

3M High Temperature Dielectric Film

Summary

- * A high performance film product to over 200 °C
- * Excellent electrical properties to over 200 °C
- * Good mechanical properties
- * Intriguing optical properties
- * Excellent environmental & chemical properties
 - Low shrinkage to 300 °C
 - Moisture insensitive
 - Low outgassing under vacuum
 - Excellent surface qualities - easy metallization of film
 - Flame retardant
 - Low smoke generation

3M FPE

High Temperature Dielectric Film

General Comments

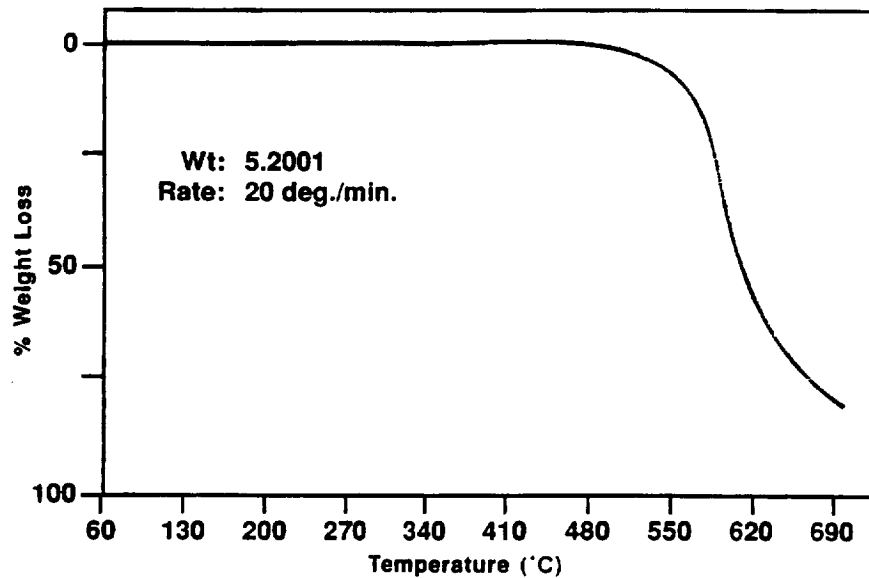
- High molecular weight polymer - 400,000 to 700,000
- Experimentally prepared film - caliper 5 μ to 400 μ
- Density - 1.22 g/cc
- Radiation stability measured to 400 megrads
- Easily metallized

3M FPE High Temperature Dielectric Film

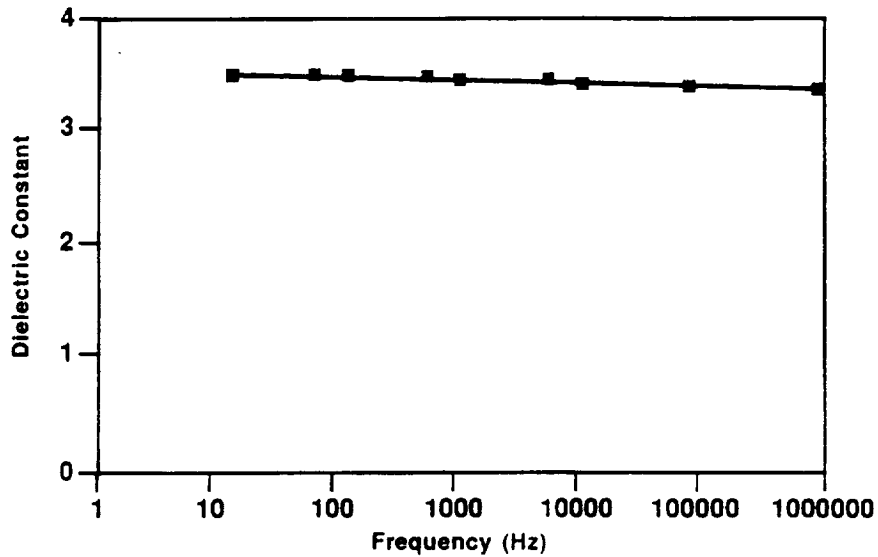
Thermal Properties

- High T_g - 335°C (DSC measurement)
- Thermal stability to 500°C (TGA measurement in air)
- Thermal conductivity - 0.13-0.15 watts/m K (23°-150°C)
- Flame retardant - high limiting oxygen index, low smoke generation, high ignition temperature, high char yield, no drip and/or ignition when exposed to flame
- Low shrinkage - <0.2% at 200°C/24 hours
 - 1% at 200°C/2000 hours
 - <0.3% at 250°C/10 hours

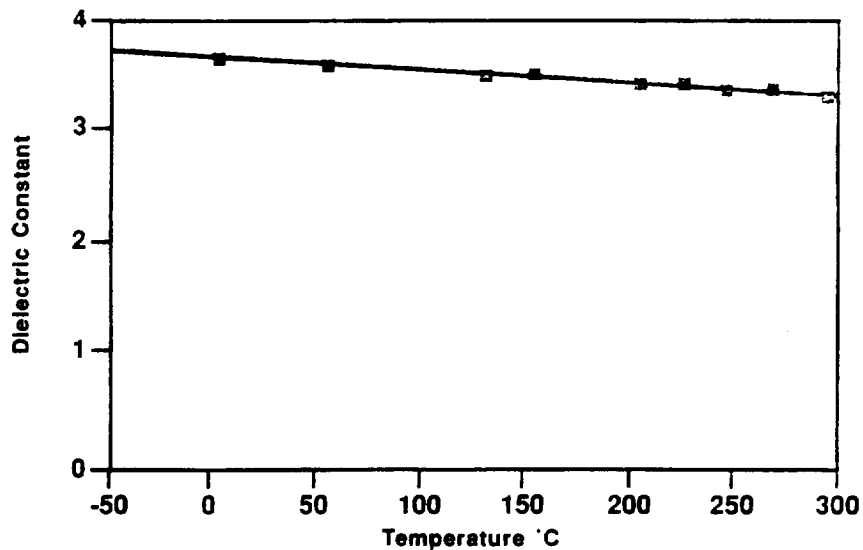
FPE High Temperature Dielectric Film



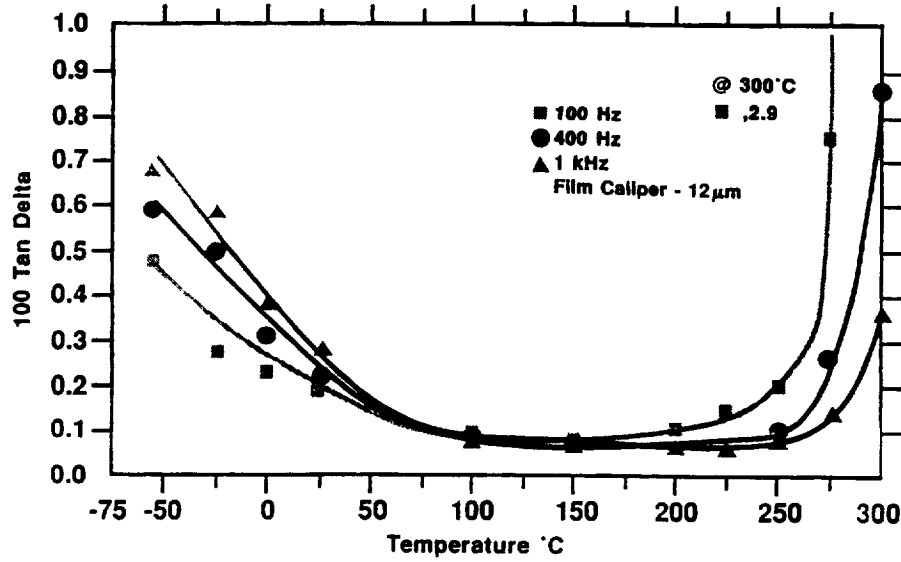
***Dielectric Constant as a Function
of Frequency - 3M FPE Film
(25°C - 3M Data)***



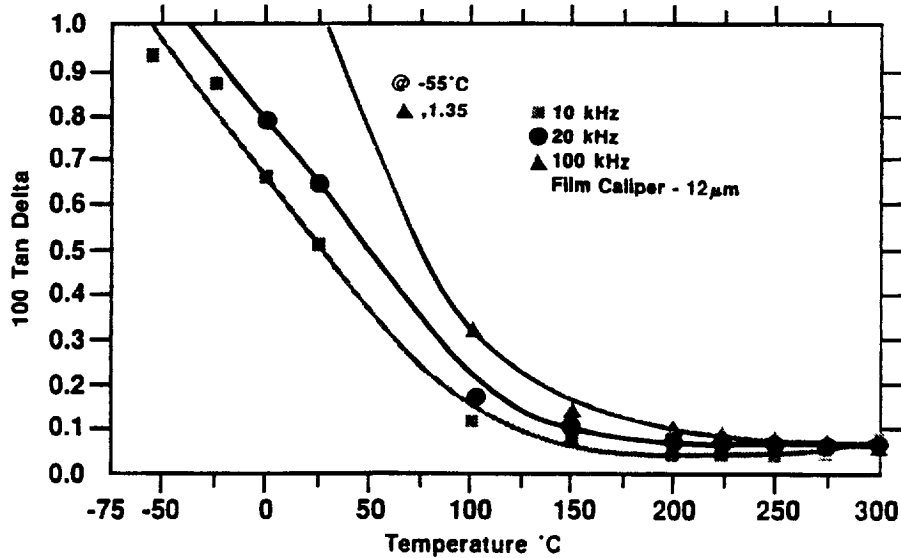
***Dielectric Constant as a Function of
Temperature - 3M FPE Film
(1 KHz - 3M Data)***



3M FPE Film Dissipation Factor as a Function of Temperature (100 Hz to 1 KHz)



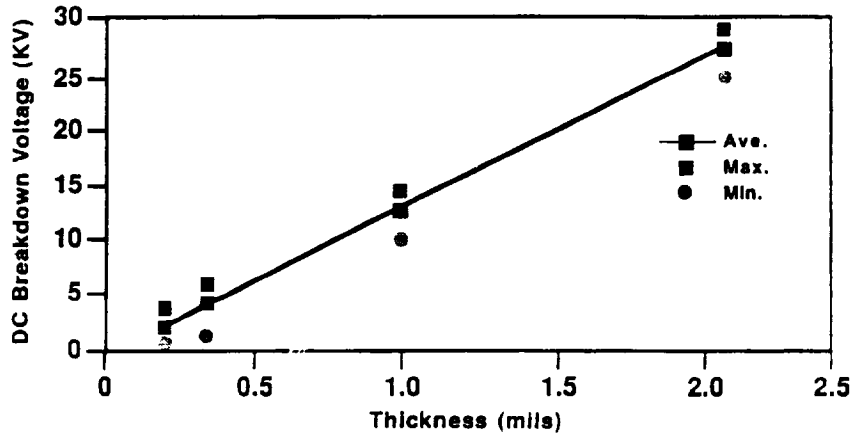
3M FPE Film Dissipation Factor as a Function of Temperature (10 KHz to 100 KHz)



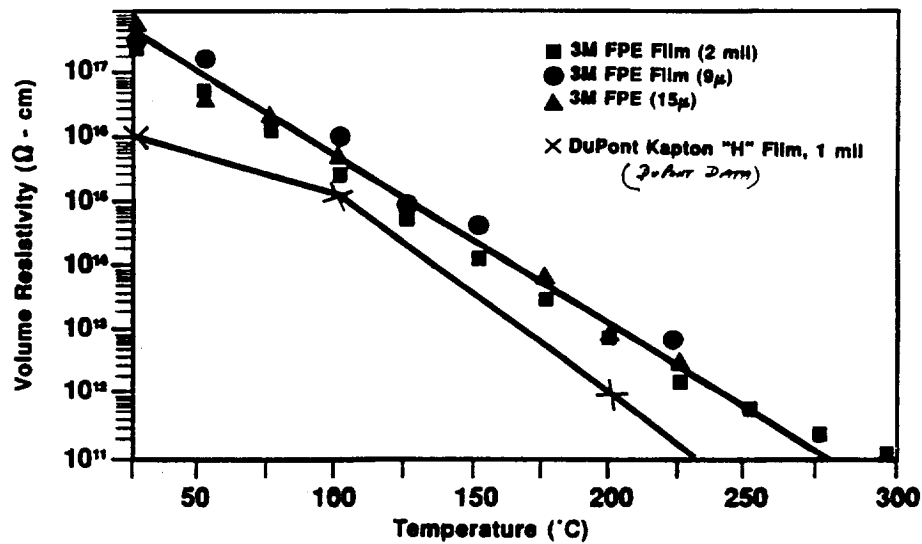
3M FPE Film Breakdown Voltage (D.C.) as a Function of Thickness

Test Conditions:

- Measurement in air at ambient conditions
- Voltage rise 250 V/sec.
- Each data point is average of 36 measurements
- Electrodes: 0.25 inch diameter brass deadweight, rounded edges



Volume Resistivity as a Function of Temperature 3M FPE and DuPont Kapton Film



Comparative DC Dielectric Strength of Insulation Films

Film	DC dielectric strength @ 1 mil, 25°C, air (KV/mil)
3M FPE	12.3
PET	7.5
Polyimide	7.0
PTFE	4.2

3M FPE High Temperature Dielectric Film

Mechanical Properties (Measurements to 300°C)

- **Tensile strength - 20,000 psi (22°C)**
- **Elongation - 70% (22°C)**
- **Modulus of elasticity - 500,000 psi (22°C)**
- **High heat distortion temperature - <<<1% (21°C - 300°C; 50 psi load), 1% (21°C - 300°C; 300 psi load)**
- **Coefficient of expansion C(α) - 4×10^{-5} m/m/°C**

3M FPE High Temperature Dielectric Film

Chemical Properties

- Humidity coefficient C(β) - $0.4 \times 10^{-4} (\text{m/m}/\% \text{RH})$
- Moisture absorption <0.6% (50% RH, 23°C, 24 hrs)
- Very low outgassing under high vacuum - Insignificant at 10^{-7} torr, at least a factor of 10 lower than polyimide
- Non-toxic by 3M testing
- Low toxic gas generation - no N, S, or X in chemical structure
- Compatible with common impregnants, weak acids, and weak bases - Fluorochemicals, Silicone oil, Castor oil, Monoisopropyl biphenyl, Ditolyl ether, Tricresyl phosphate, Phenyl xylyl ethane

Thermal Aging and Hydrolytic Stability Test Results

(WPAFB Contract F44615-88-C2913)

<u>Aging Environment</u>	<u>Mess. Temp. (°C)</u>	<u>Dissipation Factor</u>			
		<u>100 Hz</u>	<u>400 Hz</u>	<u>1 kHz</u>	<u>10 kHz</u>
Ambient	25	0.0020	0.0021	0.0026	0.0053
Air, 7 days, 300°C	25	0.0025	0.0024	0.0029	0.0046
N ₂ , 7 days, 300°C	25	0.0022	0.0021	0.0026	0.0046
H ₂ O, 2 days, 100°C	25	0.0018	0.0019	0.0025	0.0045
Ambient	225	0.0014	0.0006	0.0006	0.0004
Air, 7 days, 300°C	225	0.0012	0.0007	0.0008	0.0008
N ₂ , 7 days, 300°C	225	0.0008	0.0003	0.0004	0.0005
H ₂ O, 2 days, 100°C	225	0.0009	0.0003	0.0004	0.0003

3M FPE High Temperature Dielectric Film

Optical Properties

- **Optically transparent; colorless, water white, haze 0.1%**
- **High index of refraction polymers - 1.656**
- **Very low coefficient of birefringence - 0.0003**
- **Good U.V. stability - self-stabilizing mechanism**
- **Transmissions 90-95% from 350 nanometers through 2.5 ~~microns~~ ^{microns}**

Suggested Applications

- **Electrical insulation - class F/H/C**
- **Capacitor film high temperature, high energy density, pulse power, surface mount**
- **Wire and cable insulation**
 - **Electrical power and signal wire film wrap**
 - **Fiber optic cable wrap**
 - **Magnet wire film wrap**
 - **Magnetic filament cable wrap**
- **Conformal coatings**
- **Substrate**
 - **Electronic packaging**
 - **Thin film depositions for opto-electronic and magnetic product applications**

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