

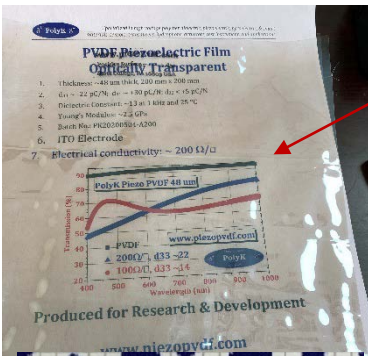
1. Roll-to-roll production of piezo PVDF film from 10 um to 1000 um: consistent quality and low cost.
2. Major thickness: 28 um, 40 um, 50 um, 100 um in large rolls for sensor manufacturer
3. Piezo PVDF-TrFE film from 3 um to > 1,000 um thick, batch process or R2R
4. Beta β Phase PVDF film (non poled) with high optical transparency: you can design your own poling pattern for special applications.
5. Special thickness based on application with short lead time. 100mm-size film for R&D or >100 m film for sensor manufacturers.
6. Special electrodes upon request: sputtered gold, silver ink, Pt, Cu/Ni, optically transparent ITO, etc. Pattern size better than 100 um.
7. Piezo film and sensor test instruments: d33 meter with static force control and temperature control, ferroelectric hysteresis analyzer, lab-scale corona poling station, piezo strain displacement test <10 nm, charge amplifiers and circuit for R&D, PVDF-TrFE resin,

**PVDF-TrFE ultrasound transducers:** customized gold electrode pattern by sputtering with mask or by laser ablation

**Piezo Film with Electrodes**

- A. 28 um & 50 um piezo PVDF with sputtered Cu/Ni Electrode. Cu/Ni (80nm or 200 nm thick) can be etched to produce customized sensors, speakers, actuators.
- B. 45 um, 100 um, 200 um, and 500 um thick PVDF with sputtered 100 nm Al electrode
- C. Transparent ITO Electrodes: 28 um & 50 um PVDF
- D. 8 um thick silver electrodes: 28 um, 45 um, 110 um

**For Typical Applications, Please visit youtube channel:**  
<http://www.youtube.com/channel/UCv-1VvjDijkdf76cZVACvEQ/videos>



**ITO Coated Optically Transparent piezo film:**  
 200 Ω/□, 48 um thick



1 mm thick hydrophone chicklet gum  $d_H$  &  $g_H$

**Piezoelectric Energy Harvesting**

**Soft Actuator Robotic & Transparent Flexible Speaker**



R2R Sputtered Cu/Ni Electrode 80-200 nm

R2R Sputtered ITO Electrode 200 Ω

Properties	PVDF	Unit
Piezo Strain Constant	13~18	$d_{31}$ (pC/N)
	-20~-35	$d_{33}$ (pC/N)
Piezo Stress Constant	210~220	$g_{31}$ ( $10^{-3}$ Vm/N)
	-330~-350	$g_{33}$ ( $10^{-3}$ Vm/N)
Dielectric Constant	~13	$\epsilon_r$
Pyroelectric Coefficient	26~30	$\rho$ ( $10^{-6}$ C/m <sup>2</sup> K)
Electromechanical Coupling Factor	10~13	$k_{31}$ (%)
	12~15	$k_t$ (%)
Maximum Voltage	>100	E (V/ $\mu$ m)
Mechanical Properties		Unit
Tensile strength	0.4~0.6	$\sigma_{MD}$ ( $10^9$ N/m <sup>2</sup> )
	0.05~0.06	$\sigma_{TD}$ ( $10^9$ N/m <sup>2</sup> )
Young's Modulus	2.3~2.8	$Y_{MD}$ ( $10^9$ N/m <sup>2</sup> )
	2.0~2.5	$Y_{TD}$ ( $10^9$ N/m <sup>2</sup> )
Elongation at Break	20~30	$\epsilon_{MD}$ (%)
	5~7	$\epsilon_{TD}$ (%)

**Piezo Film Sensor & Transducer**



Silver screen printing up to 250 mm x 350 mm for prototype



Sputtering with turbo pump, up to 270 mm diameter, Cr, Au, Ag, Pt, transparent ITO



**Piezo PVDF Film with IDG Electrode**

Comprehensive test:  $d_{33}$ ,  $d_{31}$ , K,  $g_{33}$ , Modulus, thermal shrinkage, resonance, coupling factor, etc  
 Electrode: screen-printed silver ink, sputtered gold, silver, copper, chromium, nickel, etc.



**Bauer Shock Gauge**

# Piezoelectric, Ferroelectric, Pyroelectric & Electroactive Polymer

For R&D in high energy density capacitor, piezoelectric, pyroelectric, electrocaloric ECE, & electroactive polymer EAP. Include **20 grams** of each of **Seven** typical polymer resins based on P(VDF-TrFE)

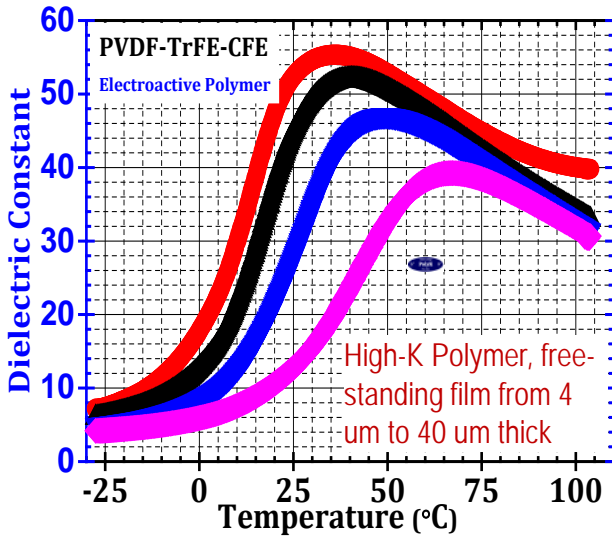
1. P(VDF-TrFE) 80/20 [mol], Curie: ~135 °C
2. P(VDF-TrFE) 75/25 [mol], Curie: ~112-121 °C
3. P(VDF-TrFE) 70/30 [mol], Curie: ~104 °C
4. P(VDF-TrFE) 65/35 [mol], Curie: ~72 °C
5. P(VDF-TrFE) 55/45 [mol], Curie: ~66 °C
6. P(VDF-TrFE) 50/50 [mol], Curie: ~60 °C
7. P(VDF-TrFE-CFE) Terpolymer 63/30/7 [mol],  $T_m$ : 130 °C. Ferrorelaxor polymer with high dielectric constant ~60 at 25 °C.
8. P(VDF-TrFE-CTFE) Terpolymer 65/31/4 [mol],  $T_m$ : 135 °C. Ferrorelaxor polymer with high K-60 at 50 °C and 1 kHz.

## Poly(vinylidene fluoride-co-trifluoroethylene) copolymers & terpolymers (CFE, CTFE)

Online Piezo & High Voltage Store [www.piezopvdf.com](http://www.piezopvdf.com)

### High-K Polymer thin film with high dielectric breakdown

1. P(VDF-TrFE-CTFE) (CFE): 2 um to 40 um thick, solution cast film, K 45-55 at 25 C, >300 V/um breakdown, modulus 100-300 MPa, melting 120-130 C
2. PVDF-HFP: 2 um to 10 um thick, biaxially oriented. K ~10, >600 V/um, Modulus 1000-1200 MPa, melting 160 C
3. PVDF film: 10 um to 100 um, uniaxially oriented film, K 12-13, >600 V/um, Modulus 2000-3000 MPa, Melting 170 C
4. In-house customized roll-to-roll film production, solution casting (up to 350 mm width, on release film or metal foils), uniaxial orientation, up to 600 mm wide.
5. Support product development



### High Voltage Dielectric, Ferroelectric, & Piezoelectric Test Instrument

1. Turnkey Dielectric Test: measure dielectric constant/loss (impedance) as a function of temperature (-180 C ~ 1000 C) and frequency (to 110 MHz)
2. Ferroelectric Polarization Hysteresis Loop: up to ±30 kV, 10 kHz, for polymers, ceramic, and composites. Broad temperature range
3. TSDC, Leakage Current, and Pyroelectric: Electrometer for current down to pA, voltage up to 10 kV or higher, temperature from -180 C to 1000 C
4. Corona poling system for voltage up to 100 kV, temperature up to 200 C.
5. Piezoelectric d33 and d31 measurement of polymers and ceramics.
6. Other mechanical, high voltage, thermal and dielectric measurement for ASTM standard test

### Piezo d33 Meter for Polymer & Ceramic

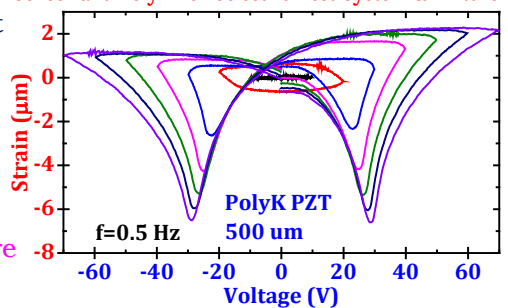
1. Range of 200, 2000, or 4000 pC/N
2. With static force sensor for better reproducibility
3. Temperature chamber from <-100 C to >600 C
4. D31 or d15 adapter

<http://piezopvdf.com/piezoelectric-d33-meters/>



- Polymers: fluoropolymers of VDF with over 20 different compositions & molecular weight
- Films: solvent cast, extrusion, poled, 1-100 um
- High-temperature polymers and film, PEEK, PPS, PI, PC, PEI, etc
- **Low-Cost Test Equipment:** ferroelectric polarization loop, dielectric constant vs temperature & frequency, leakage current

### Piezo Strain (Displacement) Measurement with Fotonic Sensor and PolyK Ferroelectric Test System & Fixture



### Ferroelectric and Capacitor Test Station



State College, PA, USA; [sale@polyk-lab.com](mailto:sale@polyk-lab.com)

[www.piezopvdf.com](http://www.piezopvdf.com)

Ferroelectric Hysteresis Test System