Electrostatic Discharge Properties of Fused Silica Coatings

Allen Andersen  
*Utah State University*

Charles Sim  
*Utah State University*

JR Dennison  
*Utah State University*

Follow this and additional works at: [https://digitalcommons.usu.edu/graduate_posters](https://digitalcommons.usu.edu/graduate_posters)

Part of the Physics Commons

**Recommended Citation**
Andersen, Allen; Sim, Charles; and Dennison, JR, "Electrostatic Discharge Properties of Fused Silica Coatings" (2012). APS 4-Corners Section Regional Meeting; Socorro, NM; 2012. *Graduate Student Posters*. Paper 4.  
[https://digitalcommons.usu.edu/graduate_posters/4](https://digitalcommons.usu.edu/graduate_posters/4)

This Poster is brought to you for free and open access by the Browse all Graduate Research at DigitalCommons@USU. It has been accepted for inclusion in Graduate Student Posters by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.
Electrostatic Discharge Properties of Fused Silica Coatings

USU Materials Physics Group
Allen Andersen, Charles Sim and JR Dennison*
Utah State University, Logan, UT 84332-4414
Phone: (435) 383-4704, E-mail: allen.andersen@aggiemail.usu.edu

Abstract

The electric field value at which electrostatic discharge (ESD) occurs was studied for thin coatings of fused silica (highly disordered SiO$_2$/SiO$_x$) on conductive substrates, such as those encountered as optical coatings and in Si microfabrication. The electrostatic breakdown field was determined using an increasing voltage, while monitoring the leakage current. A simple parallel-plate capacitor geometry was used, under medium vacuum and at temperatures down to ~150 K using a liquid N$_2$ reservoir. The breakdown field, pre-breakdown arcing and IV curves for fused silica samples were compared for ~60 nm and ~80 nm thick, room and low temperature, and untreated and irradiated samples. Unlike typical I-V results for polymeric insulators, the thin film silica samples did not exhibit pre-breakdown arcing, displayed transitional resistivity after initial breakdown, and in many cases showed evidence of a second discontinuity in the I-V curves. This diversity of observed discharge phenomena is discussed in terms of breakdown modes and defect generation on a microscopic scale.

Thin Films Fused Silica Test Results

The average breakdown field strength for each test configuration was determined as $E_{\text{breakdown}} = \frac{V_{\text{breakdown}}}{d}$, where $d$ is the measured sample thickness.

<table>
<thead>
<tr>
<th>ESD Test Configuration</th>
<th>Breakdown Voltage (V)</th>
<th>Breakdown Electric Field (V/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated at Cryo $T_\text{Cry}=157.3$ K</td>
<td>2230 ± 30</td>
<td>27 ± 2</td>
</tr>
<tr>
<td>Irradiated at $T_\text{Cry}=293$ K</td>
<td>1560 ± 1</td>
<td>19.0 ± 0.4</td>
</tr>
<tr>
<td>Irradiated at Cryo $T_\text{Cry}=142.18$ K</td>
<td>1540 ± 35</td>
<td>18.8 ± 0.6</td>
</tr>
<tr>
<td>60 nm Thin Films at $T_\text{Cry}=293$ K</td>
<td>-2.5 ± 1</td>
<td>-4</td>
</tr>
</tbody>
</table>

Based on these I-V curves, we conclude for fused silica that:

- Fused silica exhibits few partial discharge current spikes prior to breakdown, unlike LDPE and other polymers.
- Transitional ESD in fused silica usually results in a breakdown to an incomplete, finite, and variable resistance rather than a complete breakdown as occurs in polymers.
- $E_{\text{breakdown}}$ in untreated fused silica is ~35% higher at low T.
- $E_{\text{breakdown}}$ at low T is affected by a change in the number of defect states due to exposure to high radiation (but not at room T).

Conclusions

ESD tests were performed on ~60 nm thick films of essentially the same material. The I-V curves were remarkably similar to those of the thicker ~60 µm, exhibiting few pre-break discharges and transitional breakdown.

$E_{\text{breakdown}}$ for the thinner films is ~5 lower than for thicker films. This suggests that thickness-dependant, T-independent (Fowler-Nordheim like) tunneling transport mechanisms dominate for thinner films and T-dependant, thickness-independent (Schottky-like) transport mechanisms dominate thicker films.

References and Acknowledgements


We gratefully acknowledge contributions from the Materials Physics Groups including instrumentation and experimental efforts by Justin Dekany, help with thin film measurements by Matthew Stromo, and solid modeling by Bobby Johnson. This work was supported through funding from NASA Goddard Space Flight Center.