Thermal Management Concept of Ice Melting Probe for Icy Moon Exploration

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To support NASA future Ocean Worlds Exploration missions, Advanced Cooling Technologies, Inc (ACT) is developing an innovative thermal management concept for a nuclear-powered ice melting probe. The concept consists of multiple advanced thermal features that can offer the most efficient and reliable ice penetration process by maximizing the power fraction used for forward melting and mitigating a series of foreseen challenges related to icy-planetary missions. These thermal features include:

1. pumped two-phase (P2P) loop which collects the waste heat from the cold end of the thermoelectric convertors, transports and focuses the waste heat at the front end of the vehicle for ice melting with minimal thermal resistance
2. front vapor chamber for forward heat focusing and melting
3. variable conductance side walls to enable lateral melting capability (only when the probe gets stuck because of refreezing or other obstacles in its path)
4. side high-pressure liquid water displacement for probe maneuverability and steering

Under an SBIR Phase I program, ACT developed a preliminary full-scale probe design and assessed the technical feasibility of features (1) through (4). A lab-scale ice melting probe prototype with selected features was developed. Ice penetration and thermal behavior of the prototype were experimentally demonstrated in an ice environment system. Functionailties of variable conductance wall and vapor chamber were successfully proven.

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