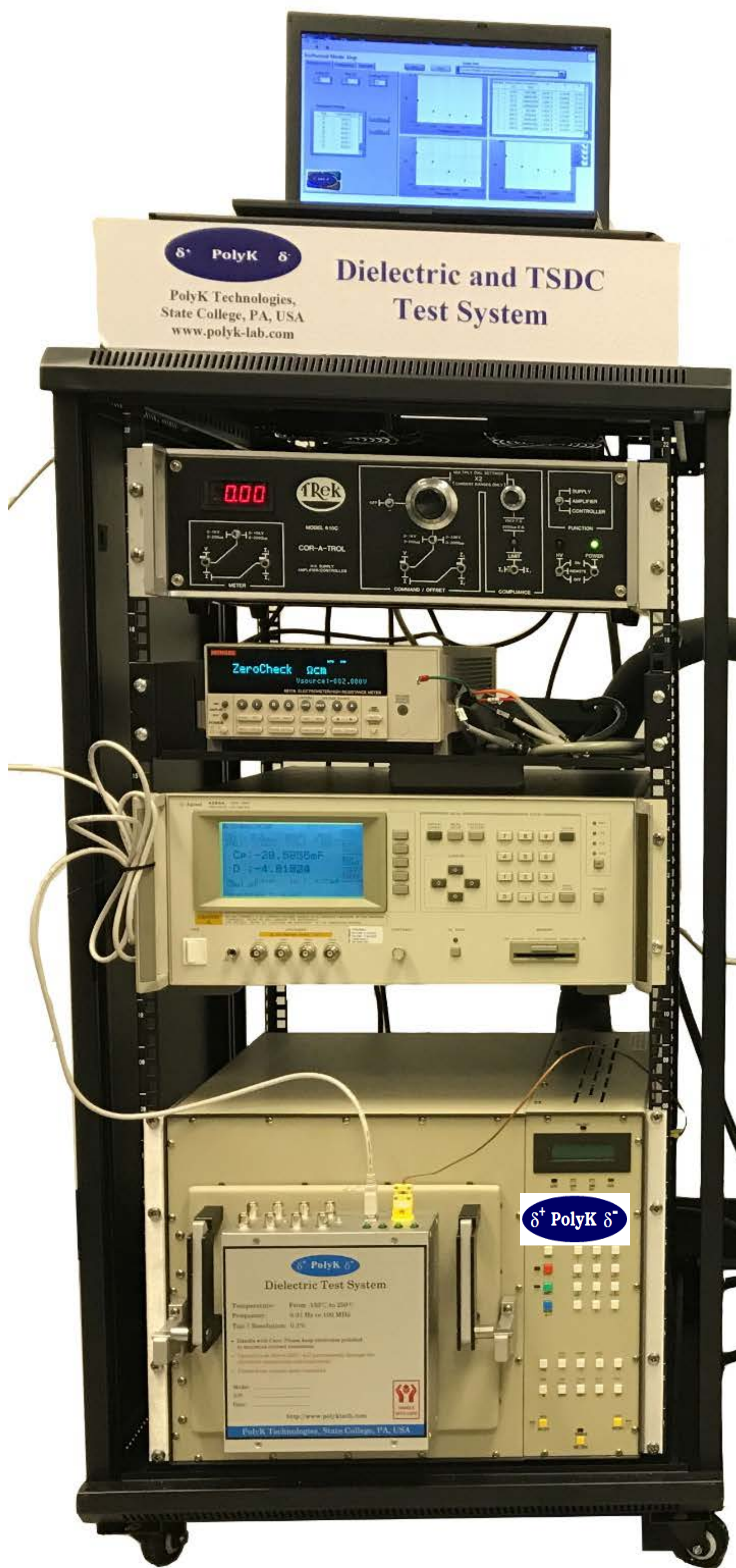


# Turnkey Test System: Dielectric and TSDC/Leakage Current



Dielectric

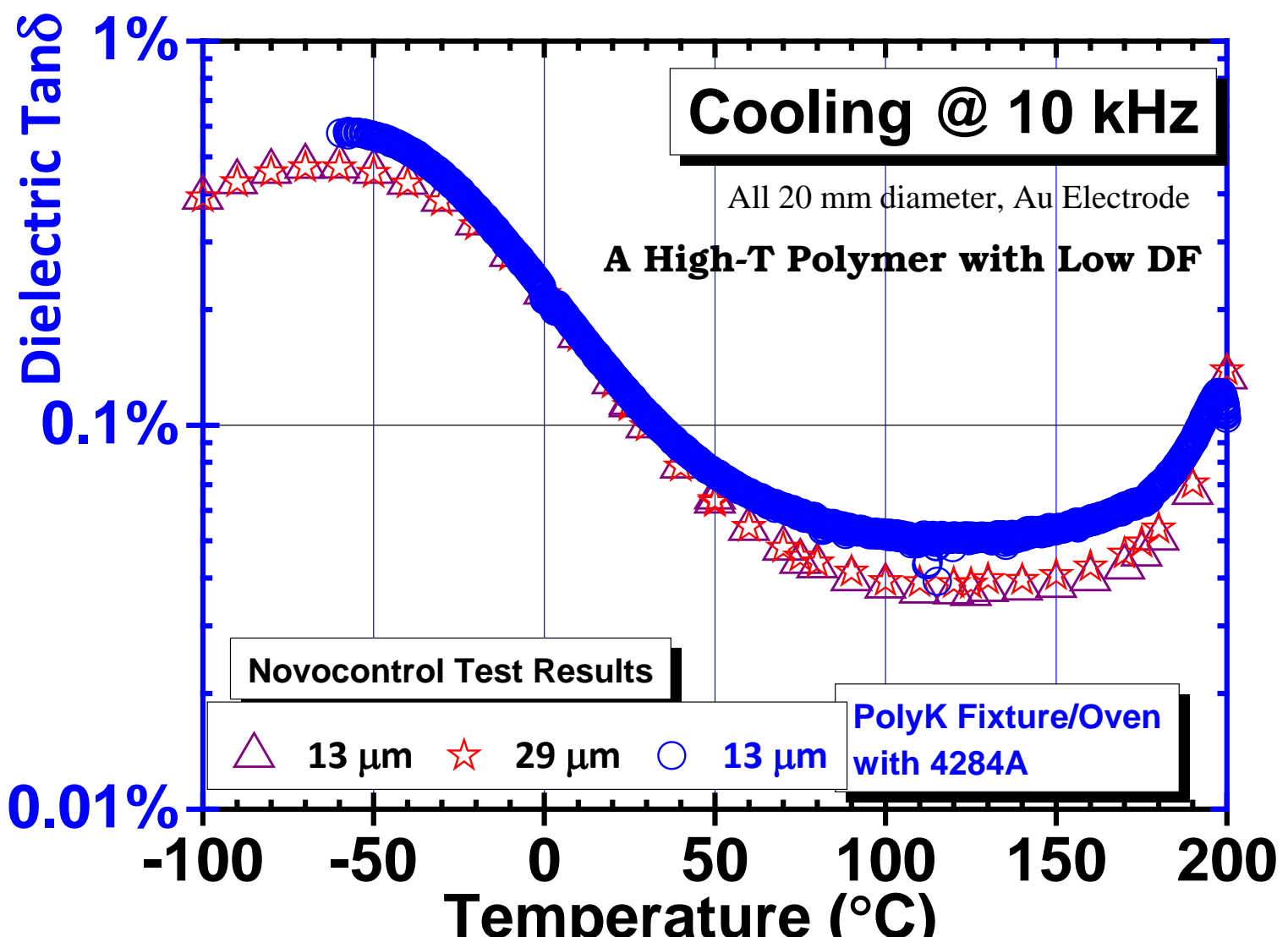
TSDC

## Dielectric

- Measure capacitance and dissipation factor vs temperature and frequency. Five specimens.
- Liquid nitrogen cooling: -184 C to 250 C
- LCR Meter: Agilent 4284A, 4980, Microtest 6630, Quadtech 7600, etc.
- Computer program: automatic control temperature ramp, isothermal, or time domain.

## TSDC

- Automatic control poling, cooling, short circuit, and temperature ramp. Current better than 1 pA
- Poling voltage: up to 10 kV, T: -184 C to 315 C
- Measure leakage current as a function of voltage, time, and temperature.
- Measure pyroelectric current. I-V measurement
- **Much lower cost than Novocontrol**



**Thermally Stimulated Depolarization Current**

Poling under High Voltage (0-10 kV)  
High T (> T<sub>g</sub>)

Hold Voltage and Quench to below T<sub>g</sub>

Short Circuit Sample

TSDC Test: Temperature Ramp

PEN 80 μm, T<sub>g</sub> 120 deg C  
Crystallized at 170 C/1Hr

Poled at 155 °C/1600 V 20 min

PVDF-TrFE 70/30,  
φ10 mm x 22 μm, 2 K/min

-400 μC/m<sup>2</sup>-K

Curie

— -4500V  
— No Poling  
— +4500V

Contact: [energy@polyktech.com](mailto:energy@polyktech.com)

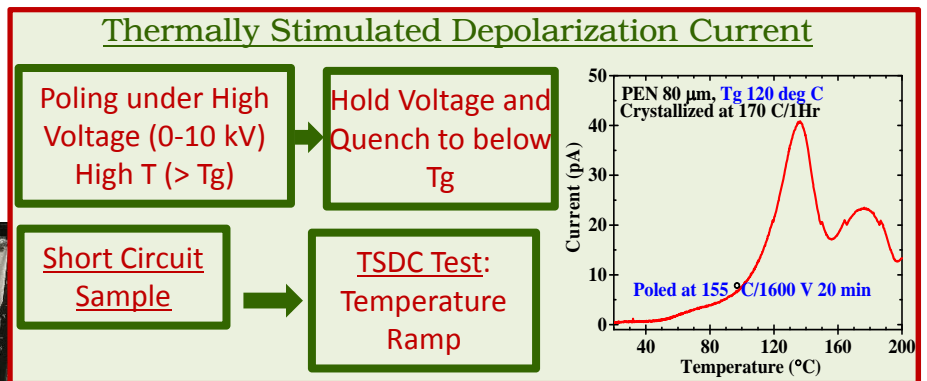
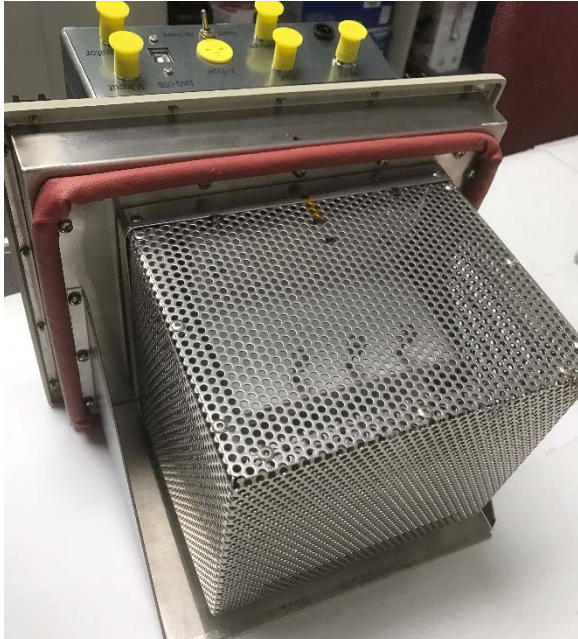
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# Electrical Leakage Current, TSDC, & Pyroelectric Test System



## Background

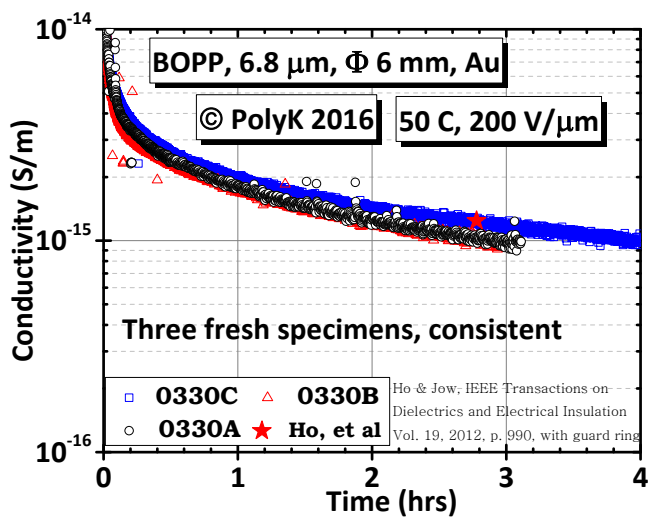
- In high energy density and power density capacitors, the electrical leakage current may contribute significantly to the power loss and thermal runaway.
- The electrical resistivity reported in many commercial material datasheets is usually measured following ASTM D 257 at low electrical field (<1 V/um) for short period of time (60 seconds). For comparison, many capacitors are operated at >100 V/um field and the conductivity increases exponentially with field. Therefore, such data in the manufacturers' datasheet are not relevant.
- Measuring leakage current of thin polymer film under high electrical field and high temperature is very challenging:
  - Current can be ~pA ( $10^{-12}$  A), interference from surroundings must be completely shielded.
  - As dielectric fluid may become conductive during long term high voltage test, the test must be done in air without dielectric fluid. Many specimens have low dielectric breakdown strength in air and it is hard to test them at >100 V/um for > 1 hour.
  - In addition, thin polymer films are usually soft and they can be easily damaged by the electrode. Therefore, it is very difficult to measure such thin film (<10 um) at field >100 V/um.



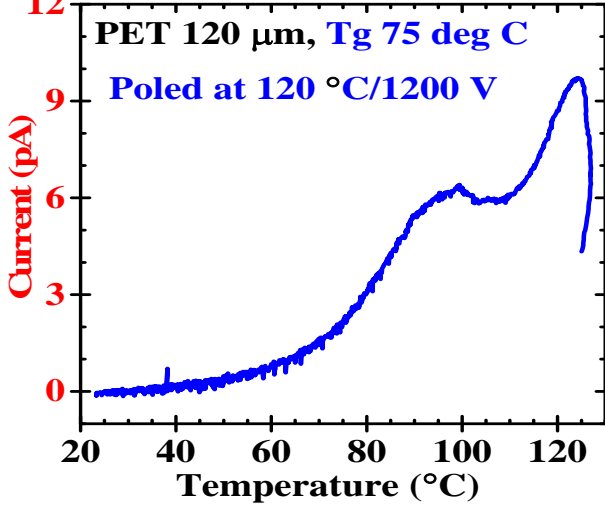
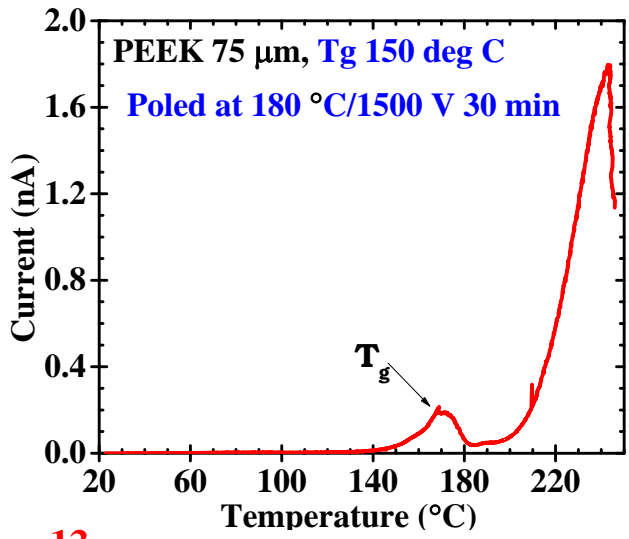
## PolyK Test System

- pA current measurement by Keithley 6517 (6514) or similar electrometers with triax shielded cables.
- High voltage was applied with stable power supply/amplifier such as SRS PS350 or Trek. Voltage: 5~10 kV
- Temperature: -180 to 300 C with liquid nitrogen cooling
- Fully shielded test enclosure with electrical insulation mounted to the inner side of the chamber door for easy sample loading.
- High voltage is applied with unique spring-loaded ball electrode to maintain reasonable electrical connection without damaging soft thin polymer film.
- pA current measurement has been confirmed in capacitor film with thickness <5 um and high voltage (200 V/um) can be applied for >20 hours without dielectric breakdown.
- LabView QControl© program automatically sets up the test and record the results with thermocouple close to sample.
- Specimen Size: up to 8 cm diameter, as small as <3 mm.
- Test system can also be used to measure TSDC (thermally stimulated depolarized current) or pyroelectric current.
- Module design concept such that the test chamber can be shared with other PolyK dielectric and high voltage test system

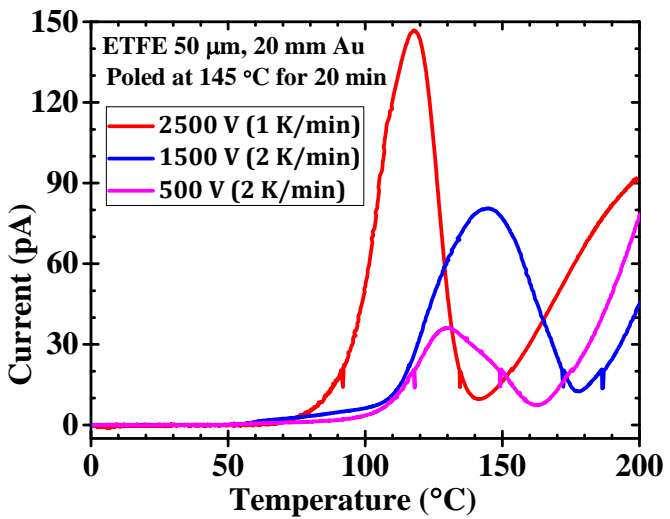
# Leakage Current, TSDC, & Pyroelectric: Typical Test Results



Commercial BOPP capacitor film, 6.8 μm thickness. Three fresh specimens have similar leakage current, which are consistent with that reported by Ho and Jow at the same temperature and field by a test system with guard electrode.



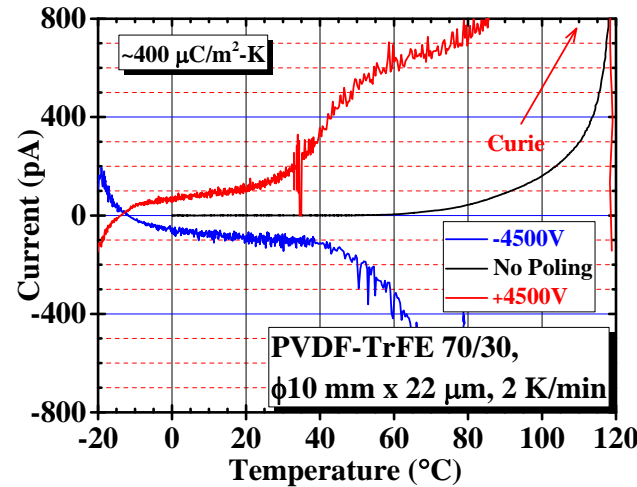
A special flexible glass dielectric with  $T_g > 750$  °C: high electric resistivity at  $> 200$  °C. Note: the noises at high T and high V are usually from the local breakdown of air or sample. The trend is still clear.



TSDC Test of ETFE with  $T_g \sim 100-120$  °C

## Applications

- Evaluate new dielectric materials for high energy density high temperature capacitors.
- Study the morphology, microstructure, and chain relaxation in polymeric materials and nanocomposites.
- Develop pyroelectric materials and pyroelectric energy harvesting.
- Particularly suitable for soft and thin materials.



Pyroelectric PVDF-TrFE after poling

# Leakage Current, TSDC, & Pyroelectric: Typical Test Results

