



The University of Texas at Austin

Center for Electromechanics

# **DIELECTRICS AND ELECTRICAL INSULATION**

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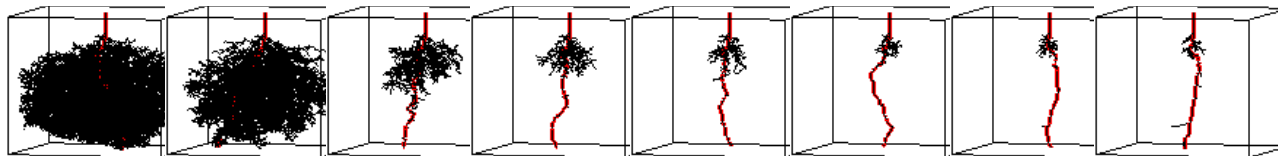
**Robert Hebner, Ph.D.**

**Center for Electromechanics**

**University of Texas at Austin**

# Background - Personal

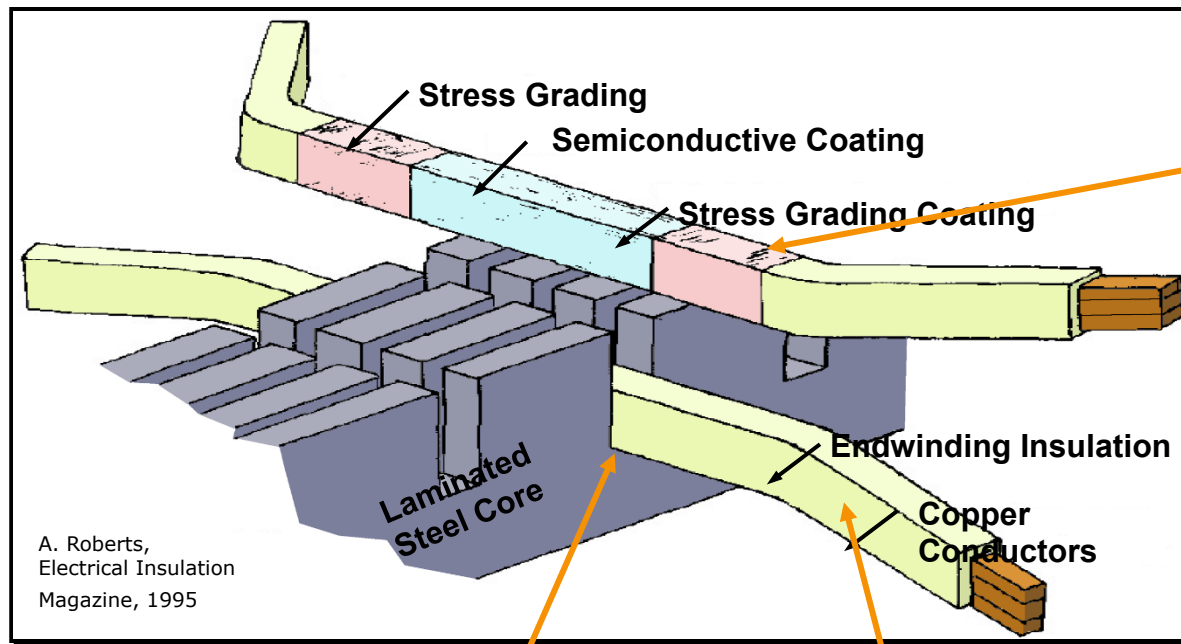
- Decades of research experience
- 50+ publications in the field
- Twice selected president of the IEEE Dielectrics and Electrical Insulation Society



Longer free path →

Simulating Mode Transitions during  
Breakdown in Liquids  
Brian T. Murphy, Robert E. Hebner,  
Edward F. Kelley

# Background - CEM



Two conference papers

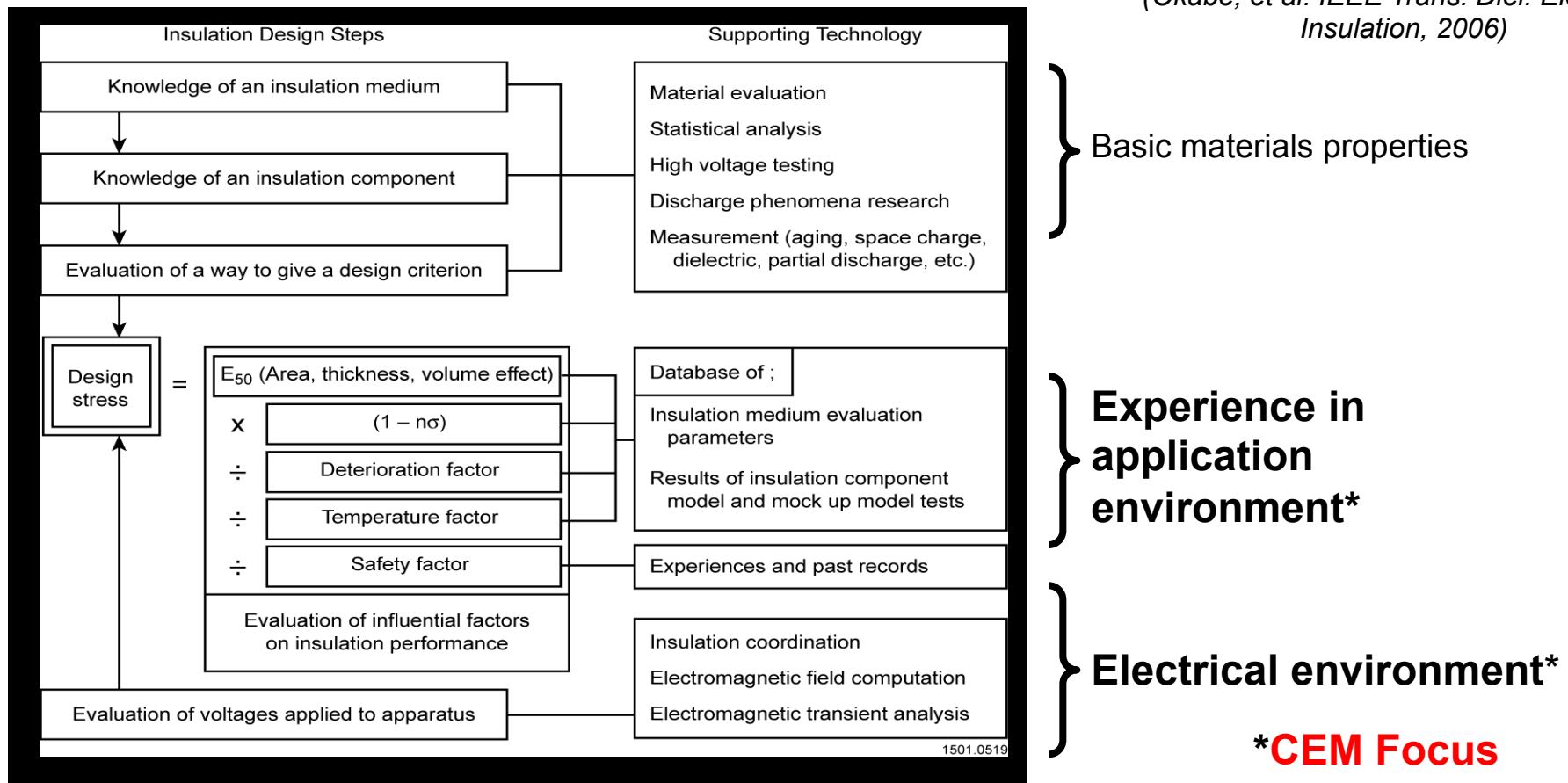
Forensic investigation

Failure due to rubbing and flow

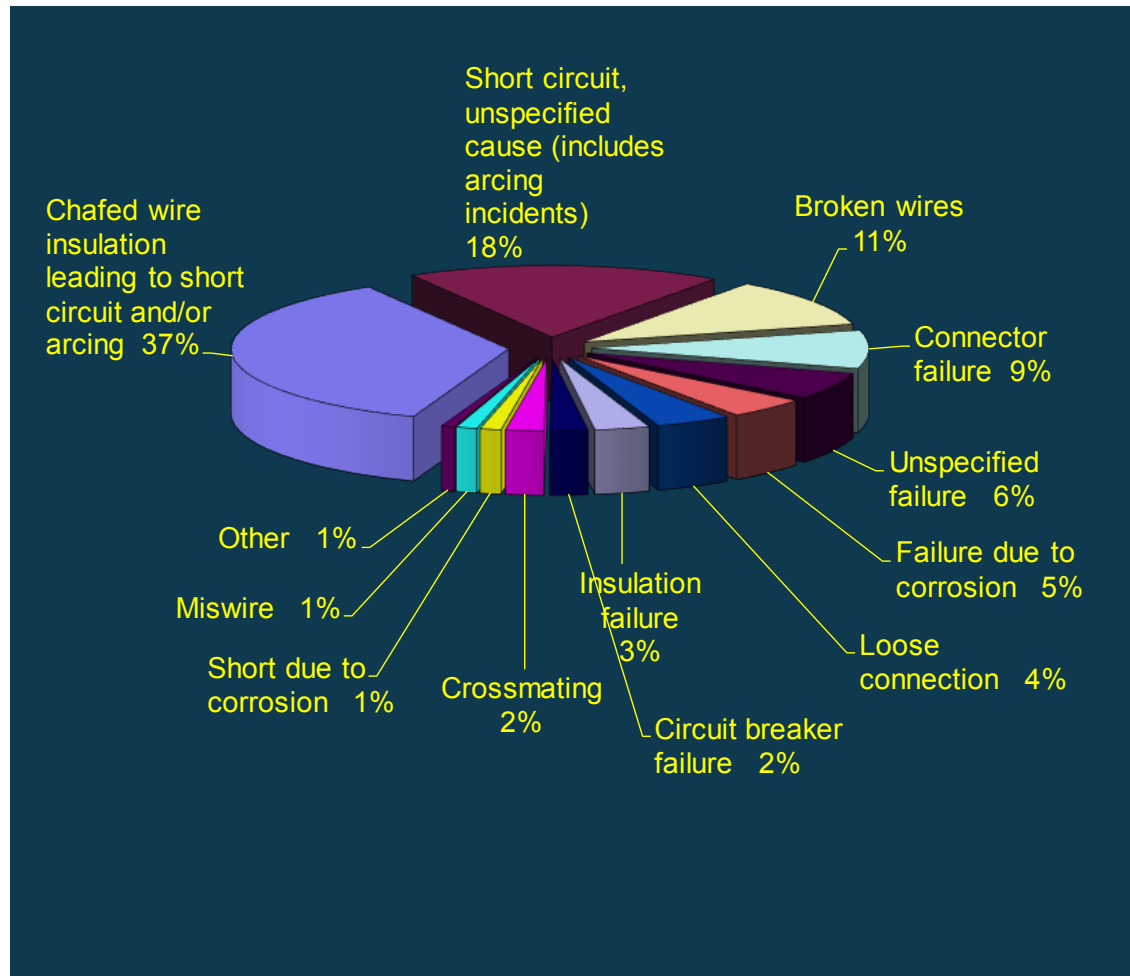
# Key Takeaways

Vendor knows material – user knows environment  
Failures are due to environment

(Okabe, et al. *IEEE Trans. Dielect. Elec. Insulation*, 2006)



# Published NAVAIR Data on Wiring Failure

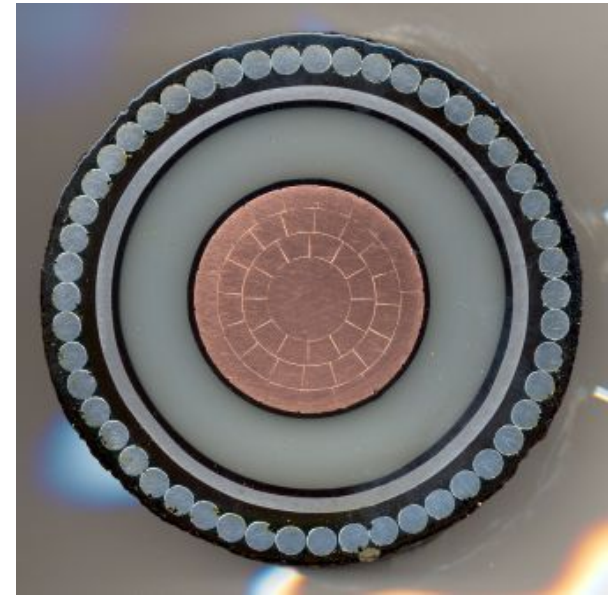


Failure primarily due to environment, not poor insulation

# Current CEM Research - Cables

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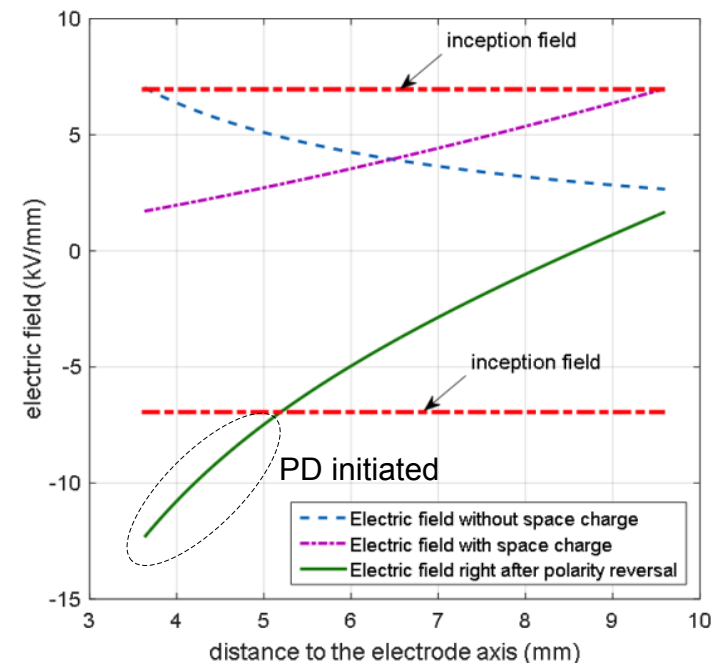
- Cable plant is too large in electrified
  - Ships
  - Aircraft
  - Automobiles
- Analysis for existing and emerging materials is that they can be significantly smaller thermally and electrically.
- Focus is developing environmental tests that predict life.
  - Multiphysics challenge
    - Electrical
    - Thermal
    - Mechanical
    - Chemical



# Technical Approach

- Focus on dc cables
  - Much less physics-of-failure data for dc
    - Worldwide interest growing
      - Cable plant can be smaller if loads are also dc
- Accelerate electrical/mechanical/thermal aging
- Use partial discharge measurements to gauge health

Space charge impact after polarity reversal – a unique dc challenge



# Strategic Partnership

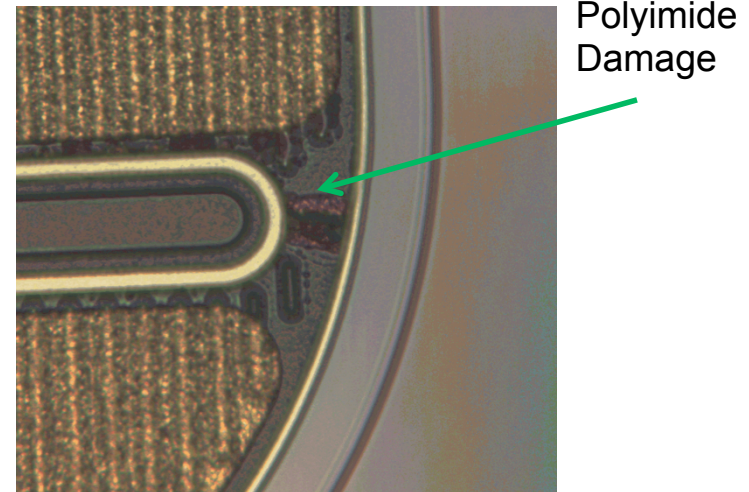
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- Gian Carlo Montanari, University of Bologna
  - Globally recognized expert in relating partial discharge to life
  - Partnership mired in legal issues at present, but expect success
- Access to EU-funded program data and materials
- Joint paper
  - Trying to explore a Bayesian, rather than strictly measurements based approach, to life estimation.

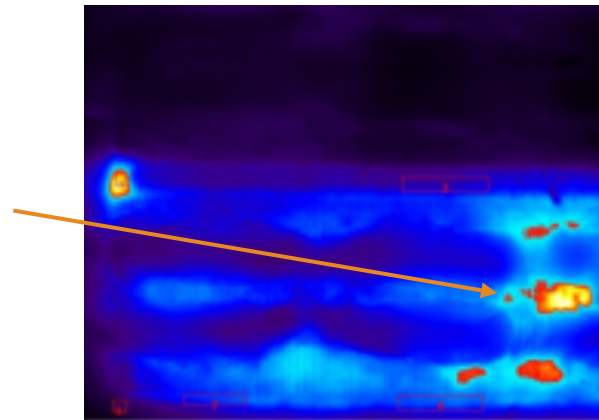


# Anticipated Next Focus

- Wide Band Gap semiconductors enable higher voltage operation.
  - Packaging problems occurring
    - Partial discharges
    - Surface discharges
    - EMI
    - Thermal failure
- CEM, ME, ECE collaborative research

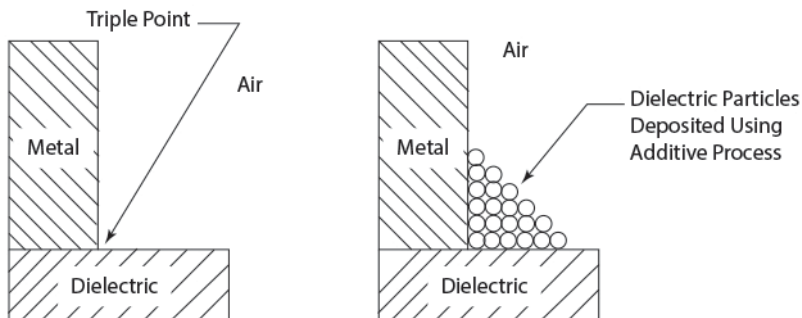


Temperature measurement  
using UT's thermal imaging  
microscope system

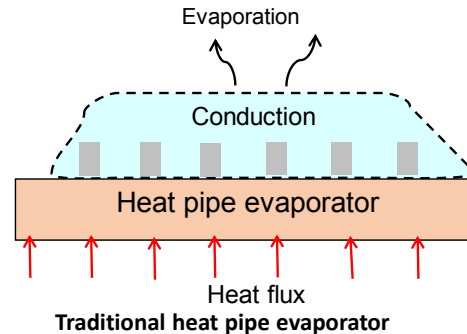


# Needed R&D

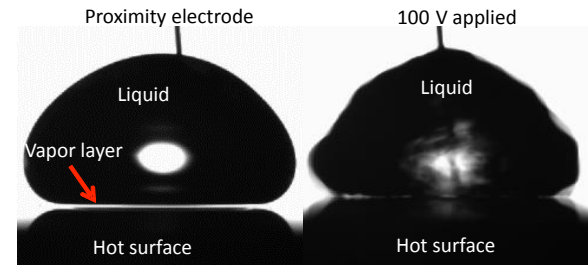
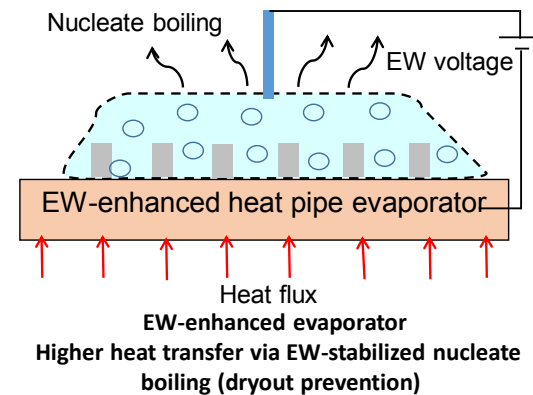
- 3-d, multiphysics model of semiconductor package
- Integrated cooling
- Functionally graded materials
  - Possibly via additive package manufacturing



Heat transfer mechanism: Conduction & evaporation



Heat transfer mechanism: Nucleate boiling



Surface dryout

Dryout prevention  
(sustained nucleate boiling)

Demonstration of nucleate boiling  
and dryout prevention using electrowetting (EW)

# Summary

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- UT research aims
  - Improved asset management via better life prediction
    - Characterizing use environment
  - Modeling and manufacturing technologies that lead to longer service life
  - Team with others for access to emerging materials