Title: Development of a Variable Conductance Cold Plate for Spatial and Temporal Isothermality
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Electronics instrumentation, such as those used in low-orbit for monitoring environmental change, are very sensitive to temperature change. Such instrumentation must be maintained at a consistent temperature despite changing radiator/condenser temperatures in order to achieve high accuracy. Such a thermal system must be low size, weight and power to accommodate satellite needs. ACT has developed a cold plate which, through variable conductance, provides spatial and temporal temperature uniformity to address this need. The developed technology builds on ACT's experience with passive two-phase devices and is comprised of three main technologies: a vapor chamber, variable conductance heat pipes, and a two-phase heat exchanger. Spatial isothermality is achieved by the vapor chamber, to which the electronics are mounted. Internal to the vapor chamber is a working fluid which exists at saturation conditions, which holds the mounting surface at a uniform temperature. Temporal isothermality is achieved by the VCHPs, which are charged with a working fluid at saturation conditions and a non-condensable gas (NCG). During operation, vapor that is generated from the evaporator end moves to the condenser end. As the heat load or as the sink temperature increases, the working fluid will see to operate at a higher temperature. This results in increased pressure as the working fluid exists at saturation conditions. This pushes the NCG towards the end of the condenser section into an NCG reservoir. As the NCG is pushed away, more condensing area is opened up. As the opposite occurs, the NCG pushes forward and blankets a portion of the condensing area of the VCHP. As a result of the changing condensing surface area, the conductance of the heat pipe becomes variable, which allows the VCHP to carry heat at a higher rate and mitigate the effects of heat load or sink temperature changes. During a NASA Phase I SBIR, ACT has developed and fabricated a subscale prototype Variable Conductance Cold Plate (VCCP). During testing, ACT demonstrated the cold plate surface temporal temperature change of less than 0.05 K/min. As a part of the Phase II SBIR, ACT is expanding on this technology to develop a VCCP with a heat-collection surfaces of 0.5 m2 in size. ACT is also currently investigating future missions for which the design can be tailored.