# Understanding Surface Breakdown in Electronegative Gases

LABORATORY DIRECTED RESEARCH & DEVELOPMENT

**Sandia National Laboratories**

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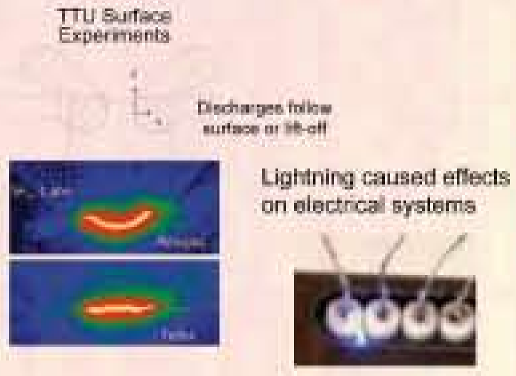
### *Project Purpose and Approach*

To develop models and understanding for how discharges interact with surfaces in dense electronegative gases, where streamer and leader phenomena are the primary breakdown mechanisms. We plan to show, by means of theoretical and experimental investigations, how they are influenced and directed by interactions with the surface.

### *Significance of Results*

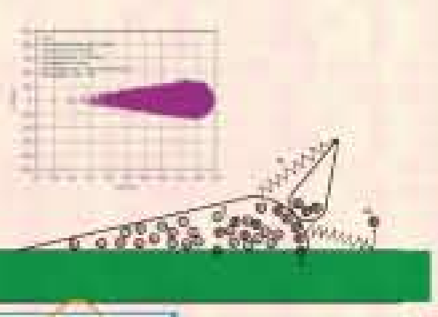
Surface flashover in dense media is by far the most frequent cause of failure in pulsed power drivers and, in the case of Z, potentially devastating. If successful, this effort will isolate significant contributing factors to surface flashover in high-pressure electronegative gases, allowing enhanced designs and greater machine reliability.





## Approach-Details

- **Modeling**
  - Improve & apply 3D local Monte Carlo modeling to capture streamer particle interactions and rates
  - Improve & apply 1.5D global fluid modeling to capture streamer growth and sustaining fields
  - Incorporate radial expansion in global model

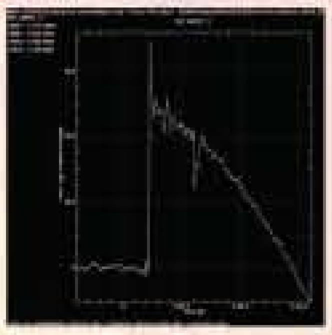


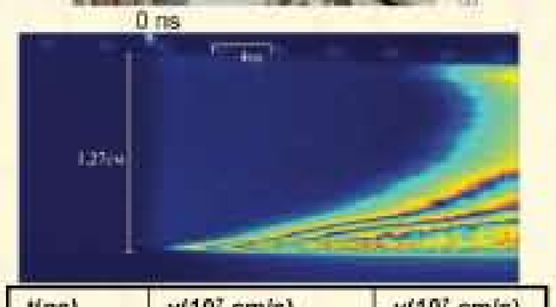
- **Experiments**
  - Utilize DC & pulsed high-pressure experiments with diagnostics
  - Utilize low-pressure experiments to measure gas and surface rate parameters

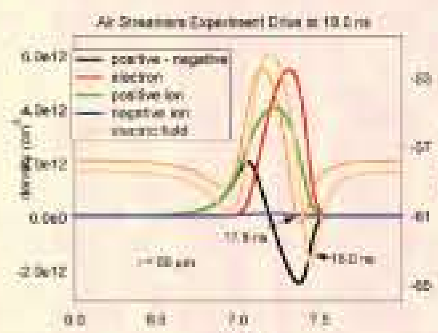

- **Links to other projects**
  - Models used for gas discharge studies in concurrent ESRF experiments
  - Develop QMD techniques in LDRD to predict surface interaction parameters

## Results

### *Model Gas Breakdown in Concurrent Experiments (air discharge velocity)*



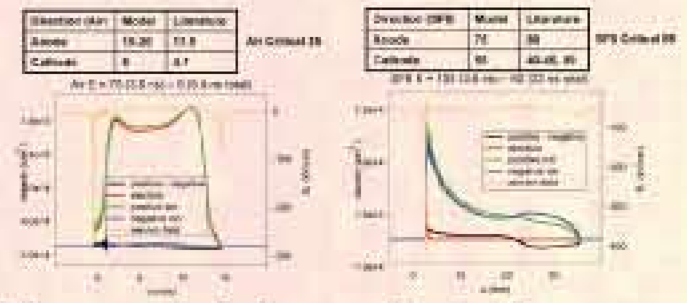



| t(ns) | v($10^7$ cm/s) experiment | v($10^7$ cm/s) calculation |
|---|---|---|
| 10 | 2 | 1.5 |
| 18 | 4 | 3.5 |

### *Critical and Sustaining Fields E(kV/cm)*

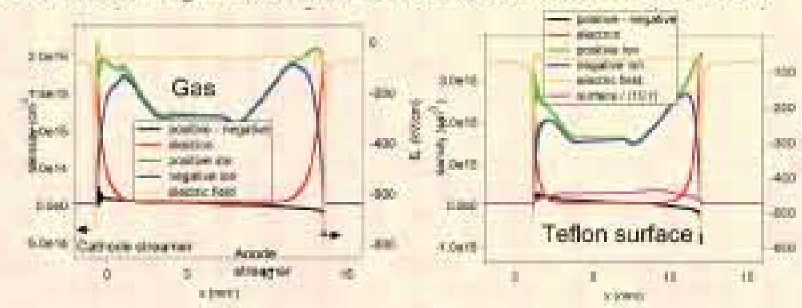
- **Gas Only Simulation Results (50 micron radius)**
  - Launched streamers at a high field and examined how they propagate at lower fields (sustaining levels)



- **Two types of influence on ionization wave thresholds**
  - How is critical field influenced by surface
  - How is sustaining field influenced by surface

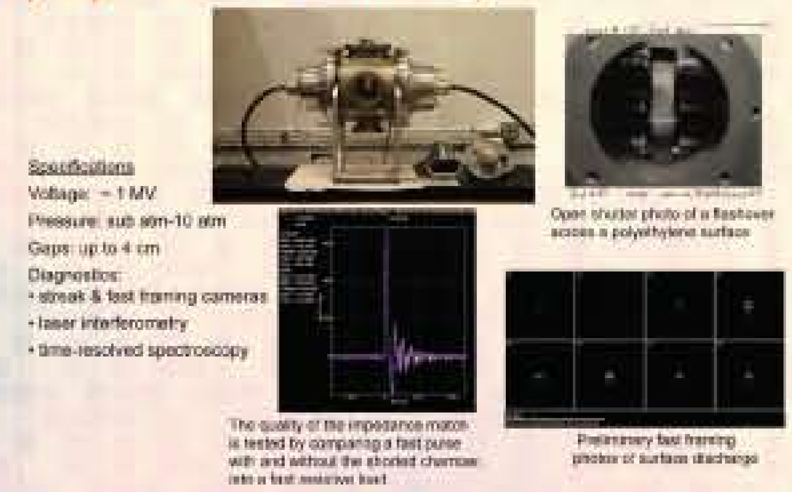
### *Known Surface Interactions Included In Model*

- **Surface Streamer Model**
  - $SF_6$ 105 kV/cm (3.6 ns) – 75 kV/cm (4.2 ns total)
  - 50 micron radius
  - $SF_6$ collisions and attachment, Photoionization
  - Surface photoemission, Secondary electron emission
- **Comparisons between gas and surface ionization waves (streamers)**




- **Oscillations result from high gradient in flux-corrected algorithm**
  - Further refinements from breakdown literature can be added

### *Preliminary Experiments are underway*

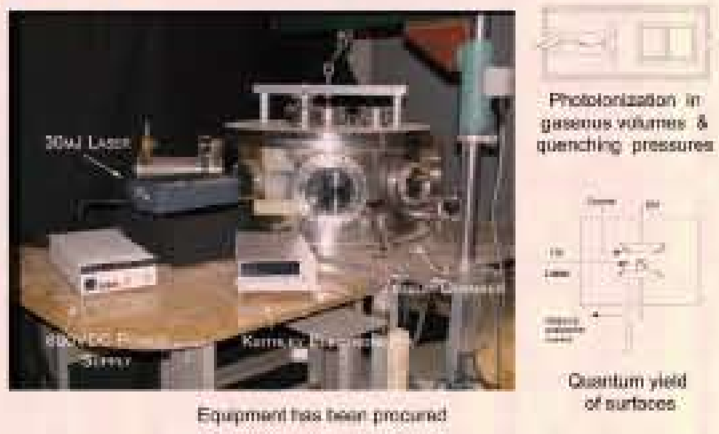



Open shutter photo of a flashover across a polyethylene surface

The quality of the impedance match is tested by comparing a fast pulse with and without the shorted chamber into a fast resistive load

Preliminary fast framing photos of surface discharge

### *Auxiliary photoionization and photoemission experiments planned*




Photoionization in gaseous volumes & quenching pressures

Quantum yield of surfaces

Equipment has been procured

## Key Accomplishments

- Incorporated all surface interactions in global gas streamer model, and examined streamer propagation and sustaining fields in both air and SF6. Extracted rate coefficients for SF6 and air from 3D local kinetic calculations with surface.
- Constructed high-pressure SF6 experimental fixture with associated pulsed drivers and conducted initial shots, with framing camera (streak camera also available).
- Results presented at IEEE Power Modulator Conference May 2008 and in proceedings:

**Streamer Initiation in Volume and Surfaces Discharges in Atmospheric Gases, J. M. Lehr, L. K. Warne, R. E. Jorgenson, Z. R. Wallace, K. C. Hodge, and M. Caldwell, IPMC Proceedings, 2008.**

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