RAW MATERIAL CHALLENGES AND NEW TECHNOLOGY INNOVATIONS IN PRESSURE SENSITIVE TAPE

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Introduction

Future growth is continually challenged by an ever-demanding call for high technology products. The pressure sensitive tape industry, in its service to the electronic assembly and processing business, electrical insulation, and general industries, is challenged to develop products for higher technology applications. Among these challenges, tapes designed for temperature extremes (cryogenic to ultra high), electrically conductive, and thermally conductive products rise to the top of the "wish" list.

Polyimide films can meet the needs of temperature extremes, conductivity, strength and chemical resistance.

This paper will review current technology in polyimide film substrates and discuss the need for developing compatible adhesives with newer polyimide films.

Current Substrate Technology

While a wide variety of substrates, or backings, are utilized in the pressure sensitive tape industry, this discussion focuses on polymer film backings. Typical properties of various polymer films are detailed in the following table.

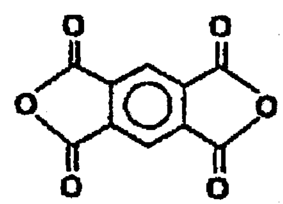
Polymer Film Properties

Film Type	Polyimide Kapton®	Polyester Mylar®	Polyester PEN
Glass Transition, Tg, °C	410	75	120
Continuous Operating Temperature, °C	240	105	180
Tensile Strength, @25°C, Kpsi	33	30	40
Modulus, Kpsi	430	550	850
Elongation, %	70	130	70
Dielectric Strength, Volts/mil	7000	7000	8000
Dielectric Constant, 1kHz	3.5	3.2	2.9
Flammability	94V-0	94VTM-2	94VTM-2
Heat Shrinkage, % (200°C, 30 Min.)	0.1	4	1
Moisture Absorption, %	2.8	0.5	0.4

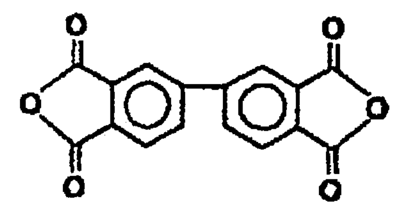
Chemistry

Most polyimide films are ODA (4,4' oxydianiline) and PMDA (pyromellitic dianhydride) structure. Kapton® polyimide film has a repeating structure of $C_{22}H_{10}O_5N_2$ and is synthesized by polymerizing an aromatic dianhydride and an aromatic diamine.

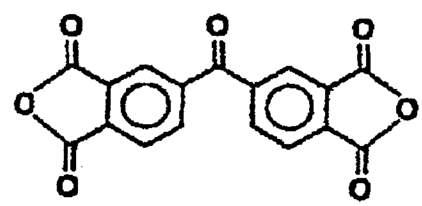
H Polymer – PMDA – ODA
E Polymer – PMDA/BPDA – ODA/PPD
K Polymer – PMDA – ODA/PPD



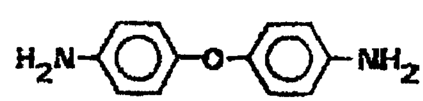
Pyromellitic Dianhydride
PMDA



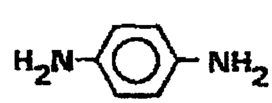
Biphenyl Dianhydride
BPDA



Benzophenone
Tetracarboxylic Dianhydride
BTDA



4, 4' Diamino Diphenyl Ether
Oxydianiline
ODA



Paraphenylene Diamine
PPD

Kapton® Type H polyimide film, introduced by DuPont nearly 40 years ago, was the first film of its type to offer the superior thermal, electrical, physical and mechanical properties over a wide temperature range required by demanding industries. The all-purpose Kapton® type HN film, developed in 1984 and derived from the H polymer family, makes innovative design solutions possible. The following chart summarizes the polyimide film family.

Evolution of DuPont Polyimide Films

YEAR	INDUSTRY REQUIREMENT	PRODUCT
1965	General Purpose Polyimide Film	H
1970	Insulating Material (Wire Wrap)	F
1974	Low Shrinkage for Flex Circuits	V
1984	Improved Film Handling	HN, FN, VN
1988	Improved Thermal Conductivity, Heat Dissipation Through Film	MT
1988	Black Non-Conductive Film, Low Light Transmission	CB
1988	Electrically Conductive, Anti-Static	XC
1990	High Adhesion for Flex Circuit, Improved Dimensional Stability	FPC
1990	New Chemistry, High Modulus, Etchable, CTE Matches Copper	E, K
1991	Pressure Sensitive Tape Industry, Improved Film Attributes	PST
1992	Voice Coils for Loud Speakers, Improved Thermal Management	MTB
1993	Bar Code Label Industry, Pigmented, Opaque Film, Enables Contrast	BCL-Y
1993	Voice Coils (Speakers), Improved Adhesion, Increased Toughness	HPP-FST
1993	All Polyimide Sheet Adhesive, No Thermal Weak Point, Formable	KJ
1993	All Polyimide Film, High Modulus Core, Heat Sealable	HKJ, EKJ
1993	Improved Aerospace Wire & Cable Film	Oasis®
1994	Corona Resistant	CR, FCR
1995	Automotive & Speaker Parts, High Elongation, Better Moisture Resistance at High Temperatures	JP
1996	All Polyimide Material Requires No Adhesive, Thick, Machined Parts, Available 9-60 mils	Cirlex®
1999	Semi-Conductive Film	CPB

Kapton Type PST is manufactured to specifications for optimum performance in pressure sensitive tape applications. This includes rigid gauge control to provide a uniform substrate for adhesive coating and uniformly high dielectric strength for electrical insulation. Kapton® source rolls are coater-user friendly (no splices, long length, quality roll conditions) allowing easy processing during adhesive coating. DuPont supplies Kapton PST in 25, 50, 75, and 125-micron thicknesses to converters where a variety of adhesives are applied. Kapton film has excellent dielectric properties of 303 V/µm (kV/mm) or 7700 V/mil for a 25µm thickness and retains these properties up to a long term operating temperature of 240°C.

Other polyimide films developed for specific electronics applications include Types KJ, KN, FPC, and E, where higher modulus is needed and thermal expansion properties are matched to metal substrates used in the flexible printed circuit industry. Type KJ is a thermoplastic adhesive used as a bonding sheet in electronic constructions. Type KN offers a thin but stiffer substrate than other polyimide films. Type FPC is surface treated for superior adhesion and thermally stabilized for excellent dimensional stability. Kapton Type E is a copolymer film with superior dimensional stability, low CHE, a CTE close to copper, and a high modulus.

Typical Property Values of Kapton® Grades HN, VN, E, EN and KN Films

Property	Film Grade and Thickness						Method
	50HN 50VN 50FPC 50KN 50EN --	75HN 75VN 75FPC -- 75EN --	100HN 100VN 100FPC 100KN 100EN 100A	200HN 200VN 200FPC 200KN 200EN 200A	300HN 300VN 300FPC 300KN -- 300A	500HN 500VN 500FPC -- -- 500A	
Nominal Thickness, mil (µm)	0.5 (13) 0.5 (13) 0.5 (13) 0.5 (13) 0.5 (13) --	0.75 (19) 0.75 (19) 0.75 (19) -- 0.75 (19) --	1.0 (25) 1.0 (25) 1.0 (25) 1.0 (25) 1.0 (25) 1.0 (25)	2.0 (50) 2.0 (50) 2.0 (50) 2.0 (50) 2.0 (50) 2.0 (50)	3.0 (75) 3.0 (75) 3.0 (75) 3.0 (75) -- 3.0 (75)	5.0 (125) 5.0 (125) 5.0 (125) -- -- 5.0 (125)	Measure in accordance with ASTM D374-79, Method A or C. Obtain the average of 10 randomly selected readings from a minimum area of 12 in^2. Recheck before rejecting any slit roll. Abnormal readings may occasionally result from dust particles or spot surface imperfections. Discard such readings as they will adversely affect the accuracy of measurements designated to indicate general sheet thickness.
Area Factor, ft^2/lb	271 271 271 265 263 --	180 180 180 -- 176 ---	135 135 135 133 132 135	67.7 67.7 67.7 66.3 65.8 67.7	45.1 45.1 45.1 44.2 -- 45.1	27.1 27.1 27.1 -- -- 27.1	Based on densities (g/cc): Types HN, VN: 1.42 Type KN: 1.45 Types E, EN: 1.46

Continual development of new polymers and enhanced polyimide films has created potential new applications for pressure sensitive tape manufacturers.

Corona resistant polyimide film (Kapton® CR/FCR) was developed specifically to withstand the damaging effects of "corona," which can cause ionization and eventual breakdown of an insulation material or system when voltage stress reaches a critical level. Kapton CR shows corona resistance or voltage endurance of greater than 100,000 hours at 20 kV/mm (500V/mil) at 50 Hz. This compares with a 200-hour life for standard Kapton Type HN under these conditions. Kapton CR also provides twice the thermal conductivity (0.385 W/m °K) of standard Kapton. Pressure sensitive tape based on Kapton CR should be used on motors insulated with Kapton CR or in any demanding application.

Filled Kapton films offer a range of different properties, which are useful when converted into pressure sensitive tape.

Thermally conductive polyimide film, Kapton® Type MT, is a homogeneous film with thermal conductivity 3X of Kapton HN.

Electrically conductive polyimide film, Kapton® Type XC, offers a precisely controlled surface resistivity. The resistive property is throughout the bulk of the film; it cannot be cracked, rubbed off, or easily damaged, as can surface coatings or metallizations.

Polyimide Properties

Best known for its electrical and thermal properties, Kapton has the highest UL-94 flammability rating: V-0. The excellent balance of electrical, thermal, mechanical, physical and chemical properties of Kapton over a wide range of temperatures (-269°C to 400°C) make it a unique industrial material.

Table 1
Physical Properties of Kapton ® Type 100 HN Film, 25μm (1 mil)

Physical Property	Typical Value at 23 °C (73°F)	Typical Value at 200°C (392°F)	Test Method
Ultimate Tensile Strength, MPa (psi)	231 (33,500)	139 (20,000)	ASTM D-882-91, Method A*
Yield Point at 3%, MPa (psi)	69 (10,000)	41 (6000)	ASTM D-882-91
Stress to Produce 5% Elongation, MPa (psi)	90 (13,000)	61 (9000)	ASTM D-882-91
Ultimate Elongation, %	72	83	ASTM D-882-91
Tensile Modulus, GPa (psi)	2.5 (370,000)	2.0 (290,000)	ASTM D-882-91
Impact Strength, N·cm (ft·lb)	78 (0.58)		DuPont Pneumatic Impact Test
Folding Endurance (MIT), cycles	285,000		ASTM D-2176-89
Tear Strength—Propagating (Elmendorf), N (lbf)	0.07 (0.02)		ASTM D-1922-89
Tear Strength—Initial (Graves), N (lbf)	7.2 (1.6)		ASTM D-1004-90
Density, g/cc or g/mL	1.42		ASTM D-1505-90
Coefficient of Friction—Kinetic (Film-to-Film)	0.48		ASTM D-1894-90
Coefficient of Friction—Static (Film-to-Film)	0.63		ASTM D-1894-90
Refractive Index (Sodium D Line)	1.70		ASTM D-542-90
Poisson's Ratio	0.34		Avg. Three Samples Elongated at 5%, 7%, 10%
Low Temperature Flex Life	Pass		IPC TM 650, Method 2.6.18

*Specimen Size: 25× 150 mm (1× 6 in); Jaw Separation: 100 mm (4 in); Jaw Speed: 50 mm/min (2 in/min); Ultimate refers to the tensile strength and elongation measured at break.

Table 2
Thermal Properties of Kapton ® Type 100 HN Film, 25μm (1 mil)

Thermal Property	Typical Value	Test Condition	Test Method
Melting Point	None	None	ASTM E-794-85 (1989)
Thermal Coefficient of Linear Expansion	20 ppm/°C (11 ppm/ °F)	−14 to 38°C (7 to 100°F)	ASTM D-696-91
Coefficient of Thermal Conductivity, W/m·K	0.12	296 K	ASTM F-433-77 (1987)
$\frac{cal}{cm \cdot sec \cdot °C}$	2.87×10^{-4}	23°C	
Specific Heat, J/g·K (cal/g·°C)	1.09 (0.261)		Differential Calorimetry
Flammability	94V-0		UL-94 (2-8-85)
Shrinkage, %	0.17 1.25	30 min at 150°C 120 min at 400°C	IPC TM 650, Method 2.2.4A ASTM D-5214-91
Heat Sealability	Not Heat Sealable		
Limiting Oxygen Index, %	37		ASTM D-2863-87
Solder Float	Pass		IPC TM 650, Method 2.4.13A
Smoke Generation	DM = <1	NBS Smoke Chamber	NFPA-258
Glass Transition Temperature (T_g)	A second order transition occurs in Kapton® between 360°C (680°F) and 410°C (770°F) and is assumed to be the glass transition temperature. Different measurement techniques produce different results within the above temperature range.		

Physical and Thermal Properties of Kapton® Type VN Film

Property	Typical Value for Film Thickness 25 m (1 mil)	50 m (2 mil)	75 m (3 mil)	125 m (5 mil)	Test Method
Ultimate Tensile Strength, MPa (psi)	231 (33,500)	234 (34,000)	231 (33,500)	231 (33,500)	ASTM D-882-91
Ultimate Elongation, %	72	82	82	82	ASTM D-882-91
Tear Strength Propagating (Elmendorf), N	0.07	0.21	0.38	0.58	ASTM D-1922-89
Tear Strength Initial (Graves), N	7.2	16.3	26.3	46.9	ASTM D-1004-90
Folding Endurance (MIT), 10^3 cycles	285	55	6	5	ASTM D-2176-89
Density, g/cc or g/mL	1.42	1.42	1.42	1.42	ASTM D-1505-90
Flammability	94V-0	94V-0	94V-0	94V-0	UL-94 (2-8-85)
Shrinkage, %, 30 min at 150 C (302 F)	0.03	0.03	0.03	0.03	IPC TM 650 Method 2.2.4A
Limiting Oxygen Index, %	37	43	46	45	ASTM D-2863-87

Time Required for Reduction in Ultimate Elongation from 70% to 1%, Type HN Film, 25 m (1 mil)

Temperature	Air Environment
450 C (840 F)	2 hours
425 C (800 F)	5 hours
400 C (750 F)	12 hours
375 C (710 F)	2 days
350 C (660 F)	6 days
325 C (620 F)	1 month
300 C (570 F)	3 months
275 C (530 F)	1 year
250 C (480 F)	8 years

Typical Electrical Properties of Kapton® Type HN and VN Films

Property Film Gauge	Typical Value		Test Condition	Test Method
	V/ m (kV/mm)	(V/mil)		
Dielectric Strength			60 Hz 1/4 in electrodes 500 V/sec rise	ASTM D-149-91 [1]
25 m (1 mil)	303	(7700)		
50 m (2 mil)	240	(6100)		
75 m (3 mil)	205	(5200)		
125 m (5 mil)	154	(3900)		
Dielectric Constant			1 kHz	ASTM D-150-92
25 m (1 mil)	3.4			
50 m (2 mil)	3.4			
75 m (3 mil)	3.5			
125 m (5 mil)	3.5			
Dissipation Factor			1 kHz	ASTM D-150-92
25 m (1 mil)	0.0018			
50 m (2 mil)	0.0020			
75 m (3 mil)	0.0020			
125 m (5 mil)	0.0026			
Volume Resistivity	cm			ASTM D-257-91
25 m (1 mil)	1.5 10^{17}			
50 m (2 mil)	1.5 10^{17}			
75 m (3 mil)	1.4 10^{17}			
125 m (5 mil)	1.0 10^{17}			

Chemical Properties of Kapton® Type HN Film, 25μm (1 mil)

Property	Typical Value Tensile Retained, %	Elongation Retained, %	Test Condition	Test Method
Chemical Resistance				
Isopropyl Alcohol	96	94	10 min at 23 C	IPC TM-650 Method 2.2.3B
Toluene	99	91		
Methyl Ethyl Ketone	99	90		
Methylene Chloride/ Trichloroethylene (1:1)	98	85		
2 N Hydrochloric Acid	98	89		
2 N Sodium Hydroxide	82	54		
Fungus Resistance	Nonnutrient			IPC TM-650 Method 2.6.1
Moisture Absorption	1.8% Types HN and VN		50% RH at 23 C	ASTM D-570-81 (1988) [1]
	2.8% Types HN and VN		Immersion for 24 h at 23 C (73 F)	
Hygroscopic Coefficient of Expansion	22 ppm/% RH		23 C (73 F), 20-80% RH	
Permeability				
Gas	*mL/m² 24 h MPa*	*cc/(100 in ² 24 h atm)*	23 C (73 F), 50% RH	ASTM D-1434-82 (1988) [1]
Carbon Dioxide	6840	45		
Oxygen	3800	25		
Hydrogen	38,000	250		
Nitrogen	910	6		
Helium	63,080	415		
Vapor	*g/(m² 24 h)*	*g/(100 in ² 24 h)*		ASTM E-96-92
Water	54	3.5		

Figure 1. Tensile Stress–Strain Curves, Type HN Film, 25 μm (1 mil)

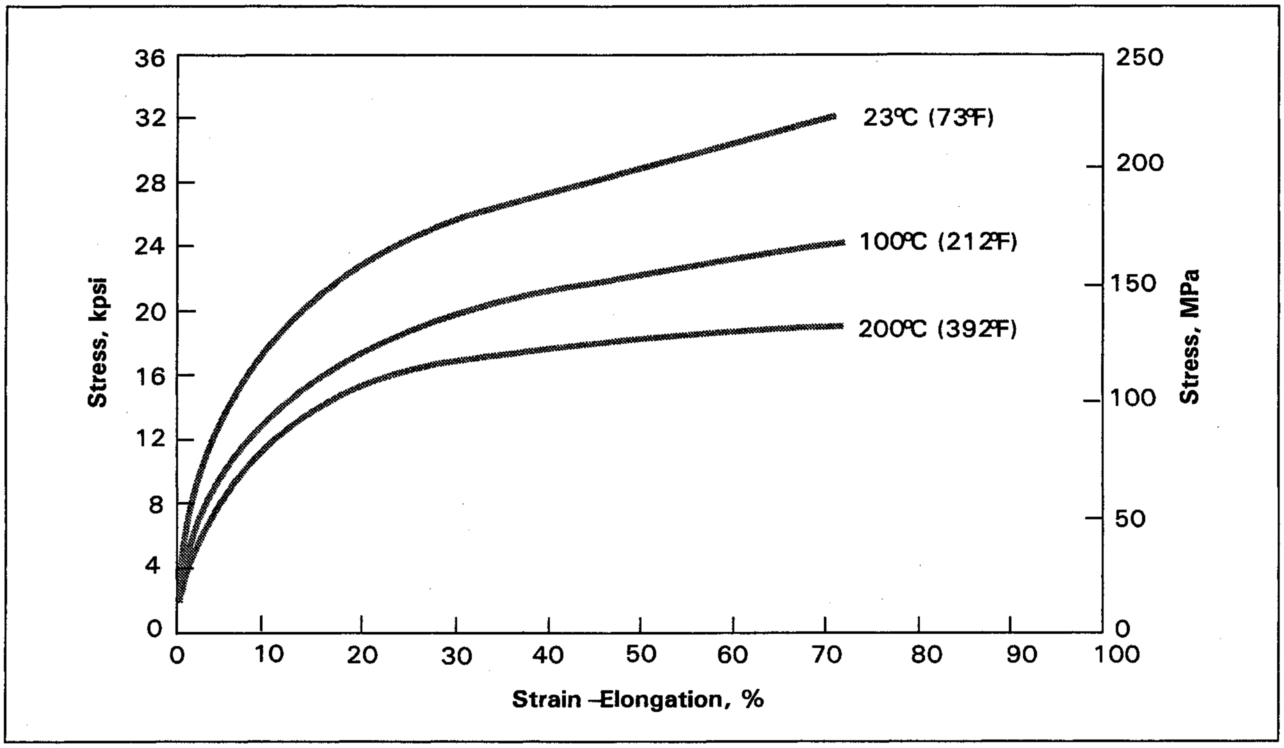


Figure 2. Tensile Creep Properties, Type HN Film, 25 μm (1 mil)

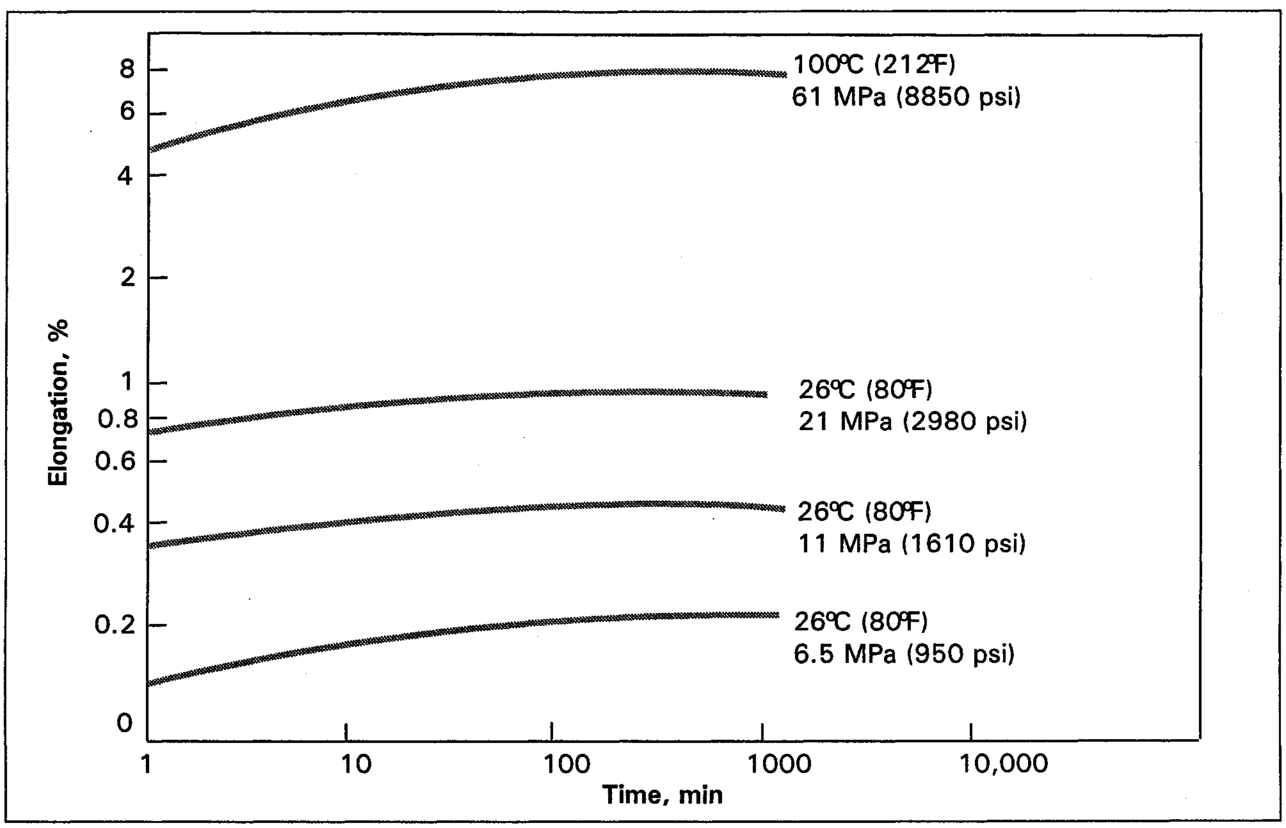
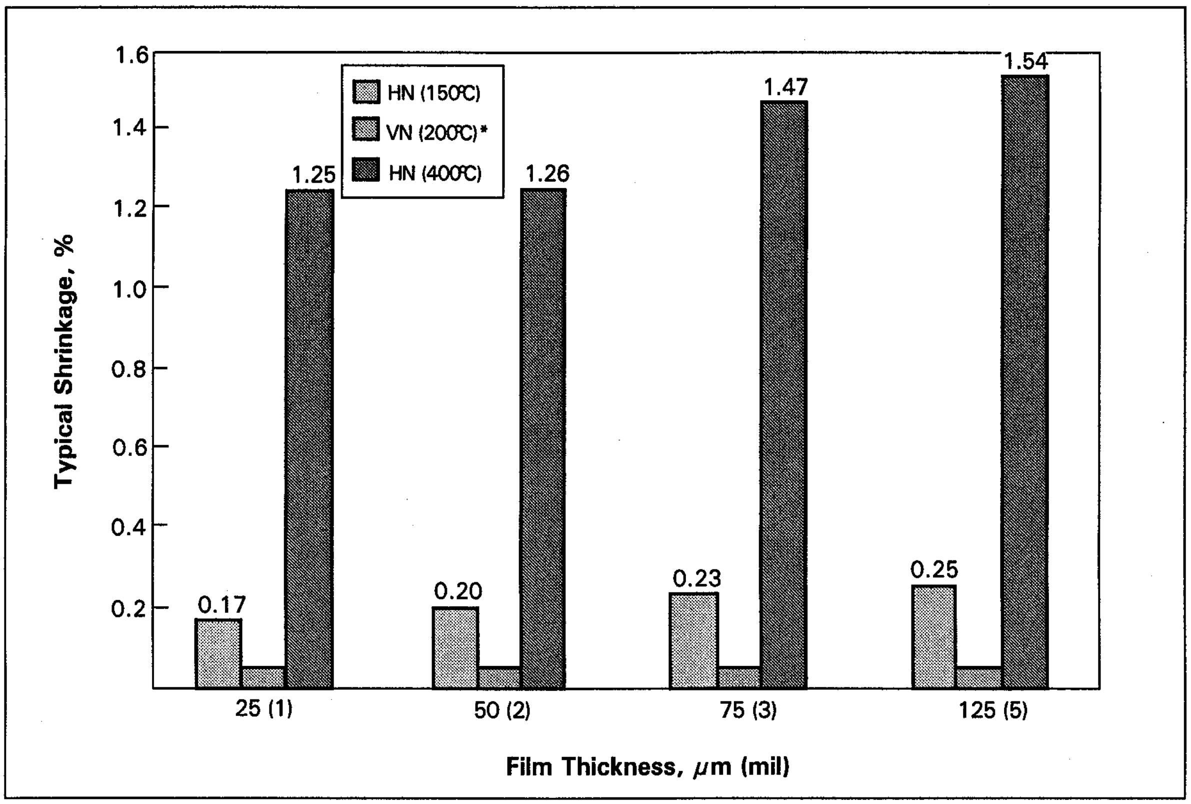
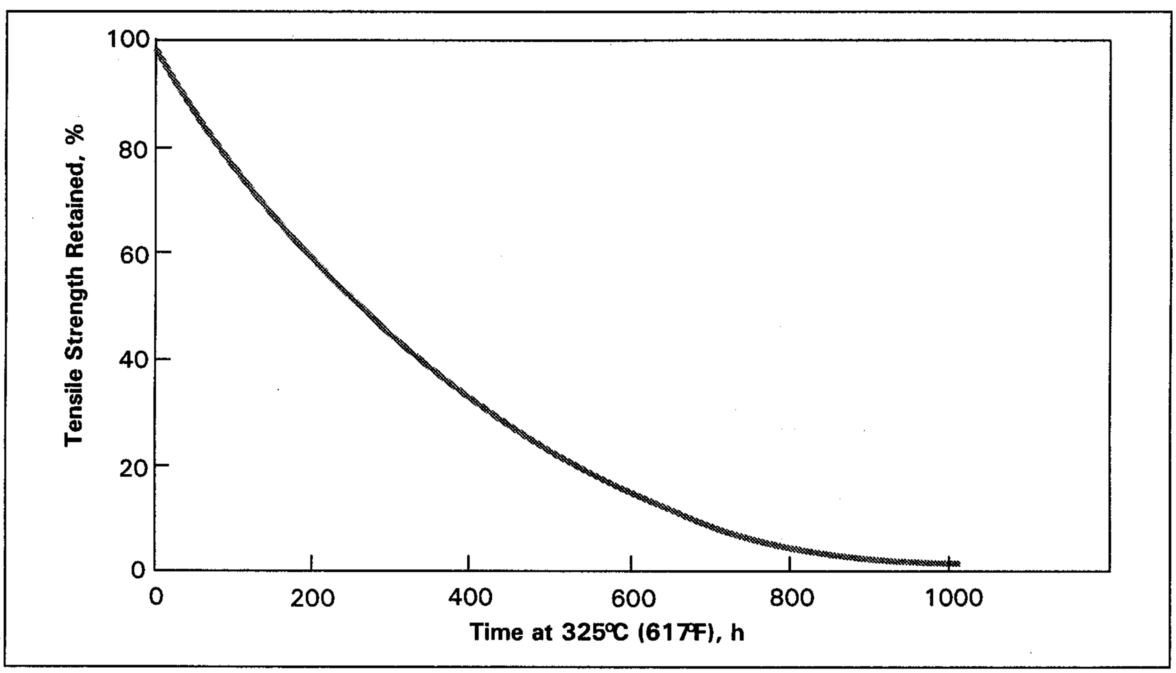


Figure 5. Residual Shrinkage vs. Exposure Temperature and Thickness, Type HN and VN Films



*Type VN shrinkage is 0.03% for all thicknesses.

Figure 6. Tensile Strength vs. Aging in Air at 325°C (617°F), Type HN Film, 25μm (1 mil)



Polyimide films developed to address specific issues, such as corona resistance, offer advantages in certain applications.

Kapton® Type CR

Typical Properties of Kapton® Type 100 CR Polyimide Film, 25μm (1 mil)

Property	Typical Value at 23 C (73 F)	Test Method
Electrical		
Corona Resistance, hr at 20 kV/mm at 50 Hz	>100,000	IEC-343
Dielectric Strength, kV/mm (V/mil)	291 (7,400)	ASTM D-149-81
Dielectric Constant	3.9	ASTM D-150-81
Dissipation Factor	0.003	ASTM D-150-81
Volume Resistivity, ohmácm	2.3 10^{16}	ASTM D-257-78
Surface Resistivity, ohm/sq	3.6 10^{16}	ASTM D-257-78
Mechanical		
Ultimate Tensile Strength, MPa (psi)	152 (22,100)	ASTM D-882-91
Yield Point at 3%, MPa (psi)	66 (9,500)	ASTM D-882-91
Stress to Produce 5% Elongation, MPa (psi)	86 (12,500)	ASTM D-882-91
Ultimate Elongation, %	40	ASTM D-882-91
Tensile Modulus, GPa (psi)	3.2 (463,000)	ASTM D-882-91
Tear StrengthÑPropagating, N (lbf)	0.03 (0.007)	ASTM D-1922
Tear StrengthÑInitial, N (lbf)	11 (2.5)	ASTM D-1004-90
Density, g/cm ^{3}	1.54	ASTM D-1505-90
Yield, m ^{2}/kg (ft ^{2}/lb)	25.5 (125)	
Thermal		
Coefficient of Thermal Conductivity, W/máK	0.385	Univ. of Delaware Method
Flammability	94 V-0	UL-94 (Tested by DuPont)
Shrinkage, % at 150 C (302 F)	0.2	ASTM D-5214-91
400 C (752 F)	0.6	

Typical Properties of Kapton® Type 150 FCR 019 Polyimide Film, 37.5μm (1.5 mil)

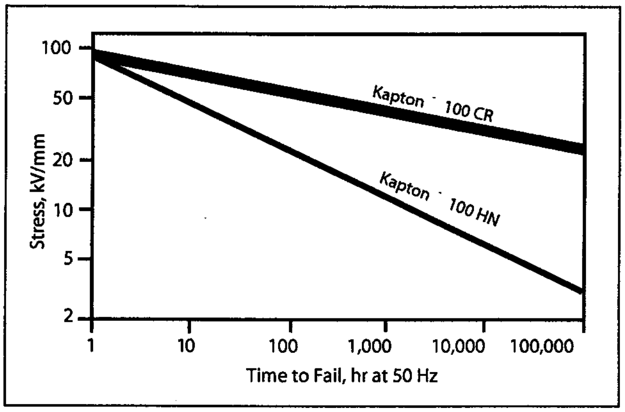
Property	Typical Value at 23 C (73 F)	Test Method
Electrical		
Corona Resistance, hr at 20 kV/mm at 50 Hz	>100,000	IEC-343
Dielectric Strength, kV/mm (V/mil)	173 (4,400)	ASTM D-149-81
Dielectric Constant	2.9	ASTM D-150-81
Dissipation Factor	0.001	ASTM D-150-81
Volume Resistivity, ohmácm	5.3 10^{16}	ASTM D-257-78
Surface Resistivity, ohm/sq	1.6 10^{15}	ASTM D-257-78
Mechanical		
Ultimate Tensile Strength, MPa (psi)	117 (17,000)	ASTM D-882-91
Yield Point at 3%, MPa (psi)	48 (7,000)	ASTM D-882-91
Stress to Produce 5% Elongation, MPa (psi)	62 (9,000)	ASTM D-882-91
Ultimate Elongation, %	43	ASTM D-882-91
Tensile Modulus, GPa (psi)	2.4 (348,000)	ASTM D-882-91
Tear StrengthÑPropagating, N (lbf)	0.05 (0.012)	ASTM D-1922
Tear StrengthÑInitial, N (lbf)	5.3 (1.2)	ASTM D-1004-90
Density, g/cm ^{3}	1.72	ASTM D-1004-90
Yield, m ^{2}/kg (ft ^{2}/lb)	15.79 (77.4)	
Bonding, N/cm (lb/in)		
Teflon® FEP to Kapton® CR	7.7 (4.4)	DuPont Test
Teflon® FEP to Copper	7.9 (4.5)	DuPont Test
Laminate Bond as Received	1.2 (0.7)	DuPont Test

Table 3
Comparison of Magnet Wire Insulating Properties for Kapton® Type 150 FCR 019 Polyimide Film and Kapton® Type 150 FN 019 Polyimide Film*

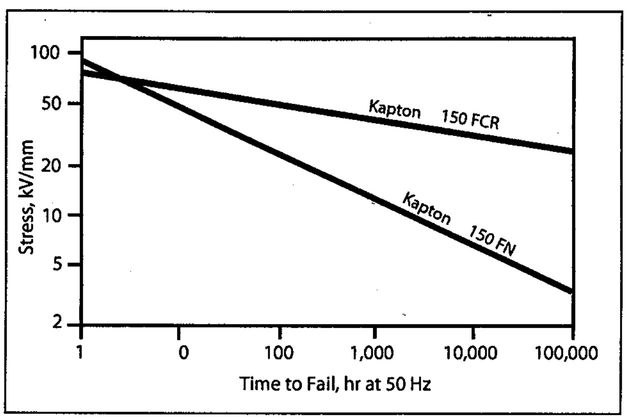
Property	Kapton® 150 FN 019	Kapton® 150 FCR 019	Kapton® 150 FN 019	Kapton® 150 FCR 019
Number of Wraps	1	1	1	1
Lapping, %	50	50	53	53
Insulation Increase, mm	0.15	0.15	0.21	0.21
Breakdown Voltage, Straight, IEC 851-5, kV				
Min.	4.5	4.0	6.0	6.0
Avg.	6.0	5.5	7.0	7.0
Bend Test, IEC 851-3				
2x Width Edgewise, kV				
Min.	4.5	4.0	5.0	5.0
Avg.	5.5	5.0	6.0	6.0
2x Thickness Flat, kV				
Min.	4.5	4.0	5.0	5.0
Avg.	5.5	5.0	6.0	6.0
Bend Test After Heat Shock (30 min at 220C [428F]), IEC 851-6, kV				
Min.	4.5	4.0	5.0	4.5
Avg.	5.5	5.0	6.0	5.5

*Data provided by Swiss Insulating Works.

Comparison of Corona Resistance of Kapton®100 CR versus Kapton® 100 HN. Based on measurements performed by DuPont, ABB Industrie AG Switzerland, and Siemens AG according to IEC 343.



Comparison of Corona Resistance of Kapton® 150 FCR 019 versus Kapton® 150 FN 019. DuPont testing performed according to IEC 343.



Kapton® Type MT

Typical Kapton® MT Properties

		MD	TD
Thermal conductivity, W/máK		0.37	
Tensile strength, kpsi (MPa)		27 (186)	25 (172)
Modulus, kpsi (GPa)		480 (3.3)	450 (3.1)
Elongation, %		80	90
Tear strength (initial) mil (g/ m)		1.7 (30)	
Dimensional stability (400 C [752 F]), %		1	
Dielectric strength, V/mil (V/ m) 100 MT 300 MT 4,5		 5,400 (212) 00 (177)	
Dielectric constant (25 C [77 F])		4.2	
Volume resistivity, ohmásq		>10^{14}	
Cut through, lb		40	
Fold endurance		200,000 cycles	
		100 MT	200 MT
Permeability, cc/m^2/day	O_2 WVTR N_2	443 95 3	226 85 2

Kapton® Type XC Conductive Film

Typical Properties of Kapton® 160XC and 275XC Polyimide Film

Property	Typical Value	Test Method
Mechanical		
Tensile Strength, md/td Kpsi	16/14	ASTM D-882-91, A
Tensile Modulus, Kpsi	520	ASTM D-882-91
Elongation to break, %	17	ASTM D-882-91
Tear Strength, initial, lb/mil	1.8	ASTM D-1505-90
Density, g/cc	1.41	ASTM D-1505-90
Optical		
Solar Absorbance	0.93	
Emissivity at 77 F	0.84 normal 0.78 hemispherical	
Light Transmission	opaque	
Electrical		
Surface Resistivity Aim, 160XC, ohms/sq.	370	Four point probe
Maximum	430	
Minimum	300	
Surface Resistivity Aim, 275XC, ohms/sq.	260	Four point probe
Maximum	290	
Minimum	230	
Thermal		
Meltpoint, polyimide, C	none	ASTM-E-794-85 (1989)

Kapton® Type XC Black Anti-Static Film

Typical Properties of Kapton® 100XC10E7 Polyimide Film

Property	Typical Value	Test Method
Mechanical		
Tensile Strength, Kpsi	17	ASTM D-882-91, A
Tensile Modulus, Kpsi	480	ASTM D-882-91
Elongation to break, %	27	ASTM D-882-91
Tear Strength, initial, lb/mil	1.8	ASTM D-1505-90
Density, g/cc	1.41	ASTM D-1505-90
Optical		
Solar Absorbance	0.93	
Emissivity at 77 F	0.84 normal 0.78 hemispherical	
Light transmission	opaque	
Electrical		
Surface Resistivity Aim, ohms/sq.	5×10^6	ETS 870 Electrometer at 100 V
Max for narrow range quality	5×10^7	
Min for narrow range quality	5×10^5	
Max for broad range quality	1×10^9	
Min for broad range quality	1×10^5	
Thermal		
Meltpoint, polyimide, C	none	ASTM-E-794-85 (1989)

Market Place

Polyimide film in the pressure sensitive tape industry is a high-value specialty market, representing a global volume of 100 tons per year. Polyimide film costs, compared to other tape substrates, is significantly higher. However, value-in-use is also high. A small amount of polyimide film business could represent significant business for the tape manufacturer due to the high-end use.

DuPont's position as a leading film supplier offers the PST industry development opportunities to expand and support growth in new applications. Your input is highly encouraged to help us focus on what polyimide film properties need to be for this growth.

Application Areas

Traditional applications include the electronics industry and motor repair.

In motor applications, Kapton, uncoated or coated with Teflon® FEP, is used to insulate individual magnet wires in high performance (180°C insulation class) motors or as a coil overwrap. When Kapton without a FEP coating is used, a Kapton-based pressure sensitive tape is used to keep starts and stops from unraveling. When motors are returned for repairs, Kapton-based pressure sensitive tape is used repair damaged winding insulation.

In printed circuit board applications, Kapton-based pressure sensitive tape is used to protect areas of printed circuit boards during the hot wave soldering or solder overflow operations. A typical application is to cover the gold-plated connector fingers on the boards during soldering. The adhesive applied by the converter must not only survive the soldering temperatures and chemicals but must peel cleanly from the protected area after soldering. Kapton-based pressure sensitive tape is also available with an anti-static adhesive designed to minimize static discharges during tape peel-off which could damage sensitive, high-value electronic components.

Other areas where a unique pressure sensitive tape construction could be used are the rapidly developing personal protection device business, such as smoke hoods and fire barrier equipment. The need for a compatible fire retardant, high temperature adhesive is apparent. Kapton is an environmentally compatible fire retardant in that it is non-toxic; other related applications are just waiting to be tried.

The communications industry needs a splicing tape for high performance materials such as optical fibers, where dielectric properties are matched to polyimide film.

Energy and thermal management are rapidly becoming major issues as the world moves towards smaller, lighter devices, particularly in the printed circuit board and chip scale packaging areas, and battery insulation.

Aerospace applications where weight is an immense critical issue demand newer materials, thinner films. Thinner adhesive coatings with compatible outgassing properties are needed.

The exploration of outer space and the proliferation of new space structures, where radiation resistance is crucial, also demand lighter, thinner, more flexible products. Materials that can be compressed and then inflated in outer space without degradation are extremely important.

Development Ideas

As the "raw material" film manufacturer, DuPont does not make pressure sensitive adhesives. However, the need for a strong relationship with adhesive manufacturers who are interested in development of adhesives compatible with the newer polyimide films is key to mutual growth and success.

Any Kapton® film produced today can be used as a pressure sensitive tape. DuPont is very interested in expanding this industry. One idea is modifying the polyimide chemistry to match adhesive technology. We have the ability to change stiffness or modulus, thickness, coefficient of thermal expansion, and balance the elasticity. Lower moisture and higher modulus films are underway. Likewise, modifying adhesive chemistry to match newer polyimide films is also needed.

Surface modification of the polyimide film to enhance adhesive acceptance is also a consideration.

Committed to industry and technology leadership, DuPont offers continuous improvement programs, such as Six Sigma, and PACE new product and process development protocol, to ensure positioning as a long-term supply leader in this industry. All Kapton films are produced to ISO 9000 quality standards at three worldwide locations. Our newest state-of-the-art Kapton casting line will have the capability of producing quality polyimide film in wider widths in response to industry demands.

Conclusion

A challenge is issued to the pressure sensitive tape industry to collaborate with DuPont, focusing on growth and the future. Where do we need to be ten years from now? What can adhesive research and development provide to address these challenging needs? DuPont offers a wealth of knowledge intensity and is ready to help your business grow.