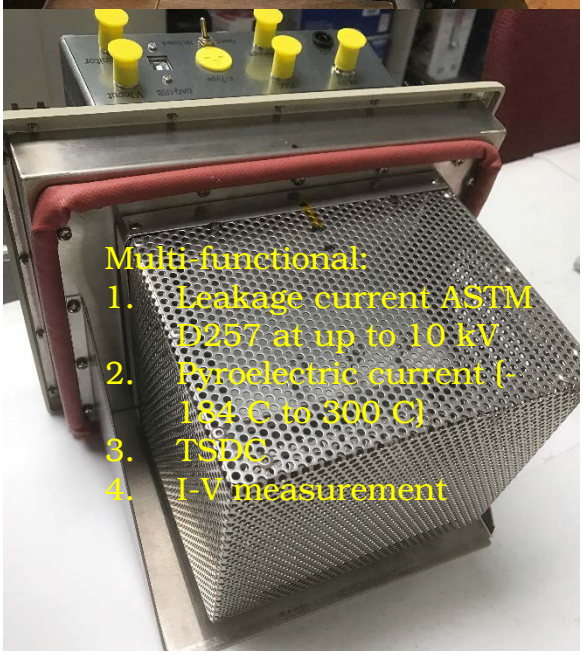
# PK-SPIV17T ASTM D257, TSDC, & Pyroelectric Test System

## Background

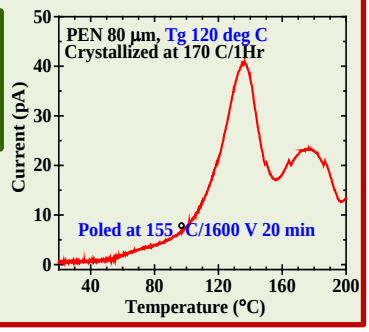
- In high energy density and power density capacitors, the electrical leakage current (ASTM D257) may contribute significantly to the power loss and thermal runaway.
- The electrical resistivity reported in many commercial material datasheets is usually measured following ASTM D 257 at low electrical 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 completed 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.




### Thermally Stimulated Depolarization Current

Poling under High Voltage (0-10 kV) High T (> Tg) → Hold Voltage and Quench to below Tg

Short Circuit Sample → TSDC Test: Temperature Ramp




## 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: -184 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

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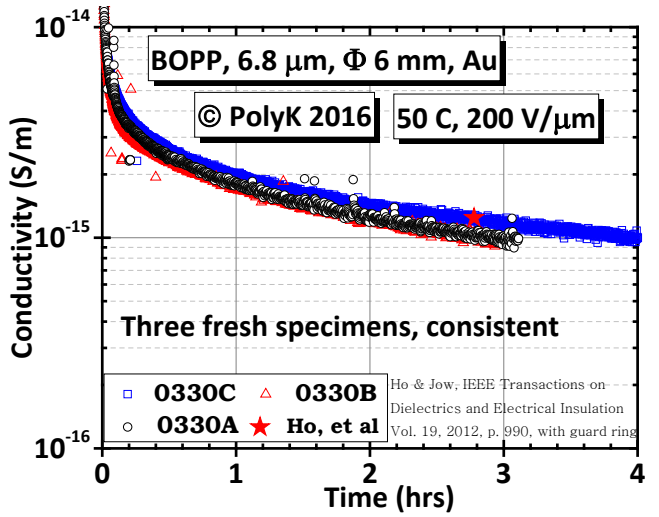
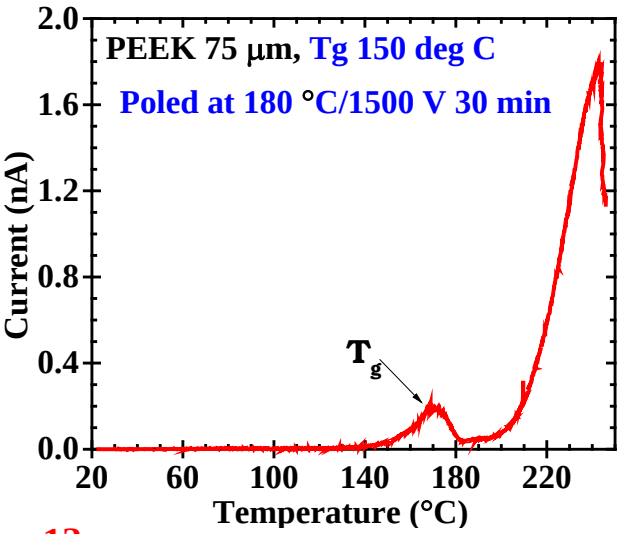
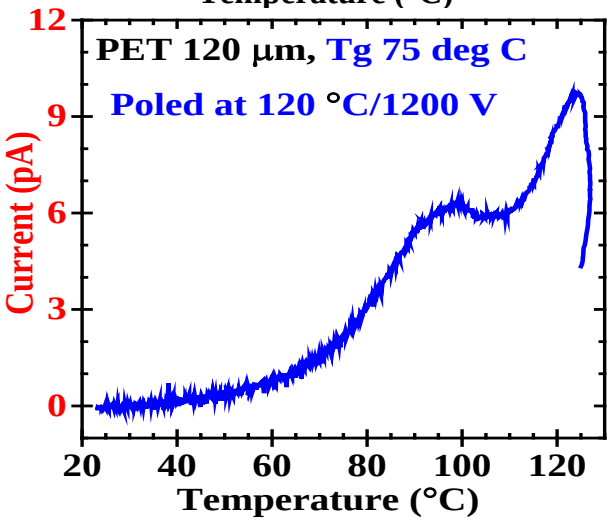
# Leakage Current, TSDC, & Pyroelectric: Typical Test Results

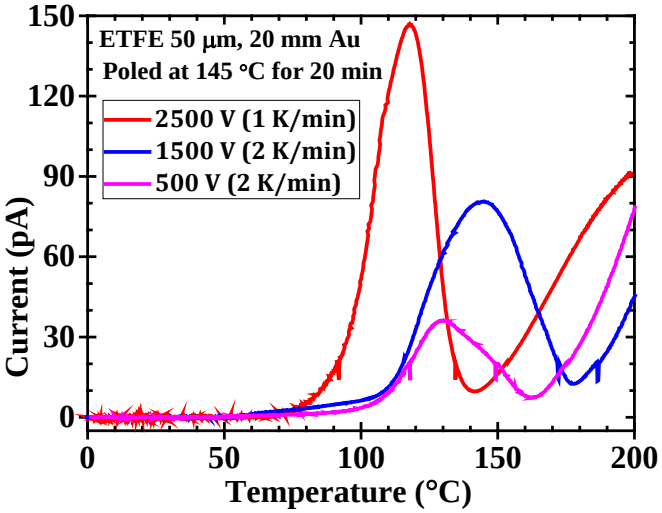



Commercial BOPP capacitor film, 6.8 um thickness. Three fresh specimens have similar leakage current, which are consistent with that reported by Ho and Jow at the same temperature and field by a test system with guard electrode.



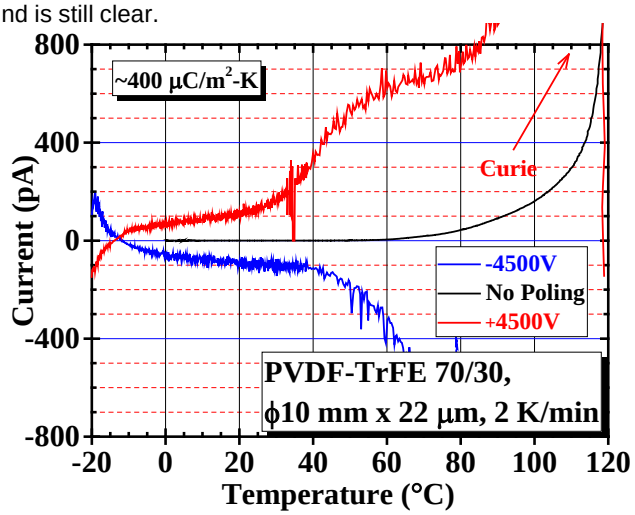

A special flexible glass dielectric with Tg >750 C: high electric resistivity at >200 °C. Note: the noises at high T and high V are usually from the local breakdown of air or sample. The trend is still clear.




**TSDC Test of ETFE with Tg ~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**

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