141R	4.0	35 (1.0)
AP 9242R	4.0	70 (2.0)
AP 8555R	5.0	18 (0.5)
AP 9151R	5.0	35 (1.0)
AP 9252R	5.0	70 (2.0)
AP 8565R	6.0	18 (0.5)
AP 9161R	6.0	35 (1.0)
AP 9262R	6.0	70 (2.0)

Add "R" to the end of the code to specify rolled-annealed copper foil (e.g., AP9121R). Add "E" to the end of the code to specify electrodeposited copper foil (e.g., AP9121E). If rolled-annealed double-treat copper foil is specified, add the letter "D" to the end of the product code (e.g., AP9121D).

*Additional balanced/unbalanced copper constructions and dielectrics (>6 mil) are available through your DuPont Representative.

** Available in ED copper only.

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Table 2
Pyralux® AP Material 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	Method 2.5.6.1	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	—	195	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.)

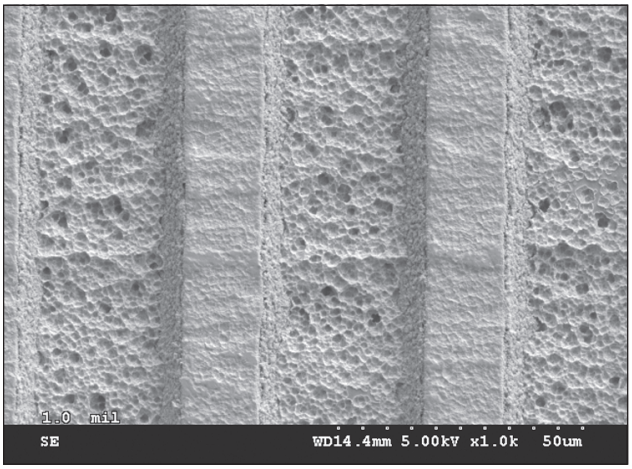
*See Page 6, Figures 6 and 7 for dielectric constant and loss tangent performance at higher frequencies

Product Highlights and Applications

1 mil Pyralux® AP

AP-7163E*
AP-7164E
AP-8515
AP-9111

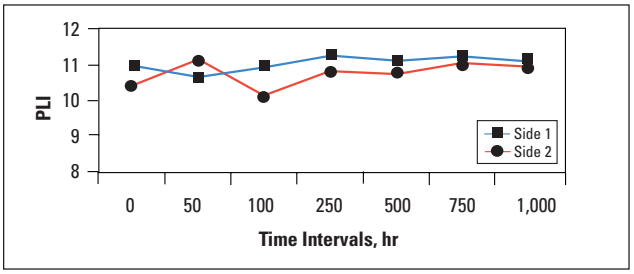
A Thin High-Performance Sheet Clad Laminate for High Density Flex Circuits



Double sided 1 mil Pyralux® AP was developed for high-reliability flexible circuit applications requiring thin dielectric profiles and superior performance offered by its all-polyimide construction. The high material modulus provides excellent handling characteristics in a thin adhesiveless laminate. All 1 mil Pyralux® AP constructions are UL rated and fully certified to IPC-4204/11. 1 mil Pyralux® AP features:

- 1.0 mil adhesiveless core dielectric with excellent thickness uniformity for consistent electrical performance
- High adhesion strengths and uniform performance profiles
- Excellent long-term thermal exposure performance (**Figure 1**) and harsh environment compatibility

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



2 mil Pyralux® AP

AP-7156E*
AP-7125E
AP-8525
AP-9121

The Flagship All-Polyimide Flexible Composite

2 mil Pyralux® AP adhesiveless laminate is ideal for double sided, multilayer flex as well as rigid flex applications requiring advanced material performance and high reliability. All-polyimide constructions enable designers, fabricators, and assemblers to achieve higher density, premium performance flexible circuitry. 2 mil Pyralux® AP supports advanced circuit designs through its core polyimide chemistry strengths:

- Low thermal expansion coefficient for rigid flex fabrication and assembly
- Excellent thermal resistance to high-temperature assembly
- Good dimensional stability consistency
- Superior mechanical and electrical properties and compatibility with severe environment applications

2 mil Pyralux® AP is fully compatible with existing PCB processes and material handling systems. A *double-treat* RA copper offering provides the fabricator a unique construction to minimize surface preparation costs and increase overall final yields.

Typical 2 mil Pyralux® AP Material Properties:

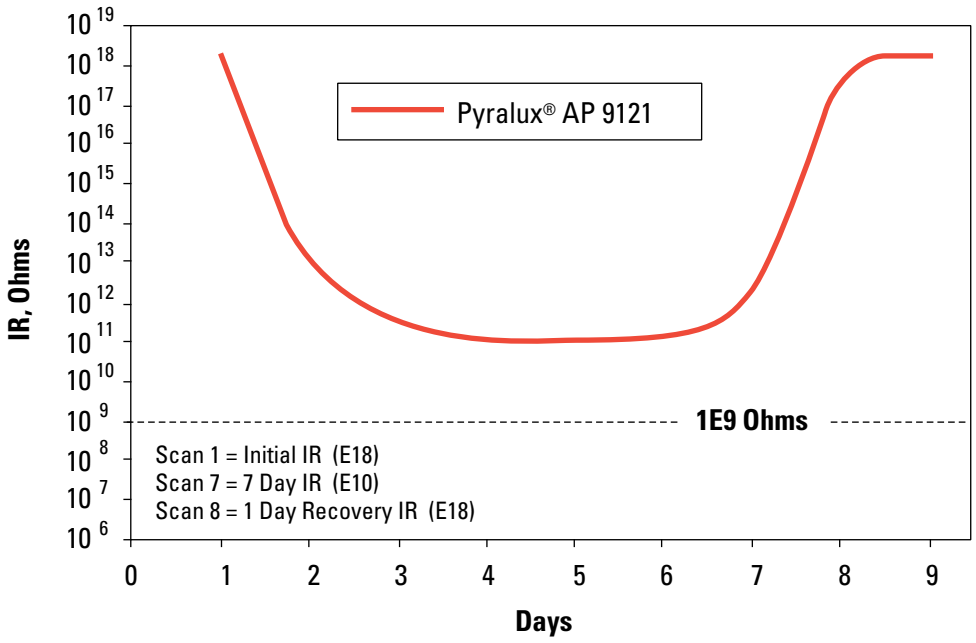
Table 3
288°C (550°F) Solder Float Performance

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

* See **Table 1**. Additional copper/metal constructions available on request.

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

Chemical Resistance

Table 4
Chemical Absorption

	Weight Change (%) 24 hr Immersion			Weight Change (%) 24 hr Immersion	
	Pyralux® AP (polyimide)	Pyralux® LF (acrylic)		Pyralux® AP (polyimide)	Pyralux® LF (acrylic)
2 N Sulfuric Acid	0.95	3.44	KOH (1.5%, 55°C)	(9.42)	(51.85)
Isopropanol (IPA)	0.79	7.77	Permanganate	0.25	(46.50)
Methyl Ethyl Ketone (MEK)	0.42	39.45	Para-formaldehyde	0.59	4.57
Cupric Chloride Etchant	0.65	6.41	EDTA (E-less plating)	0.62	5.01

Test Method: IPC-TM-650, 2.6.2
Notes: All chemical immersions are 24 hours followed by roll drying. Values in parentheses indicate weight loss after immersion. Other values represent weight gain.

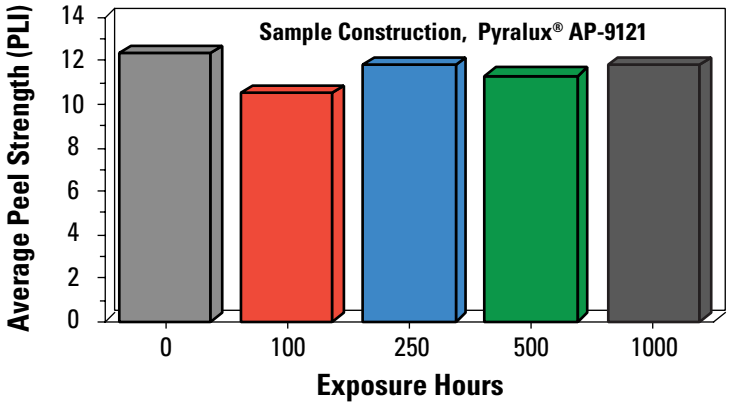
Table 5
Automotive Fluids Resistance

Immersion Fluid	% Retention of Original Peel Strength	Weight % Change After Immersion	Immersion Fluid	% Retention of Original Peel Strength	Weight % Change After Immersion
Anti-Freeze	95	1.8	Transmission Fluid	100	0.7
Detergent Solution	96	3.5	Unleaded Gasoline	99	2.8
Motor Oil (10W30)	102	0.6	Diesel Fuel	100	2.3
Brake Fluid	102	0.7	Sour Gasoline	100	1.6

Test Method: IPC-TM-650, 2.4.9 (peel strength)
Note: Sample data based on 2-minute immersions, 100 cycles. Test construction: AP-9121

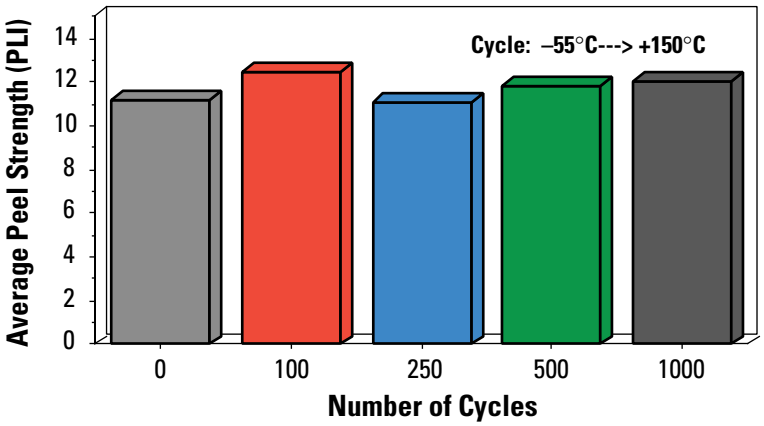
2 mil Pyralux® AP—Environmental Performance

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



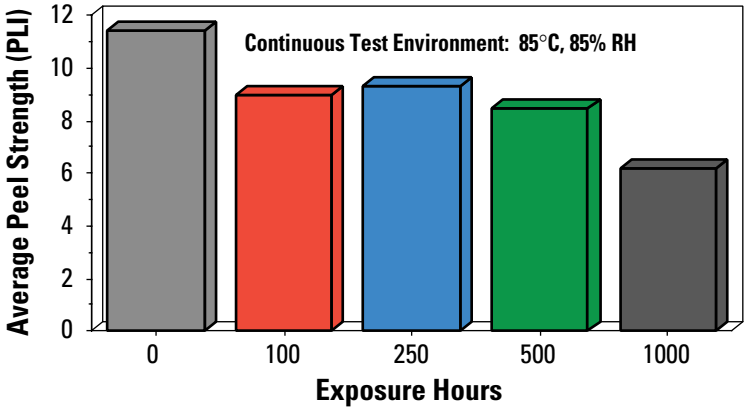
Peel Test Method: IPC-TM-650, 2.4.9
Note: Values represent average MD and TD results.

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

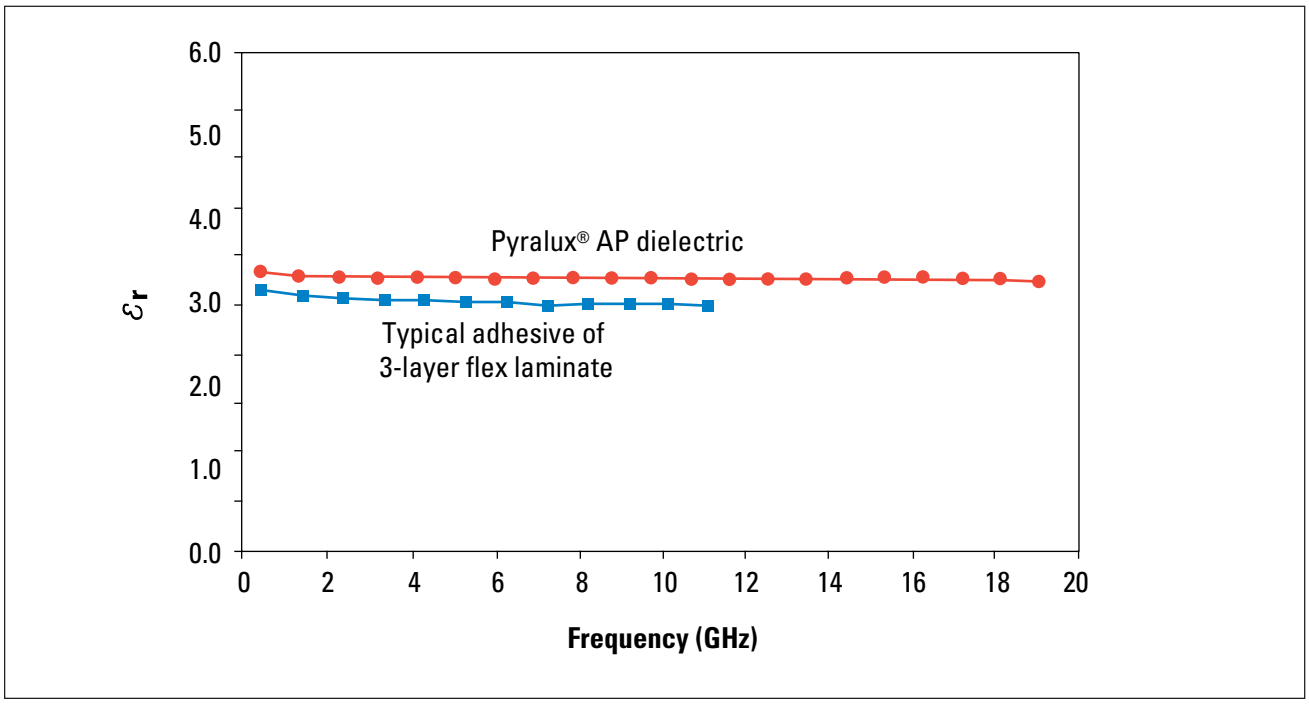
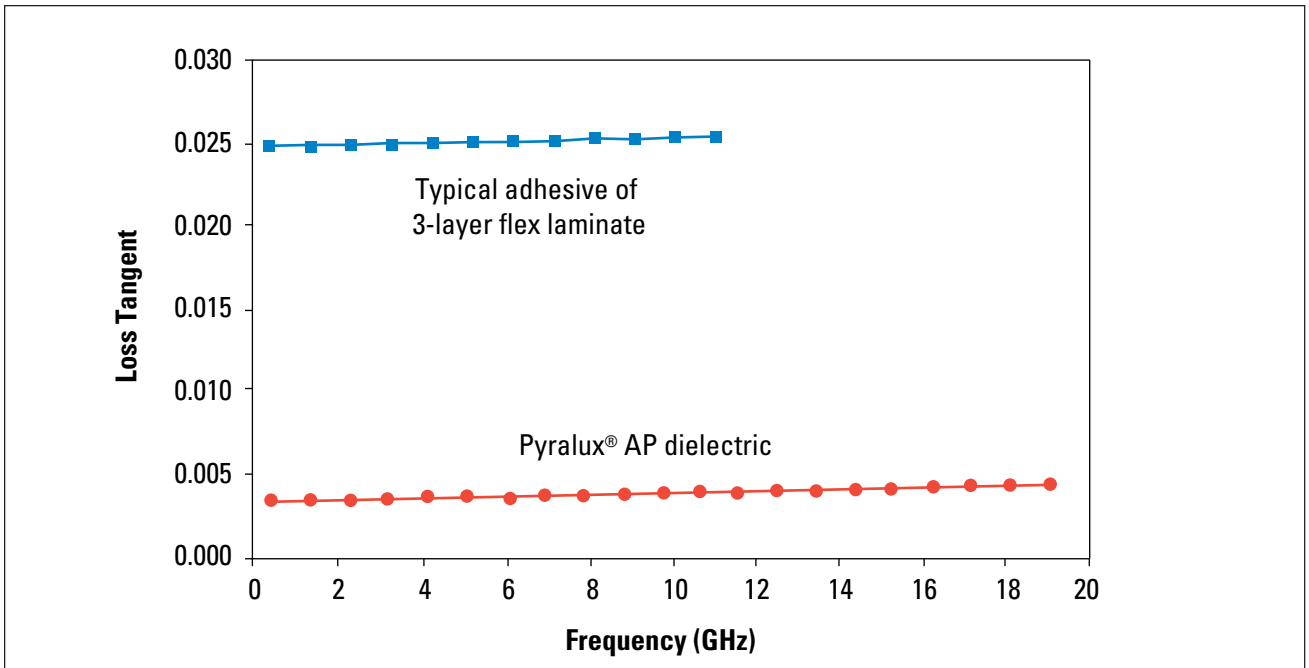


Figure 7. Loss Tangent vs. Frequency



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.

3–6 mil Pyralux® AP

AP-9131*
AP-9141
AP-9151
AP-9161

A New Alternative for High Frequency and Controlled Impedance Design

Pyralux® AP is the first all-polyimide flexible circuit material to be offered in dielectric core constructions of 3–6 mils and greater. These clads provide designers and fabricators new options in building high reliability/high yield circuits for controlled impedance and high frequency applications.

Among its application advantages, Pyralux® AP offers:

- Greater production yields and flexibility in controlled impedance applications from unique Pyralux® AP core dielectric thickness
- Excellent dielectric thickness tolerance for consistent electrical performance
- Full mechanical/electrical benefits of Pyralux® AP adhesives material in double-sided multilayer and rigid flex applications.

All Pyralux® AP products are fully certified to IPC-4204/11.

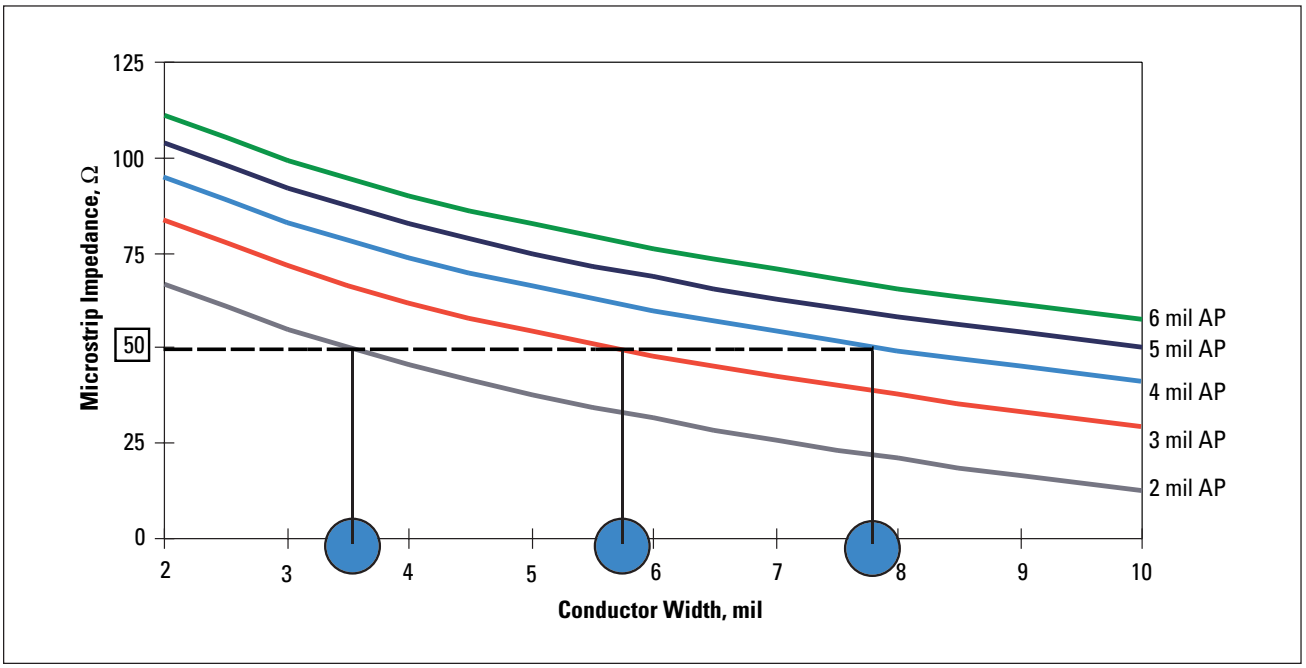
Figure 8 illustrates the fabrication benefits of thick Pyralux® AP core (vs. standard 2 mil) in a nominal 50 Ω impedance microstrip circuit. Copper traces with 2x greater line/space resolution can be used to achieve identical electrical performance while greatly reducing fabrication yield loss from fine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

In addition to enhanced dielectric thickness, Pyralux® AP retains the superior inherent material advantages of adhesiveless laminate for double-sided multilayer flex, as well as rigid-flex applications. The following contribute to Pyralux® AP's advanced performance and high reliability:

- Low thermal expansion coefficient providing better compatibility with Cu and higher rigid-flex fabrication yields
- Consistent dimensional stability
- Excellent adhesion of copper to dielectric
- Superior thermal resistance for high temperature applications and assembly processes
- Good compatibility with all flexible circuit processing and handling systems

* 1 oz RA constructions. Additional copper/dielectric constructions available on request.

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



Pyralux® AP Processing

Pyralux® AP copper clad handling and processing requirements are identical to standard 2 mil Pyralux® AP clads. They are fully compatible with all conventional flexible 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.

General Information

Quality and Traceability

Pyralux® AP copper clads are manufactured under a quality system registered to ISO9002 by Underwriters Laboratories. The clads are certified to IPC-4204/11. Complete material and manufacturing records, which include archive 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 Conditions and Shelf Life

Pyralux® AP does not require refrigeration and will retain its original properties for a minimum of one year when stored in the original packaging at temperatures of 4–29°C (40–85°F) and below 70% relative humidity. The material should be kept clean and well protected from physical damage.

Safe Handling

Anyone handling Pyralux® AP 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® AP products, some individuals may be more sensitive than others. Gloves, finger cots, and finger pads should be changed daily.

Pyralux® AP 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® AP, 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® AP clads should use suitable gloves to minimize potential cuts.

Packaging

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

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

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

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