An Exploration of Wood-Based Cube Satellite Chassis

The Wolfpack CubeSat Development Team, Palm Beach Gardens, Florida

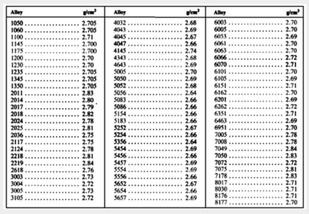
Sebastian Timbal (sstimbal@gmail.com), Kevin L. Simmons(ksimmons@bluecubesat.com)

Introduction

- Cubesat chassis are typically constructed using Aluminum alloys.
- Aluminum-based chassis are considerably heavy when compared to chassis constructed with alternative materials.
- Wood may prove to be a far more lightweight and cost-effective material for constructing CubeSat chassis.

The Advantage of Wood Over Aluminum

- Wood-based chassis are far lighter than aluminum-based chassis.
- The lighter chassis translates to a reduced cost to launch a CubeSat payload.
- Wood-based CubeSat chassis are therefore more financially viable for small research teams.



Alloy	g/cm³	Alloy	g/cm³	Alloy	g/cm³
1050	2.705	4032	2.68	6003	2.70
1060	2.705	4043	2.69	6005	2.70
1100	2.71	4045	2.67	6053	2.69
1145	2.700	4047	2.66	6061	2.70
1175	2.700	4145	2.74	6063	2.70
1200	2.70	4343	2.68	6066	2.72
1230	2.70	4643	2.69	6070	2.71
1235	2.705	5005	2.70	6101	2.70
1345	2.705	5050	2.69	6105	2.69
1350	2.705	5052	2.68	6151	2.71
2011	2.83	5056	2.64	6162	2.70
2014	2.80	5083	2.66	6201	2.69
2017	2.79	5086	2.66	6262	2.72
2018	2.82	5154	2.66	6351	2.71
2024	2.78	5183	2.66	6463	2.69
2025	2.81	5252	2.67	6951	2.70
2036	2.75	5254	2.66	7005	2.78
2117	2.75	5356	2.64	7008	2.78
2124	2.78	5454	2.69	7049	2.84
2218	2.81	5456	2.66	7050	2.83
2219	2.84	5457	2.69	7072	2.72
2618	2.76	5554	2.69	7075	2.81
3003	2.73	5556	2.66	7175	2.83
3004	2.72	5652	2.67	8017	2.71
3005	2.73	5654	2.66	8176	2.71
3105	2.72	5657	2.69	8177	2.70

Table courtesy of Aluminium Guide

Material	g/cubic centimeter
Aluminum	2.70
Birch wood	0.67
Magnolia wood	0.57
Cherry wood	0.56

The Environmental Impact of Wood

- A recent study by the National Oceanic and Atmospheric Administration has shown that aluminum satellites disintegrate into metal particles in the stratosphere while burning up upon reentry.
- These particles have been found in ten percent of atmospheric aerosols, leading to the concern that they may be harmful to the Earth's ozone layer.

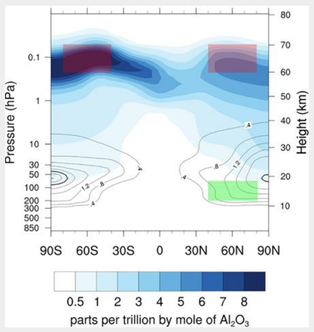
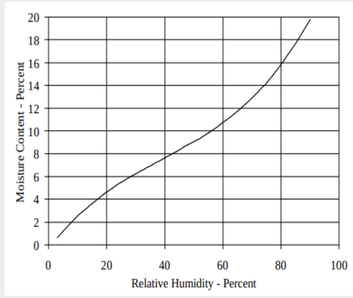


Chart courtesy of the National Oceanic and Atmospheric Administration

- Rather than disintegrate into particles, naturally-sourced wood-based satellite chassis burn up into gases, which is a much more atmospherically- friendly alternative.

The Behavior of Wood in LEO

- Wood will not rot in orbit, as organic compounds are absent in the vacuum of space.
- In a vacuum, wood cannot expand or contract, as there is no moisture or humidity for the grain to absorb.



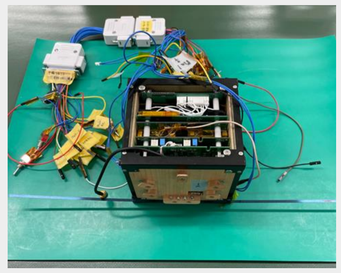
Moisture content as a function of relative humidity(Eckelman, 2)

- The average expansion and contraction of wood is approximately 0.26% per percent of moisture content.
- Wood cannot normally combust in space, due to the lack of oxygen.
- The autoignition temperature of wood, 1112 degrees fahrenheit, is far above the temperatures typically reached in Low Earth Orbit (LEO).
- Wood has been found to reliably withstand temperatures ranging from -238 F to 302 F, well past the range of temperatures commonly reached in LEO (-85 F to 257 F degrees).

Ongoing Research on Wooden CubeSats

- A researcher at Japan's Kyoto University is currently working with the Japan Aerospace Exploration Agency (JAXA) and the National Aeronautics and Space Administration (NASA) to send the first wood-based CubeSat into orbit in 2024.
- The Kyoto wood-satellite team sent wood samples into orbit in 2021. The three best performing samples were birch, cherry, and magnolia wood.
- After five years of building and testing, Kyoto University's CubeSat, LignoSat, is scheduled to launch in September of 2024.

LignoSat image courtesy of BBC Science Focus



LignoSat image courtesy of Nanosats Database

Experimental Wooden CubeSat Mission Proposal

- This author proposes a CubeSat mission to test the behavior of magnolia wood in the form of a full 1U CubeSat chassis.
- The chassis will be constructed of five 10x10x0.25 cm magnolia panels.
- Along with the magnolia chassis, eight wood samples will make up the sixth wall of the chassis.
- The samples will consist of oak, hickory, balsa, mahogany, maple, walnut, cherry, and birch wood.
- Two cameras will be mounted to the CubeSat, capturing the interior and exterior of the wall made up of samples, as well as two walls of the magnolia chassis.
- Additionally, two thermometers will be mounted inside and outside of the CubeSat to monitor how the drastic temperature changes affect the wood sample.
- The interior of the CubeSat will be equipped with basic communication instruments.
- A small LED will be mounted to the interior to provide visibility for the interior camera.
- Two sides of the magnolia exterior will host solar panels to provide power to the payload instruments.