Designing an Electrolytic Cell using Carbon Nanopaper for Cube Satellite Propulsion

Brent Hartnett*, Dr. Adam Huang
Arkansas Center for Space and Planetary Sciences
University of Arkansas, Fayetteville, Arkansas 72701, USA

Abstract: Since 1999, over twenty one foreign and domestic universities have created cube satellite programs because of their lower fabrication and launch costs as opposed to conventional small satellites as secondary payloads. However, propulsion systems are still in early development. Previously NASA explored the possibility of electrolyzing a water payload to generate propellants for large scale spacecraft, hydrogen and oxygen, because of water's ease of storage and low cost.[2] The goal of this project was to design a small electrolytic cell to investigate whether is could be adapted for nanosats. Carbon nanopaper was selected as an electrode due to its high surface area which is 600 m^2/g.[4] The cell was designed hypothetically for a 1 N thruster.

Cube Satellites

- 4X4X4 inch (10X10X10 mm) satellites that usually carry one to two scientific instruments
- Can be built as a unit cell or many cubes, typically in a common longitudinal axis
- Cheaper to design and launch than conventional small satellites as secondary payloads
- Fabrication costs 40-60K
- Cal Polytech's PPod Launcher is the standard means of deploying cubesat to desired orbit
- Propulsion systems in early development

Figure 1. Cube Satellite Ref 1.

Figure 2. PPod Launcher Ref. 1

Objectives

- Design small electrolytic cell to ascertain whether is can be adapted for cube sat
- Resulting hydrogen and oxygen gas used for warm gas microthrusters

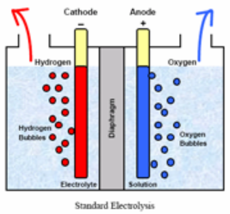

Figure 2. Electrolytic Cell Ref. 5

Experimental Setup

- Based off of setup from paper by Papale
- Pressure sensors 100 psi range
- Water pumped using Range 9 12 volt fuel pump

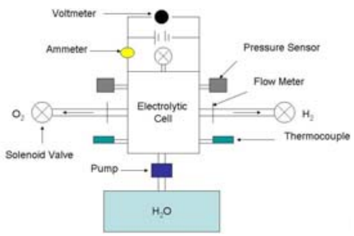

Figure 4. Experimental Setup

Initial Design

Figure 4. Designed Cell

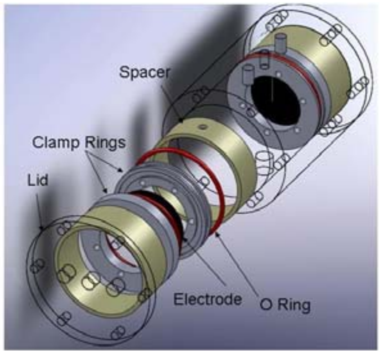

Figure 5. CAD Model

Preliminary Results

- Water seeped through nanopaper
- Inner o ring seal ineffective due to flawed gland dimensions

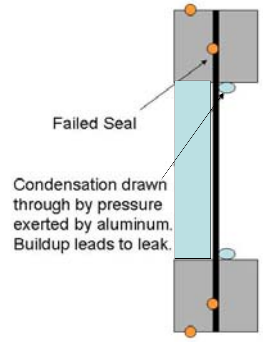

Figure 6. Causes for leaks

Redesign

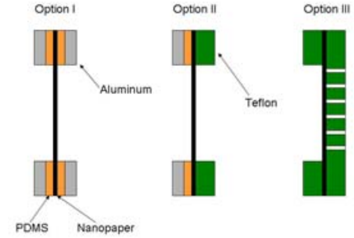

Figure 8. Proposed solutions for leak problem

- O Ring seals omitted from second design
- Clamp rings reconstructed without o ring glands
- Option I uses polydimethylsixane (PDMS) gaskets
- Option II replaces an aluminum ring and a PDMS gasket with a Teflon gasket
- Option III omits both PDMS gaskets and aluminum rings, replacing them with a solid Teflon ring and a porous layer of Teflon
- Option III may inhibit gas flow and another method of transporting electricity to the electrode must be redesigned

Future Work

- Reconstruct cell to test options I, II, and III
- Set up experimental design and collect data

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