ABSORBER COATINGS FOR MID-INFRARED ASTROPHYSICS

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3. DEPARTMENT OF PHYSICS AND ASTRONOMY, THE JOHNS HOPKINS UNIVERSITY
• Physics and Mathematic Major

• Physics Club and Outreach

• Studied Computational Biophysics, moving on to Planetary Science research
BACKGROUND

• HIRMES - High Resolution Mid-InfrarEd Spectrometer
  • Functioning in the 20-200 micrometer range
    • Eliminate

• SOFIA – Stratospheric Observatory for Infrared Astronomy
APPROACH

• **Goals**
  - Create a material that absorbs stray light
  - Lightweight, easy applicable
  - Known dielectric function
    - What is this?
      - Describes the electric response to incident radiation
  - Diffusively reflects rather than specularly reflects
  - Withstand cryogenic temperatures (µK)

• **First Step**- Characterize the materials
  - Dielectric functions

• **Second Step**- Matlab Model
  - Model each sample layer with found dielectric function

• **Third Step**- Manufacturing
  - Create sample plates
**APPROACH**

3M Glass Microspheres
~100 microns in diameter

Epotech 377H Graphene-Loaded Epoxy
sC(5):377(65):SiOx(30)

Specular

Diffuse

Aeroglaze Z306
<table>
<thead>
<tr>
<th>Sample Letter</th>
<th>Thickness of Epoxy (µm)</th>
<th>Final Layer Count</th>
<th>Composition (Layer Order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>579</td>
<td>2</td>
<td>Epoxy, Z306</td>
</tr>
<tr>
<td>B</td>
<td>644</td>
<td>3</td>
<td>Epoxy, Z306, K1</td>
</tr>
<tr>
<td>C</td>
<td>449</td>
<td>3</td>
<td>Epoxy, K1, Z306</td>
</tr>
<tr>
<td>D</td>
<td>505</td>
<td>4</td>
<td>Epoxy, K1, Z306, K1</td>
</tr>
<tr>
<td>E</td>
<td>707</td>
<td>1</td>
<td>Epoxy</td>
</tr>
<tr>
<td>F</td>
<td>494</td>
<td>2</td>
<td>Epoxy, K1</td>
</tr>
</tbody>
</table>
DIELECTRIC CHARACTERIZATION

- Frequency response data taken with a microwave network vector analyzer

![WR28.0 Sampleholder: K1 Microspheres](image)

- Periodic structure of reflection shows constructive and destructive interference
- Shows the “true density” as seen by an incident electromagnetic wave
- Loss is due to dielectric properties of microspheres, scattering due to geometry is not considered
THE MODEL

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (µm)</th>
<th>Dielectric (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>500</td>
<td>1 + 1x10^8i</td>
</tr>
<tr>
<td>Epoxy 377H</td>
<td>500</td>
<td>7.4 + 0.4i</td>
</tr>
<tr>
<td>3M K1 Microspheres</td>
<td>100</td>
<td>1.1 + 0.002i</td>
</tr>
<tr>
<td>Aeroglaze Z306</td>
<td>50</td>
<td>2.6 + 0.6i</td>
</tr>
</tbody>
</table>

Response vs. Wavelength
RESULTS

• **Conclusions**
  • Our proposed material can be manufactured at a small scale
  • Model predicts correct response
  • Drawback – model cannot predict response from diffuse scattering due to microspheres

• **Further Studies**
  • Measure optical frequency-dependent response with a Fourier Transform Spectrometer
ACKNOWLEDGEMENTS

Coe College Advisors

Steve Feller  
Ugur Akgun  
Firdevs Duru  
Mario Affatigato
ACKNOWLEDGEMENTS

AIP/SPS
ACKNOWLEDGEMENTS

I would like to give special thanks to the Observational Cosmology Lab at NASA Goddard Space Flight Center and my mentors:

- Edward J. Wollack
- Karwan Rostem
- Dave Chuss and Riley McCarten, Villanova University
- Paul Mirel, Observational Cosmology Lab, NASA GSFC
- Kyle Johnson, George Washington University