

Experimental Results of Ice Formation at Low Temperatures and Pressures

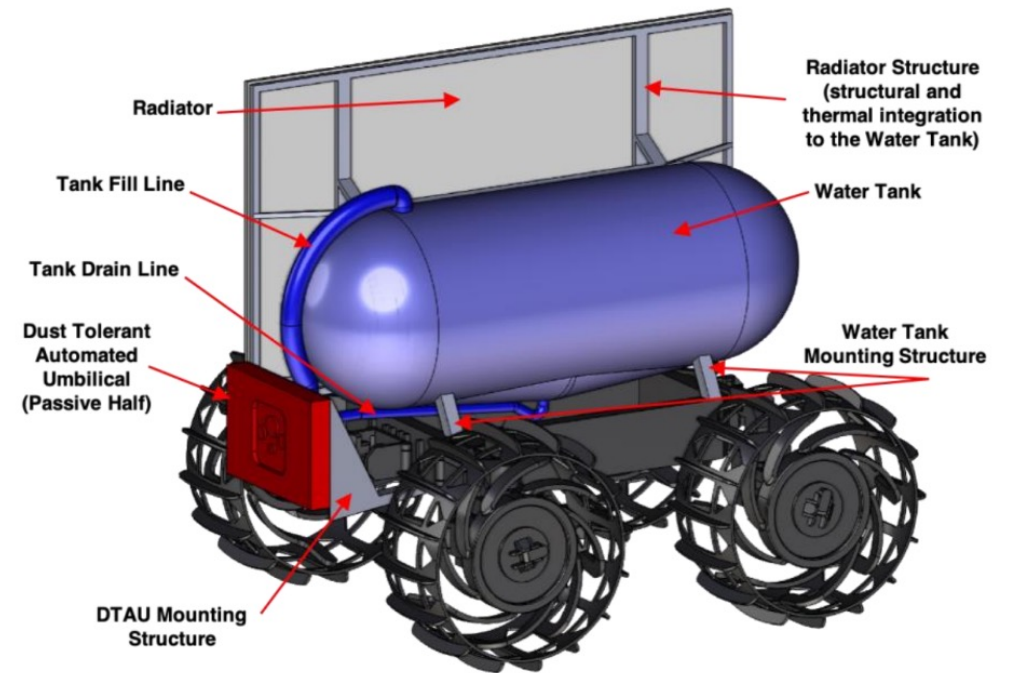
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Introduction

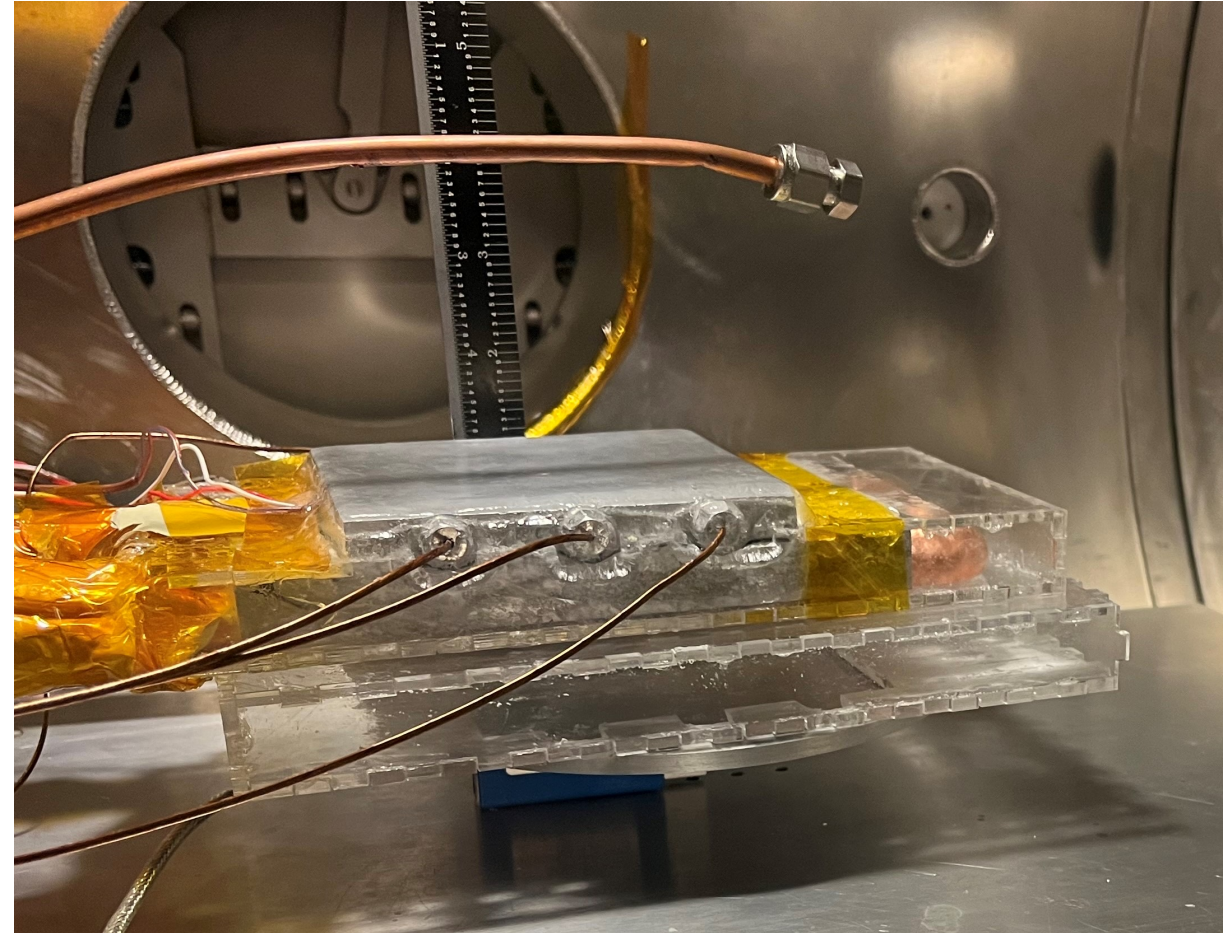
- ISRU for water capture on the moon is important for sustained lunar presence
- Storage of water as a solid provides an efficient method of transfer
- Understanding of low-pressure ice formation is critical for efficient storage and transport of the ice
- Generating a thermal model allows for optimization of pressure and temperature conditions without extensive testing



Linne, D. L., Kleinhenz, J. E., and Paz, A., "Lunar Water Pilot Plant Conceptual Design," *ASCEND 2020*, AIAA, 2023, p. 4236.

Experiment

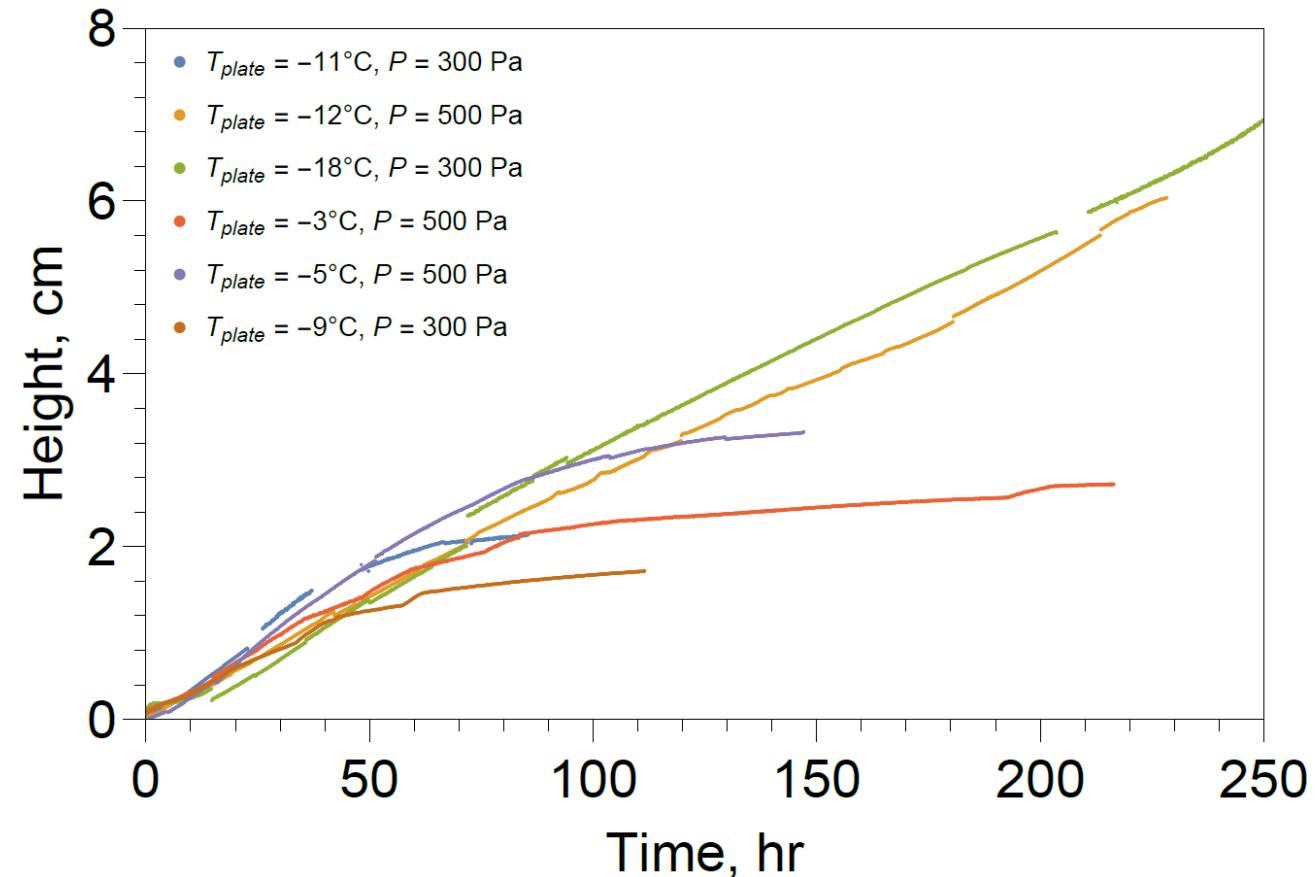
- Housed in the NASA GRC 2-ft dirty vacuum chamber
- Water vapor introduced through copper tubing
- Desublimates on the cold plate
- Cold plate temperature and setpoint pressure are varied



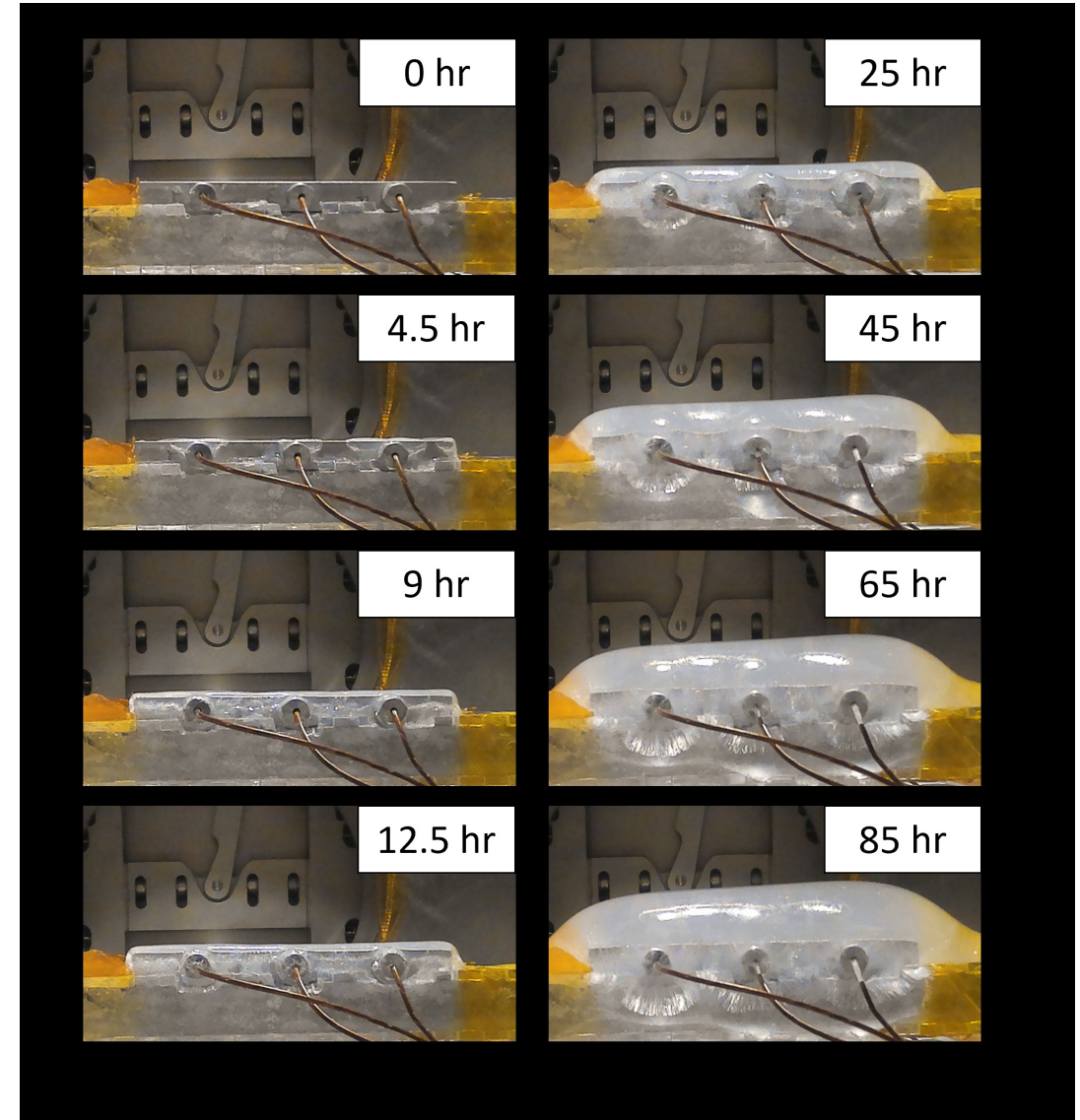
Hardware installed in chamber

Experimental Results

Previously published
experimental ice heights

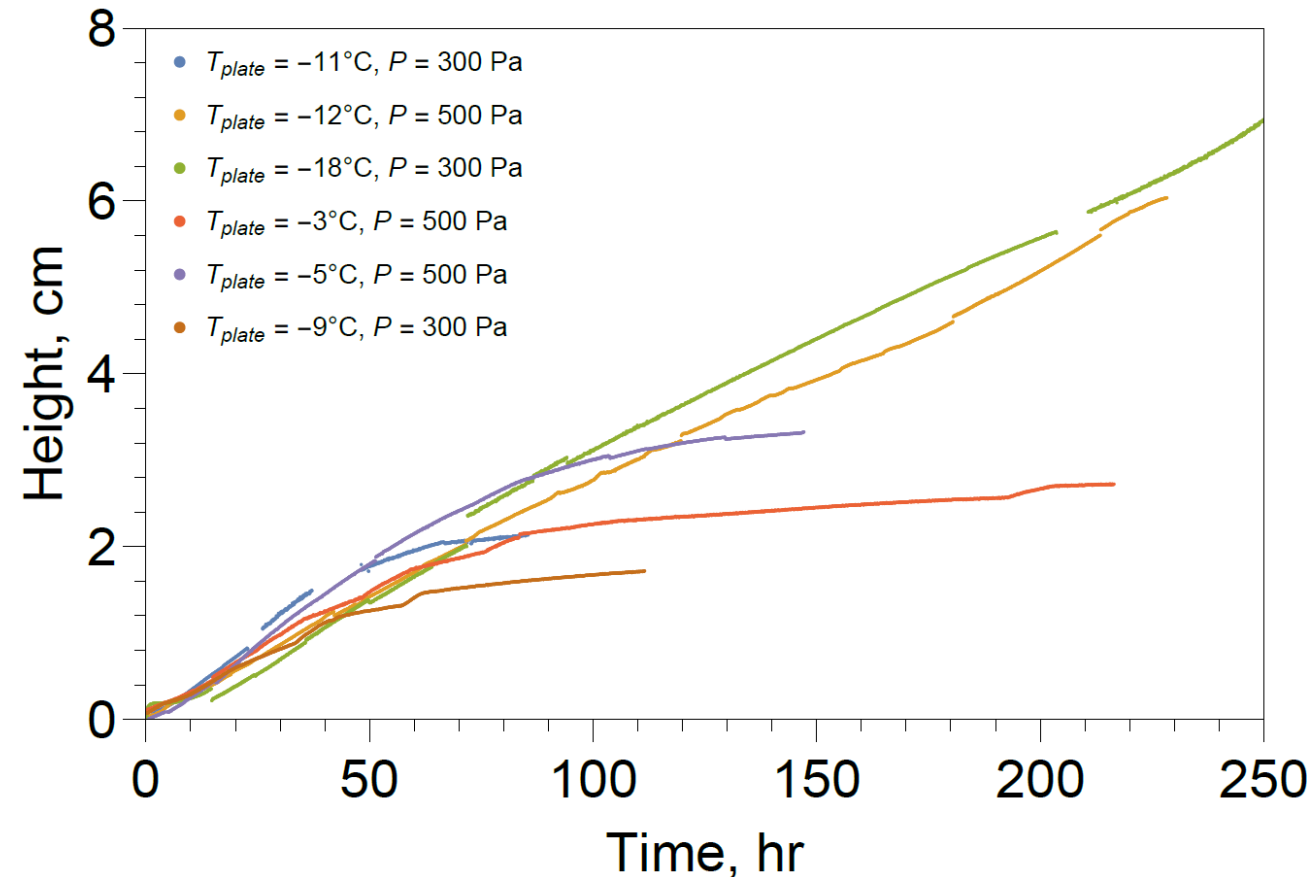


Compton, B. M., Krause, T. S., and Deans, L. M. S., "An Experimental Study on Low Pressure Frost Formation for Lunar Polar Water Capture," 52nd International Conference on Environmental Systems (ICES), 2023.

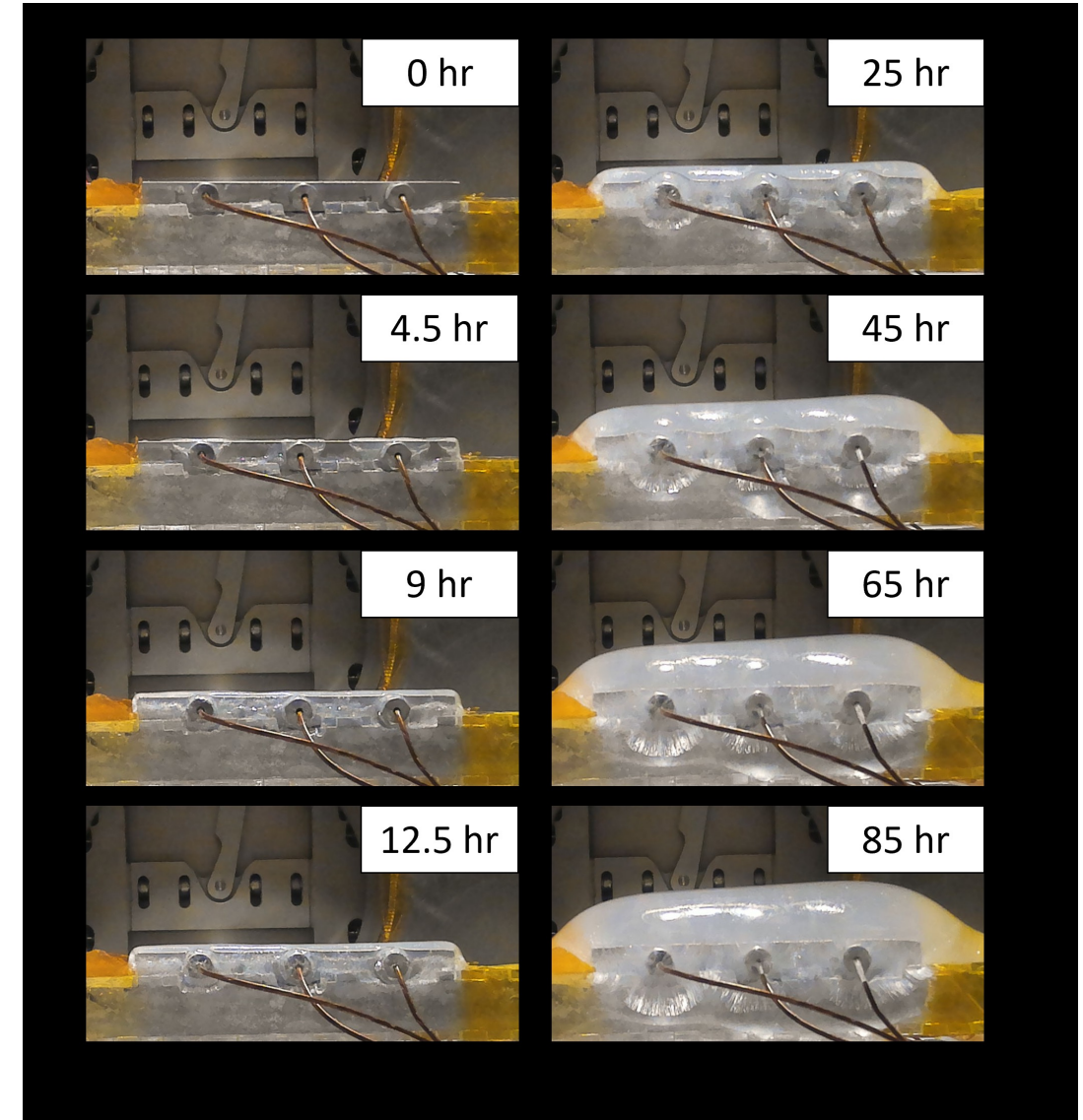


Experimental Results

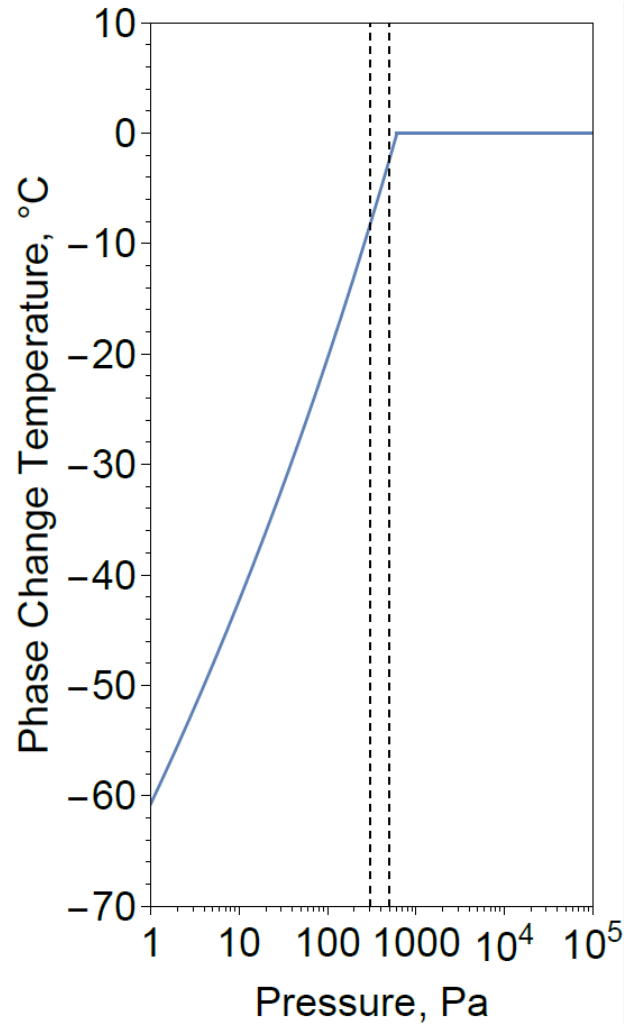
Results showed densities much greater than anticipated



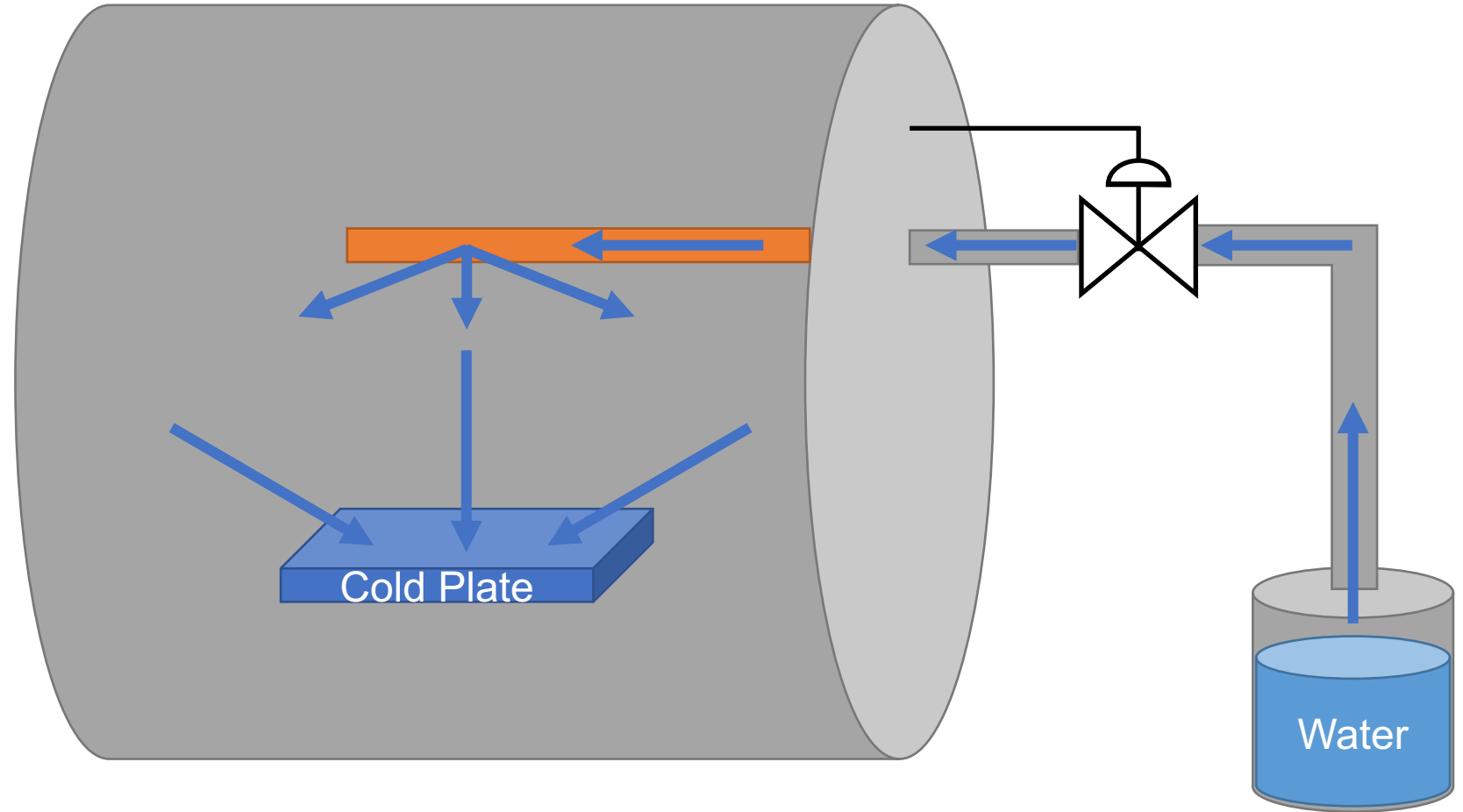
Compton, B. M., Krause, T. S., and Deans, L. M. S., "An Experimental Study on Low Pressure Frost Formation for Lunar Polar Water Capture," 52nd International Conference on Environmental Systems (ICES), 2023.



How Does the Ice Form?

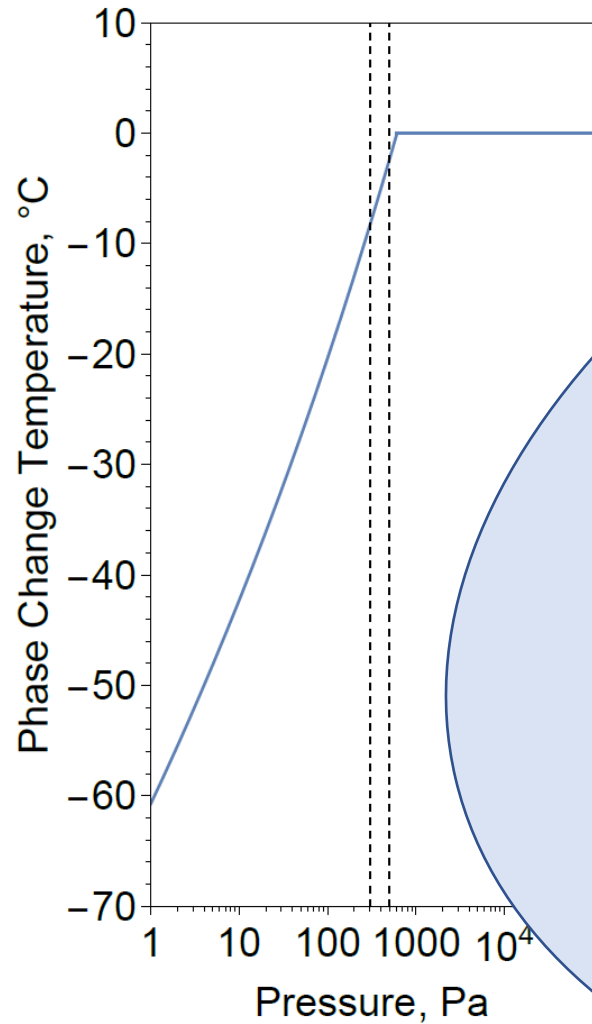


Phase Change Temperature

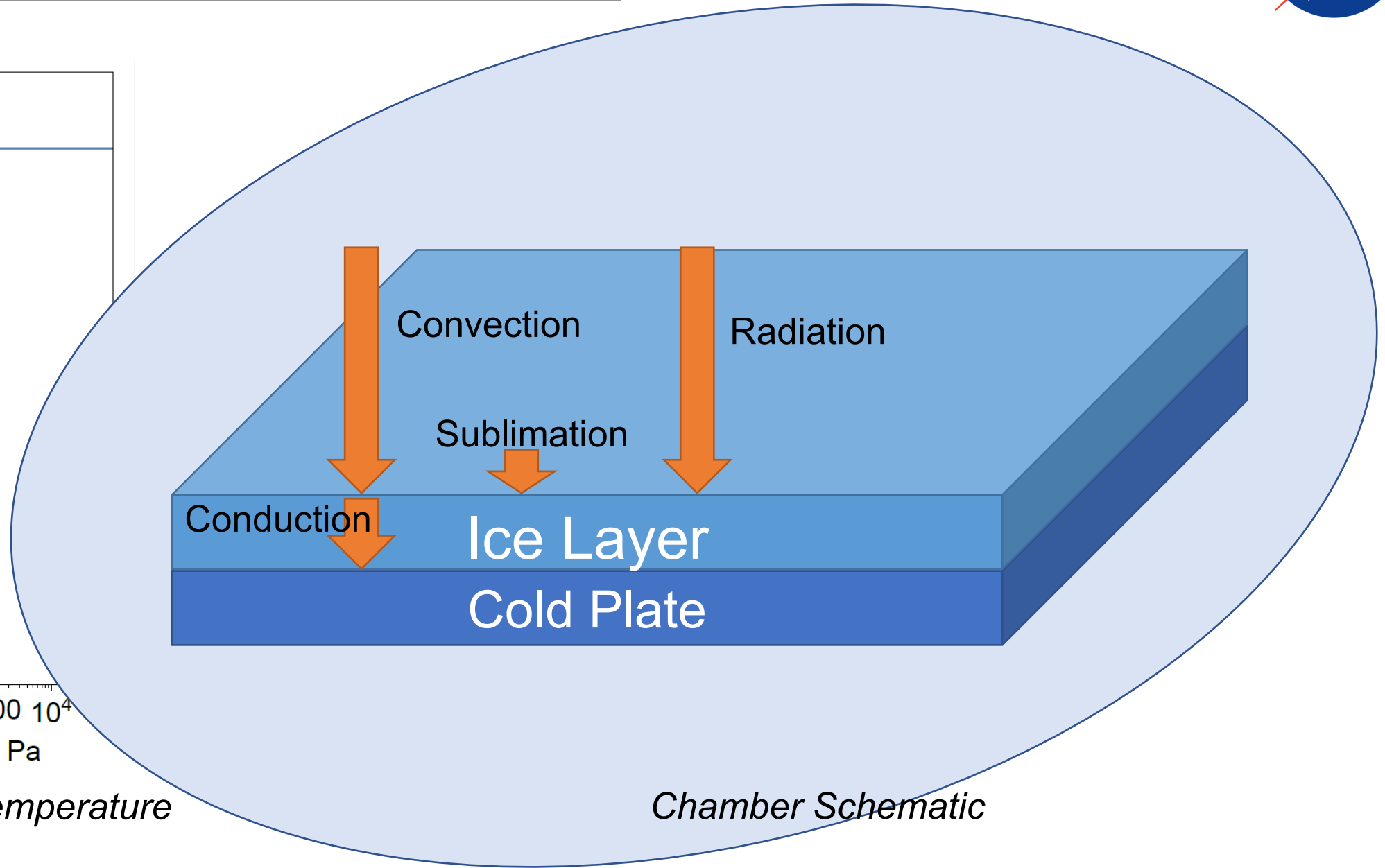


Chamber Schematic

How Does the Ice Form?

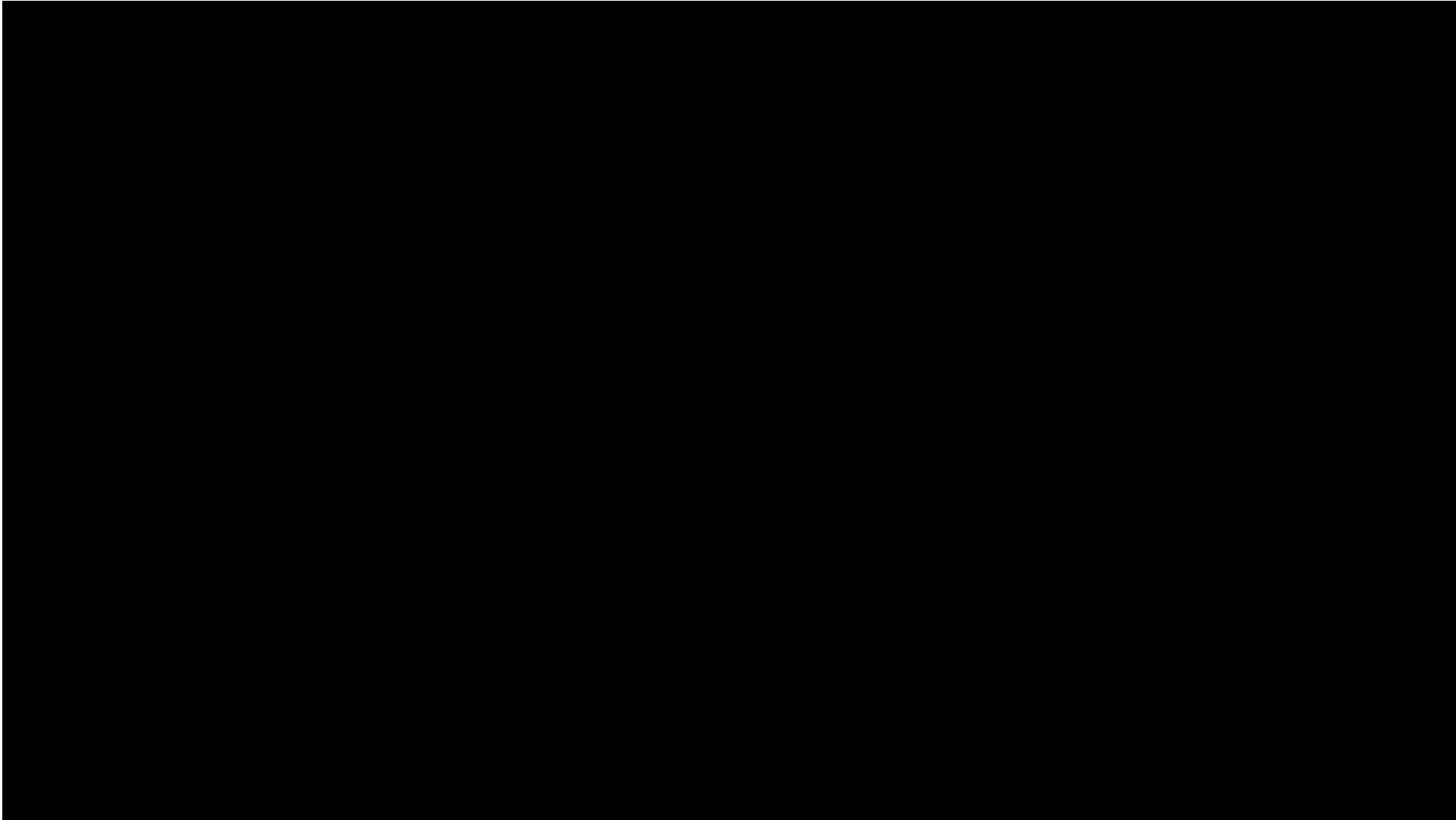
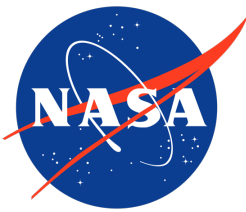


Phase Change Temperature



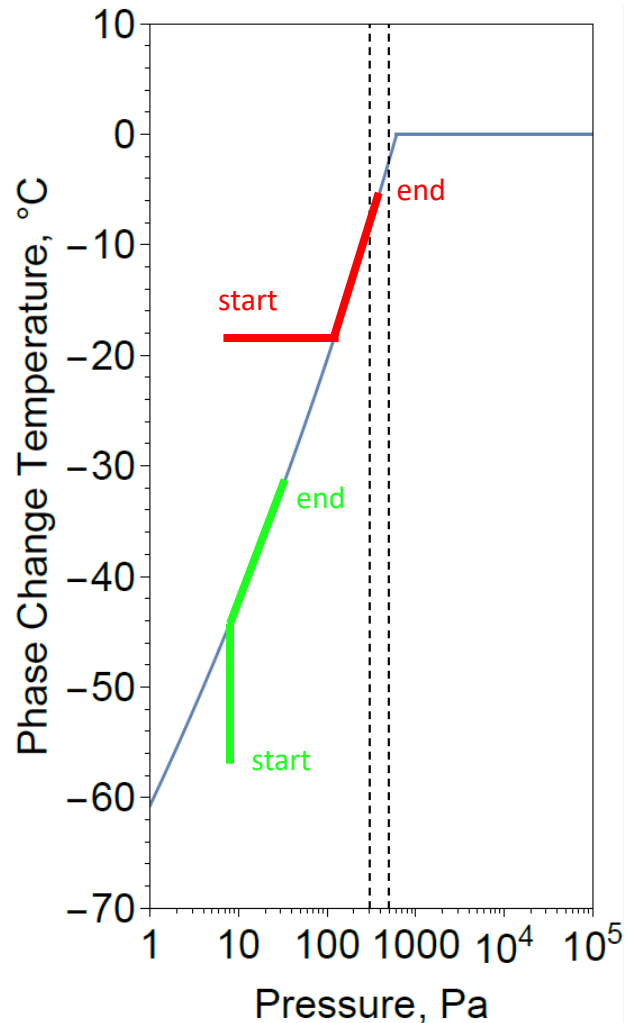
Chamber Schematic

Results at Lower Temperatures



Frost Growth on the Cold Plate

Is the test diffusion limited?



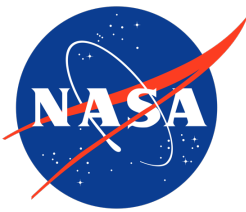
Phase Change Temperature

Previous tests:

- Chamber pressure builds, then ice begins forming
- Ice growth limited by conduction through the ice layer
- Chamber can be assumed to be quiescent

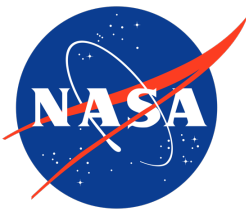
Current tests:

- Ice begins forming as soon as the water vapor is introduced
- Ice growth limited by diffusion of the water vapor
- Asymmetric growth of the frost layer based on water introduction rail



Conclusions and Future Work

- Experiments show very different frost densities at lower cold plate temperatures
- Frost layer shows resublimation characteristics when the cold plate temperature increases, indicating high sensitivity to plate temperature
- Further work is underway to characterize the density dependence on plate temperature



Acknowledgements

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