All-Solid-State Electrochromic Multilayer System For Surface Heat Radiation Control

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Radiation Characteristics

The blackbody spectrum

Emissivity $\varepsilon$ and Device Performance Parameters

$\varepsilon = \int_0^\infty \int M(\lambda, T) d\lambda d\Omega$

$R = \text{reflectance}$

$M = \text{blackbody spectral emittance}$

Reflectance modulating single-grid electrochromic device

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness [nm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a-WO$_3$</td>
<td>160</td>
</tr>
<tr>
<td>a-Ta$_2$O$_5$</td>
<td>350</td>
</tr>
<tr>
<td>a-WO$_3$</td>
<td>160</td>
</tr>
</tbody>
</table>

Purpose of cover layers:
- protect the polymeric WO$_3$-layer
- prevent Li$^+$ chemical reactions
- prevent moisture incorporation
- act as an optical impedance match to improve switching performance

Simulated device performance

- ZnSe thickness was optimized for several environment temperatures (1) 300K, (2) 600K, (3) 900K
- Stability of ZnSe single layers in atomic oxygen (AO) and during UV radiation was tested (simulation of low earth orbit conditions)
- Change in ZnSe optical constants during AO and UV treatment was used to simulate degradation effects for device performance
- ZnSe thickness was optimized for several environment temperatures

Simulated device performance with a 600 nm thick ZnSe cover

Emittance modulation and ratio as function of ZnSe thickness and temperature

Conclusions

- Operational all-solid-state electrochromic devices for thermal emittance modulation
- Single-grid device with opposite switching behavior than predicted by simulation, because of non-ideal Li$^+$ distribution
- Best experimental device performance for single-grid device
- Cover layer improves device switching behavior and reliability
- Atomic oxygen exposure and UV radiation cause degradation of the ZnSe layer, and therefore a change in emissivity modulation and ratio of the device

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