Introduction

Goal: remove lunar dust from solar cells.

Dust is a big problem. Lunar regolith is [1, 2]
• particularly adhesive ($0.01 \leq f_c \leq 0.1$ [kPa]),
• difficult / expensive to remove, and
• destructive to lunar mission longevity.

On solar cell arrays, dust [3]
• causes reflective loss,
• blocks light, and
• reduces power generation.

The Missouri S&T Big Idea team proposes to use piezoelectric actuators bonded to the back side of a solar cell to vibrate the cell at natural frequencies and eject accumulated dust.

Challenges

Materials:
• Induce enough surface acceleration to overcome particle adhesion
• Withstand $-181\,^\circ C \leq T \leq 101\,^\circ C$
• Actuator-substrate bond fatigue life: endure “as-needed” actuation

Power:
• Safely store and discharge power in actuation
• Vibrate actuator at solar cell natural frequency
• Track resonance to adjust drive frequency, control duty cycle, and detect failure

Mechanical:
• Optimize placement of actuators to maximize surface acceleration
• “Scale up” to full solar arrays application

The Piezoelectric Effect

Figure 1: Piezoelectric effect illustration.

Existing Work

Yezad Anklesaria showed that piezoelectric actuators could remove contaminants such as table salt, aluminum oxide, silicon carbide, mineral oil, water, and toothpaste from quartz-crystal glass.

Table 1: Anklesaria’s piezoelectric lens cleaner efficacy matrix.

<table>
<thead>
<tr>
<th>Salt</th>
<th>Silicon carbide</th>
<th>Aluminum oxide</th>
<th>Water (cps)</th>
<th>Mineral oil (cps)</th>
<th>Toothpaste (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 [µm]</td>
<td>75 [µm]</td>
<td>9.5 [µm]</td>
<td>0.890</td>
<td>700</td>
<td>85e3</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Partial</td>
<td>Yes</td>
<td>Partial</td>
<td>Partial</td>
</tr>
</tbody>
</table>

Figure 2: Table salt ejection from glass substrate.

Higher Modes

Figure 3: Higher mode illustration.

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References


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