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Charge Storage Measurements of Resistivity for Dielectric Samples from the CRRES Internal Discharge Monitor

Nelson W. Green
Utah State University

A. R. Frederickson

JR Dennison
Utah State University

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Relativistic velocities were experimentally determined using charge storage methods for six samples remaining from the internal discharge monitor (IDM) of the Compton Gamma Ray Observatory (CGRO). These tests were performed over a period of four or five weeks each in a vacuum of <1 × 10⁻⁶ Torr with an average temperature of 25°C to simulate space environments. Samples tested included different dielectric materials as well as non-dielectric materials in an effort to determine the primary cause of measured charge transport. Preliminary measurements of resistivities were evaluated with extended ASTM test methods. The one-minute wait time suggested for the standard ASTM test is much shorter than the measured polarization current decay times for each sample indicating that the primary currents used to determine ASTM resistivity are caused by polarization rather than charge transport in the applied electric field rather than charge transport through the bulk of the dielectric. Testing over much longer period of time in vacuum was intended to allow this polarization current to decay away and to allow the determination of charged particles transport through a dielectric material. The difference in measured resistivity is largely attributed to the dominance of polarization currents in the first hours after the application of an electric field itself. A simple model of the measured surface voltage as a function of elapsed time for the IDM samples incorporates the initial voltage drop, the time constant for the polarization decay, and a voltage offset. This model is compared to experimental data in the figures and the goodness of fit values are determined.

**Abstract**

Charge storage experiments were performed on six dielectric samples remaining from the Compton Gamma Ray Observatory's internal discharge monitor (IDM). Preliminary measurements of resistivity were evaluated with extended ASTM test methods. The one-minute wait time suggested for the standard ASTM test is much shorter than the measured polarization current decay times for each sample indicating that the primary currents used to determine ASTM resistivity are caused by polarization rather than charge transport in the applied electric field rather than charge transport through the bulk of the dielectric. Testing over much longer period of time in vacuum was intended to allow this polarization current to decay away and to allow the determination of charged particles transport through a dielectric material. The difference in measured resistivity is largely attributed to the dominance of polarization currents in the first hours after the application of an electric field itself. A simple model of the measured surface voltage as a function of elapsed time for the IDM samples incorporates the initial voltage drop, the time constant for the polarization decay, and a voltage offset. This model is compared to experimental data in the figures and the goodness of fit values are determined.

**Table 1**

<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Thickness</th>
<th>Color</th>
<th>White Room Test</th>
<th>Vacuum Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR4</td>
<td>CEM</td>
<td>0.125</td>
<td>Red</td>
<td>125</td>
<td>123</td>
</tr>
<tr>
<td>PTFE</td>
<td>CEM</td>
<td>0.125</td>
<td>Blue</td>
<td>145</td>
<td>173</td>
</tr>
<tr>
<td>Alumina</td>
<td>OCM</td>
<td>0.25</td>
<td>Black</td>
<td>150</td>
<td>124</td>
</tr>
</tbody>
</table>

**Figure 1**

- **A** shows a time record for each of the six dielectric samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **B** shows a plot of surface temperature as a function of time for each of the six dielectric samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **C** shows a plot of surface temperature as a function of time for each of the six dielectric samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **D** shows a plot of surface temperature as a function of time for each of the six dielectric samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.

**Figure 2**

- **A** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **B** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **C** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **D** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.

**Figure 3**

- **A** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **B** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **C** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **D** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.

**Figure 4**

- **A** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **B** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **C** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.
- **D** shows a comparison of the measured surface voltage as a function of elapsed time for the IDM samples. The data is typically measured for 4-5 weeks in vacuum with an average temperature of 25°C.