High Temperature Thin Film Polymer Dielectric Based Capacitors for HEV Power Electronic Systems

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Overview

Timeline

- Project start: October 2008
- Project end: September 2010
- Percent complete (50%)

Budget

- Total project funding
  - DOE: $250K
- Funding received in FY08 and FY09 include:
  - FY08 - $100k
  - FY09 - $150k

Barriers

- Barriers
  - Capacitor Cost (up to 23% of inverter)
  - Thermal control
  - Volume

Partners

- Electronic Concepts, Inc.
- Sandia National Laboratories

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Electronic Concepts, Inc.

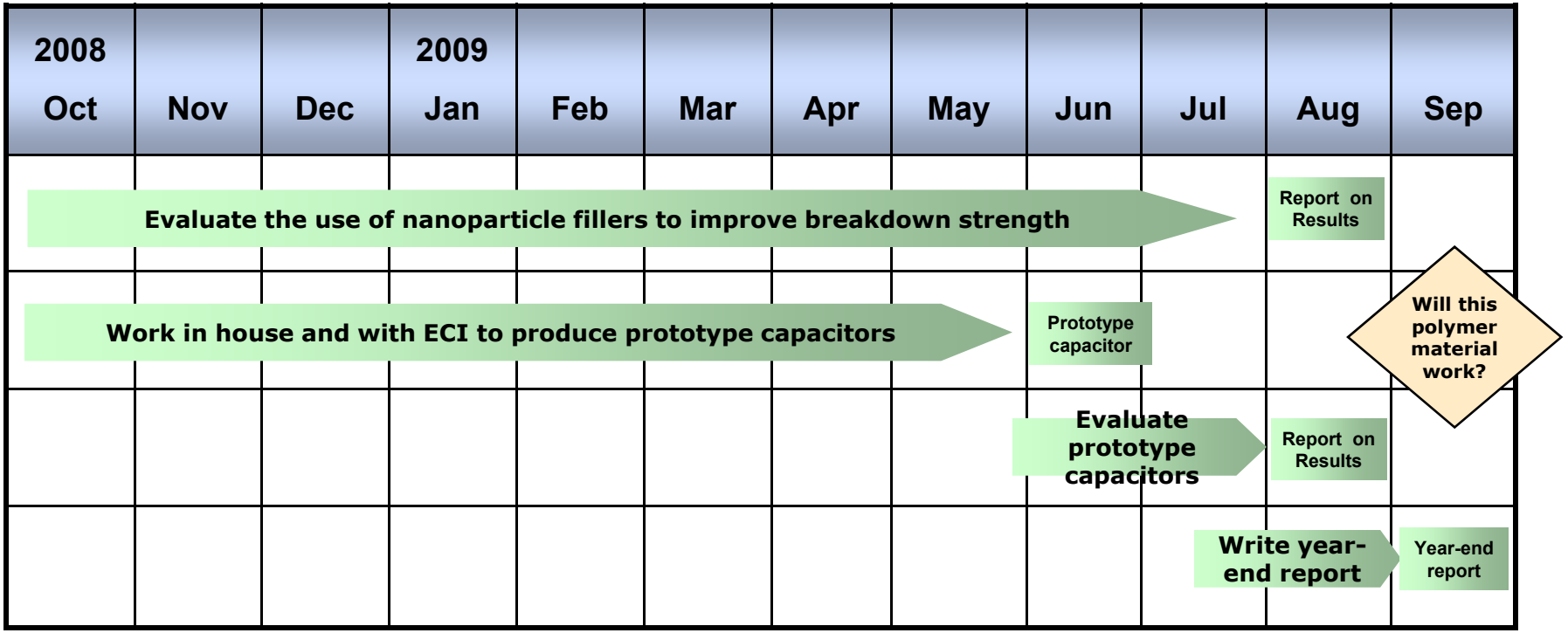
Project Objectives

- DC bus capacitors are currently the largest and the lowest reliability component of fuel cell and electric hybrid vehicle inverters. Furthermore, current DC bus capacitors cannot tolerate temperatures greater than 120°C.

- Our project goal is to develop a replacement technology for DC bus capacitors for use in electric hybrid and fuel cell vehicles. ***Our technical goal is to enhance high temperature performance and volumetric efficiency compared to present dielectrics.*** Specific metrics include the development of polymer film dielectrics with dissipation factors of 0.01 or less at 150 ºC.

Milestones

Project schedule

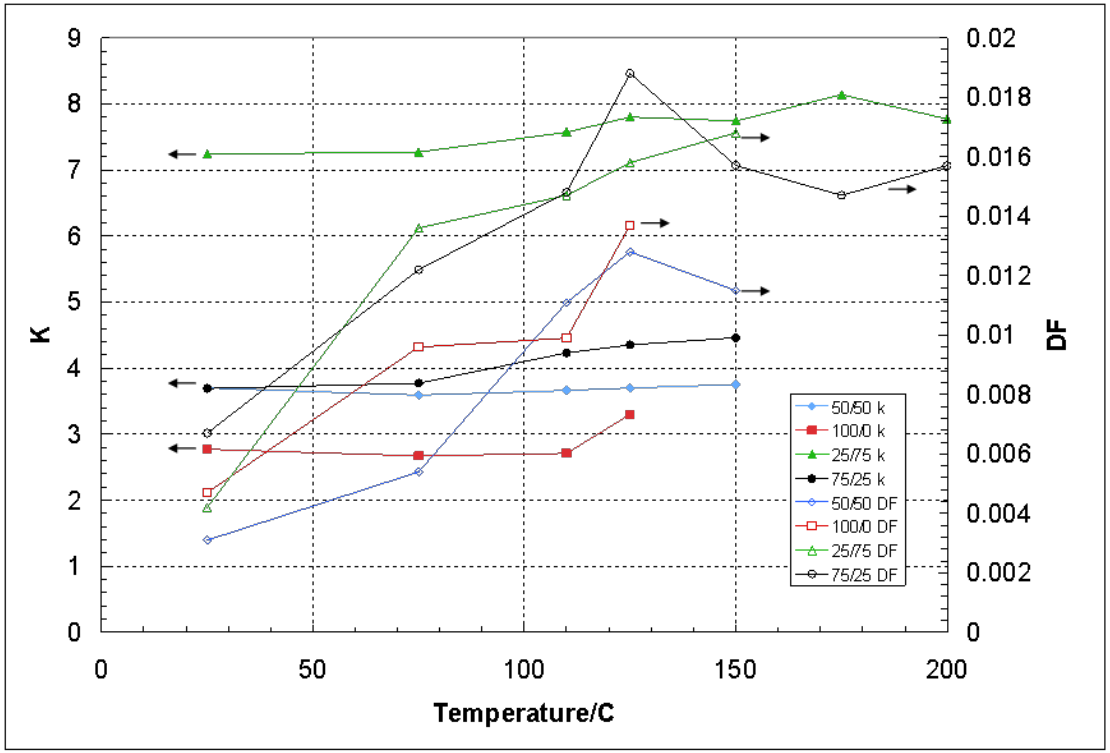


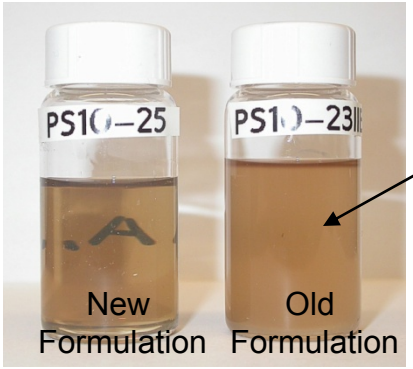
Approach

- **Developing high temperature high dielectric polymer capable of forming very thin films**
  - **Controlled polymerization chemistry based on the Ring Opening Methathesis Polymerization allows for fine control of polymer composition and molecular weight**
- **Working with ECI to produce rolls of polymer film and prototype capacitors**
- **Develop nanocomposites of high temperature polymer dielectrics to improve energy density**

Technical Accomplishments/Progress/Results

- Synthesized and characterized the copolymer stoichiometry to balance high temperature dielectric performance with need to process and manipulate the thin dielectric film
- Initial film formation runs at ECI produced film, however, the material was not suitable for capacitor formation
- Addressing film formation process issues as they arise at ECI
  - Reformulated polymer to provide better casting solution longevity and performance





Will eventually phase separate

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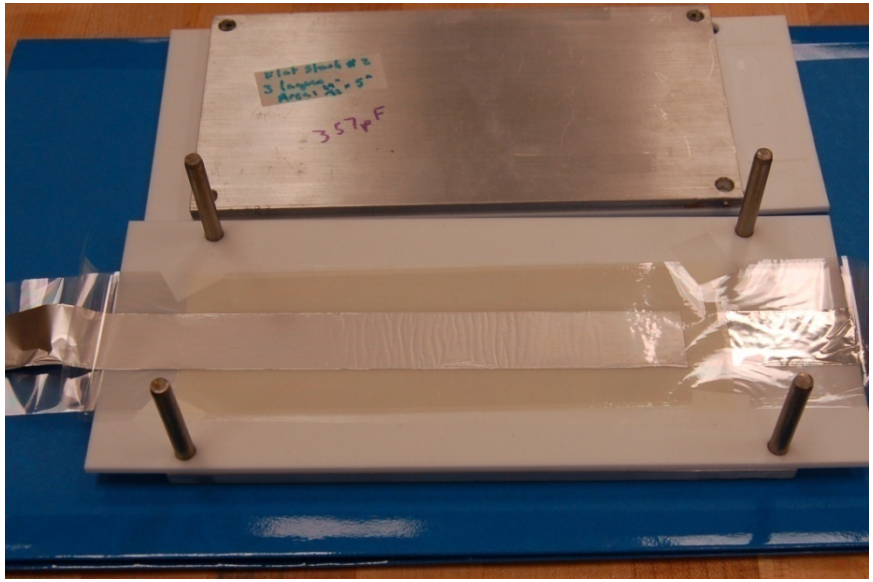
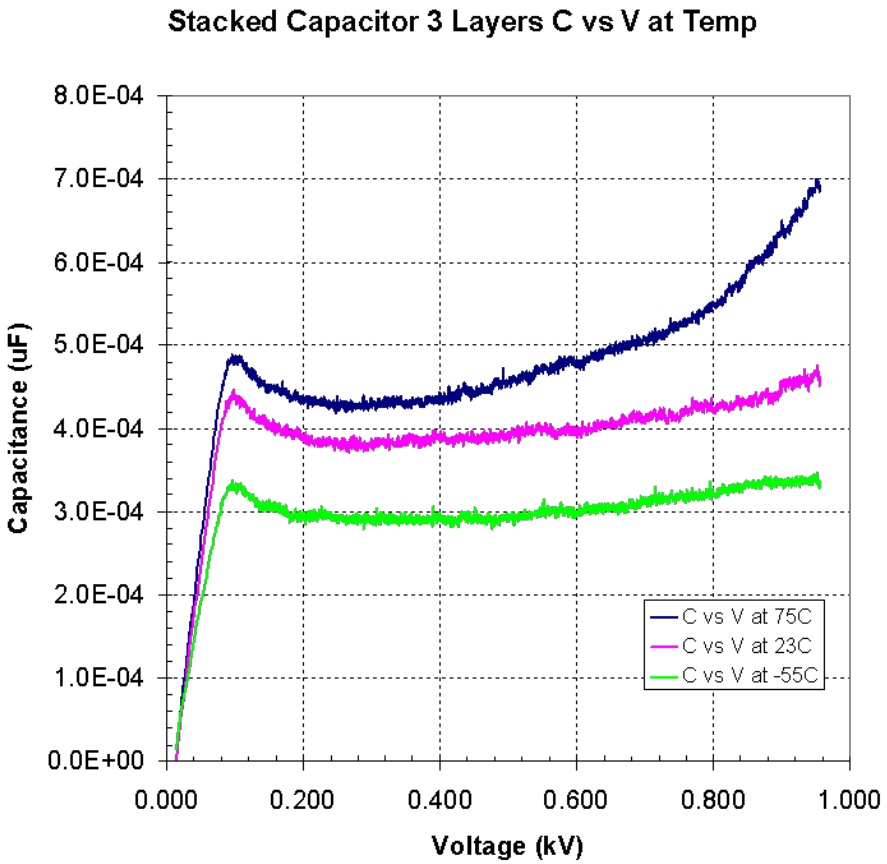
Technical Accomplishments/Progress/Results





- Assembled two stacked capacitors at Sandia using 5 μm Al as electrodes with 8 μm thick dielectric films produced using a solvent casting process

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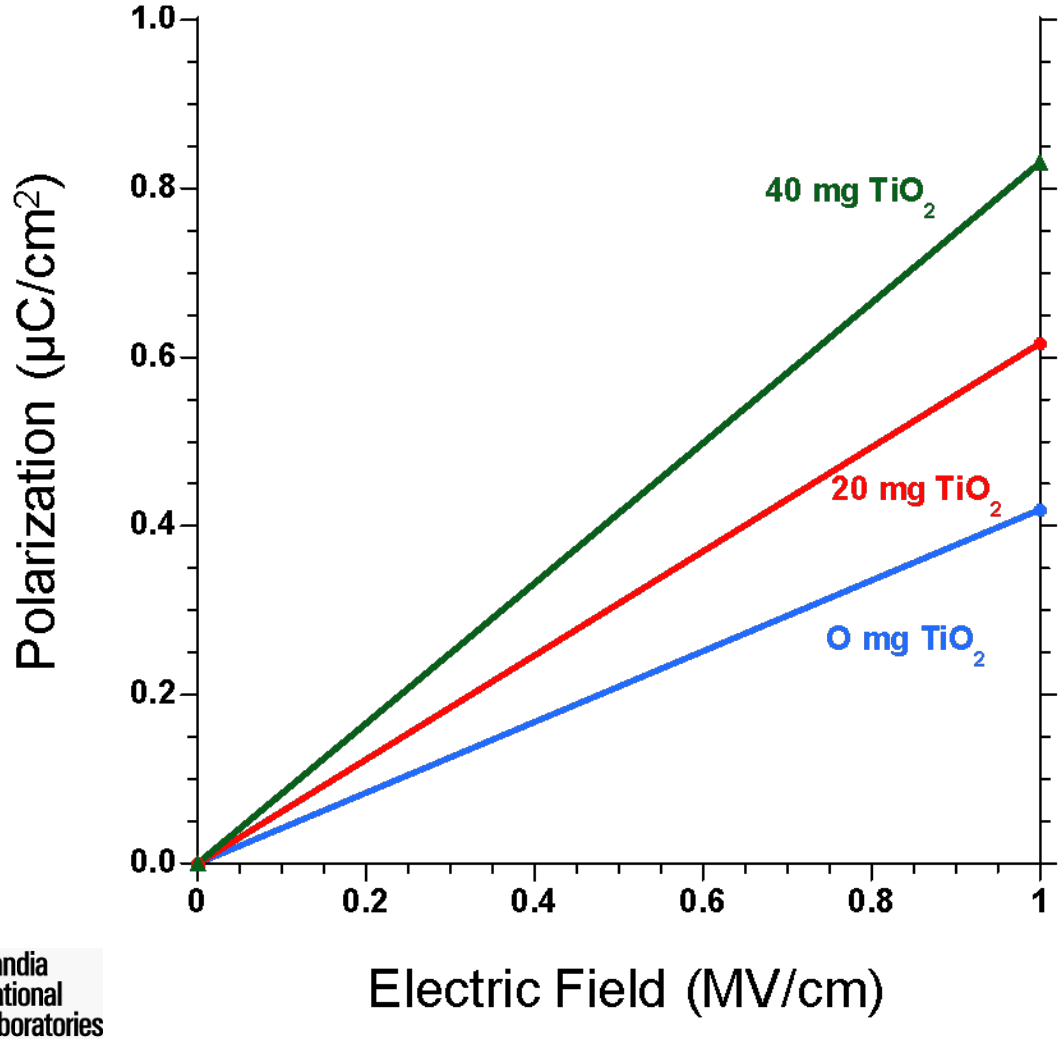
Technical Accomplishments/Progress/Results

High Field Polarization With Increasing TiO_2 Nanoparticle Additions



Effective K Values
For 1 MV/cm Field

P	K	TiO2
0.42	4.6	0
0.61	6.9	20 mg
0.82	9.2	40 mg

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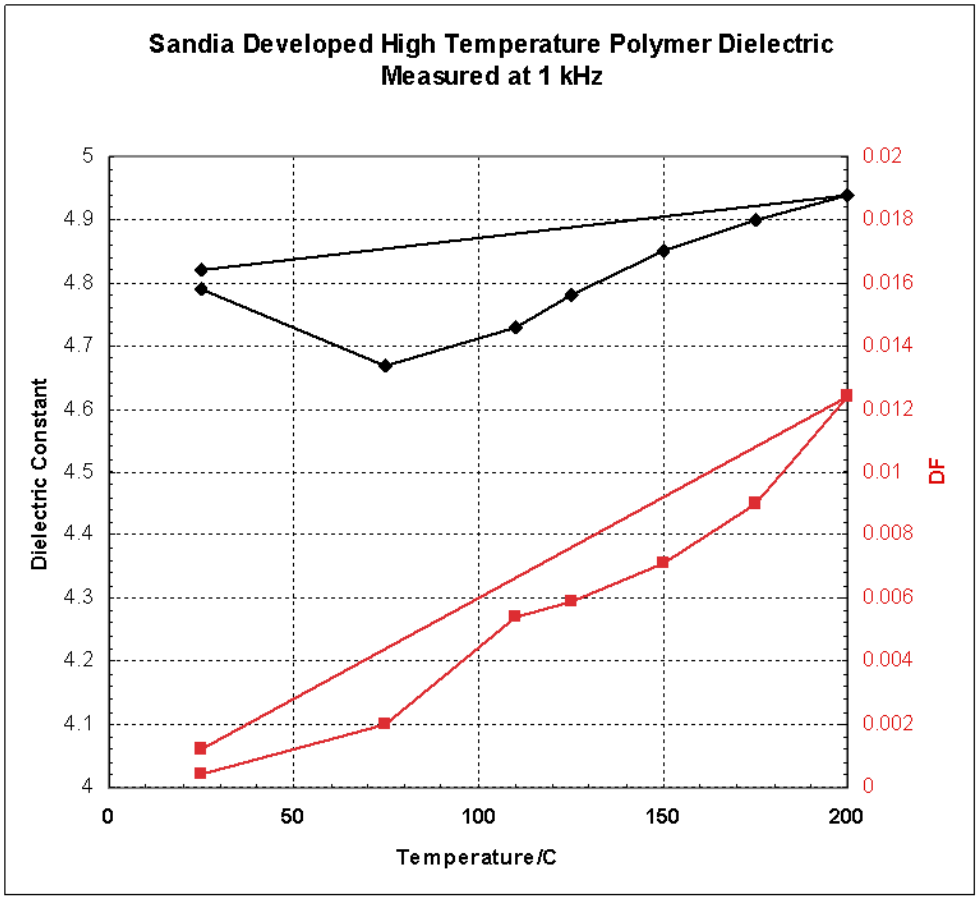
Future Work

- **Continue transition polymer film technology to industry - Producing films and prototype capacitors at ECI**
  - **A specific goal is to produce 100 m of capacitor film**
  - **Evaluate additional novel high temperature polymer formulations as needed to optimize solution casting process**
- **Evaluating polymer dielectric at various frequencies**
- **If nanoparticle loading shows improvement in breakdown strength, begin production of prototype capacitors and evaluate**
  - **A specific goal will be the production of a prototype "stacked capacitor"**

Summary

- We have characterized the high temperature film electrical to provide the stoichiometry that meets high temperature performance metrics while allowing for film processing
- Working with ECI to produce prototype capacitors and solving problems as the occur related to transitioning from a laboratory to a pilot scale operation



•Developing nanocomposite chemistry to increase energy density of high temperature dielectrics

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