Title: Modular Membrane-Controlled Three-Phase Deployable Radiator

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Abstract: In this study, a near infinite turndown, 7.0 kg Modular Membrane Controlled Three-phase Deployable Radiator prototype was designed, fabricated, and demonstrated over a range of applied heat loads from 0 W to 500 W. The study includes steady state modeling of the radiator panel, component experimental testing, and a full-scale prototype experimental demonstration using liquid nitrogen cold wall to achieve solid, liquid, and vapor internal to the channels simultaneously. We designed and fabricated the three key individual components (bimetallic panel, PCM bypass control valve, and membrane phase separator) and demonstrated the components function together as a system. The key functions demonstrated include: 1) liquid/vapor membrane phase separator prevents vapor bypass of the panel. 2) PCM actuated control valve opens/closes a bypass based on fluid return temperature to modulate panel heat transfer characteristics, 3) bimetallic panel incorporates material strength of Inconel with the preferred thermal properties of aluminum which enables freezing/thawing of ammonia inside tubes, and 4) freezing/ thawing of ammonia inside tubes modulates the active panel surface area relative to heat load allowing high turndown.

A summary of modeling results that indicate the prototype would achieve the desired results will be discussed. The experimental component testing results showed favorable performance including good phase separation. The full-scale prototype results will be discussed showing the component behavior within the full system including a full freeze/thaw cycle behavior.