5-1-2022

Managing Humidity in Electronics Using Water Vapor-Selective Membranes

Songhao Wu
wu1117@purdue.edu

Andrew J. Fix
Purdue University, fixa@purdue.edu

Allison Mou
Purdue University, amou@purdue.edu

David M. Warsinger
Purdue University, dwarsing@purdue.edu

James Braun
Purdue University, jbraun@purdue.edu

Managing Humidity in Electronics Using Water Vapor-Selective Membranes

Songhao Wu, Andrew Fix, Allison Mou, David Warsinger, James E. Braun
Purdue University

Introduction & Motivation

- Handling humidity in electronics and sensors is a major issue for ensuring reliable, long-lasting devices.
- Water vapor-selective membranes can be incorporated into electronics enclosures to provide dehumidification
- No previous research has applied such membrane in small electronics devices

Humidity Control for Electronics Device

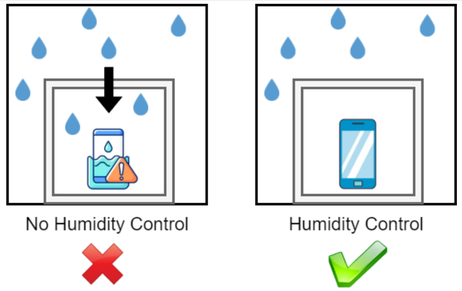

Figure 1 General concept of enclosed device to protect electronics from humidity

Existing Technology

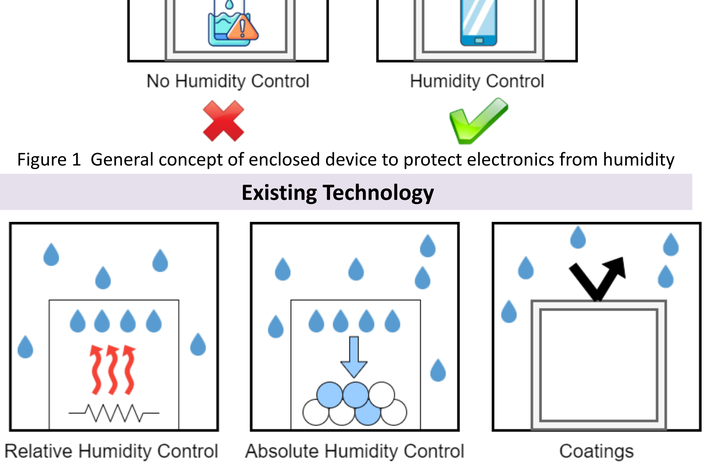

Figure 2 Existing technology for humidity control

Methodology

- 1D-Mass balance on this control volume:

$$V_e \frac{dH_a}{dt} = \dot{m}_{in} - \dot{m}_{membrane}$$

- First-order Euler approximation used for simplicity:

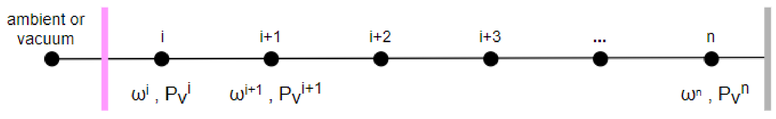

Figure 3 Simplified Representation of the one-dimensional discretization used to carry out the first-order numerical simulation of vapor transport in the system.

System Description

- System dimension $W \times L \times H$: $36.5 \times 58 \times 23.5\ mm$

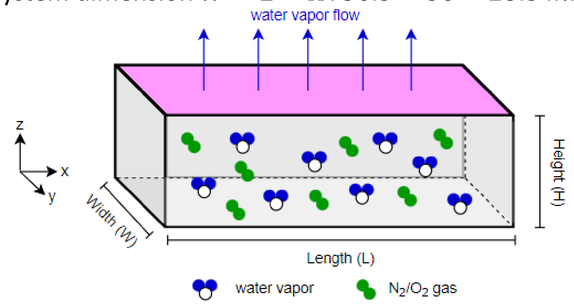

Figure 4 Summary of the electronics enclosure control volume geometry

Results

- Water vapor-selective membranes was successfully made
- Higher water vapor contents needs more time for removal
- Varying channel height impacted humidity distribution

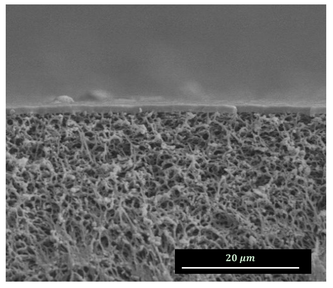

Figure 5 Pebax + Go Membrane SEM

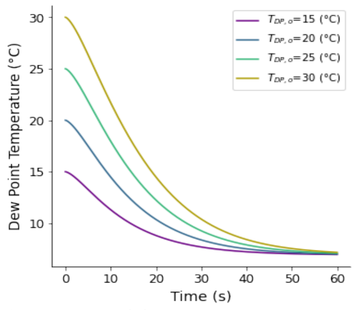

Figure 6 Internal dew point temperature vs. time

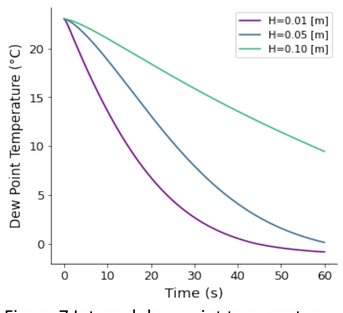

Figure 7 Internal dew point temperature vs. time with varying volume height

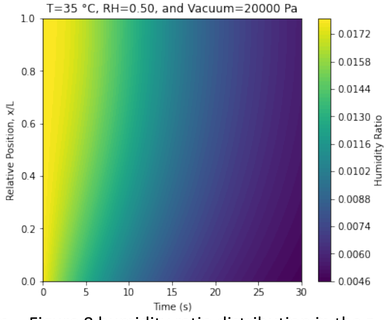

Figure 8 humidity ratio distribution in the z direction vs time

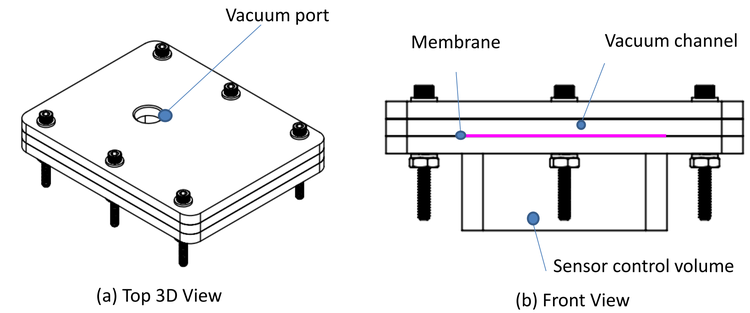

Figure 9 Enclosure Assembly CAD Drawing

Conclusion/Future Work

- Rapid removal of water vapor is possible with membrane
- As enclosure height has negative impact on the humidity removal rate
- Experiments will be conducted to validate modeling results.

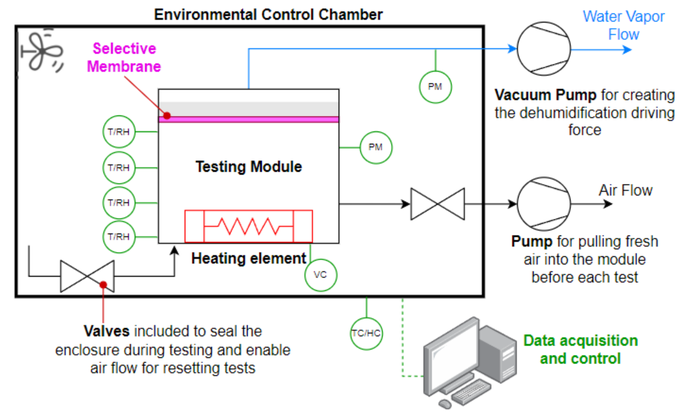

Figure 10 Vacuum-Driven experimental system schematic

References

- M. Tencer and J. S. Moss, "Humidity management of outdoor electronic equipment: Methods, pitfalls, and recommendations," IEEE Transactions on Components and Packaging Technologies, vol. 25, no. 1, pp. 66–72, 2002, doi: 10.1109/6144.991177.

Acknowledgments: The authors acknowledge support from the Lilly Endowment, Inc.