Thermal Control of CubeSats Utilizing an Electrochromic Variable Emissivity Device

Spacecraft Thermal Management Systems 2020 - 2021

Mechanical Engineering, Chemical Engineering, & Material Science Engineering Department
Khalid Rafique, John LaRue, Daniel Knight, Allen Kine

Background

• Spacecraft Thermal Management Systems (STMS) is an undergraduate, interdisciplinary research project that works to develop an electrochromic cell for Cube and Nano Satellites.
• The electrochromic variable emissivity device (VED) will act as a method of controlling heat loads on satellites through a color change.
• In its colored or high emissivity state, the VED will prevent a net heat flux into the satellite.
• In its transparent or low emissivity state, the VED will permit heat dissipation from internal electrical components.

Project Significance

• The VED will function as a lightweight and affordable method of thermal management for a 10 cm x 10 cm Cube Satellite.
• Other thermal management methods will incur a large payload and commercial VED's cost $500 per square inch.

Requirements

The objective is to create a VED that:
• Can withstand 6 months in orbit and is capable of 3,000+ life cycles at an altitude of 500 km - 800 km.
• Has an emissivity modulation value of 0.5.
• Has a gel-electrolyte that has a conductivity value of > 10^-3 S/cm.
• Can function effectively in low pressure vacuum conditions of 10^-10 mbar.

Chemical Division

The objective of the Chemical and Material Science Division is to create, develop, and test the chemical and material properties of the VED device.

Mechanical Division

The objective of the Mechanical Division is to assist the Chemical Division by providing services such as VED control, orbital simulations, and environmental testing for the device.

• Performed vacuum environmental testing on thin films for 30 minutes at a temperature of 80 °C.
• Achieved thermal vacuum pressure of 17 mbar.
• Achieved orbital trajectory simulation for various types of orbits.

Future Work

• Perform lifecycle tests on the thin films and smart window.
• Determine emissivity of the smart window/and thin films.
• Complete combination set-up to analyze electrochromic ability during electrochemical life cycle tests.
• Begin synthesis of new gel-electrolyte samples.
• Achieve satellite temperature difference between 15 °C - 30 °C in Sun Synchronous Orbit (SSO) simulations.
• Test new pump arrangement to obtain a lower vacuum pressure.

Other Achievements

• Characterized the new sputtered film using SEM and XRD.
• Determined the thermal conductivity value of the smart window and absorbance of the electronic paper display (EPD).
• SimulatedCubeSat model in orbit on STK.
• Determined method to control voltage application to the smart window.
• Theoretically determined best pump arrangement to obtain lowest pressure for the thermal vacuum.

Contact Information

Project Manager - Anhber Truong | anhber@uci.edu
Project Coordinator - Brandon Grejeda | bgrejeda@uci.edu

Acknowledgments

Special thanks to the advisors Qiyun Lin, Izzy Zou, Daniel Knight, Steve Weinstock, Chuanjun Li, and the UC engineering department for advising all the students on the project to further enhance their technical and practical knowledge. Thank you for being a great resource as the students search for new alternatives to insulator learning during these unprecedented times.