Passive Cryogenic Thermal Switch with Tunable Close Temperature for Redundant Cryocooler Systems

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Thermal switches are an enabling thermal technology in cryogenic space applications, particularly in systems with redundant cryocooler configurations. However, information on low-mass, passive, and highly reliable cryogenic thermal switches, like the one presented here, remains relatively scarce in published literature. This paper details the development, testing, and benchmarked performance of a passive cryogenic thermal switch using a novel combination of high positive and negative coefficient of thermal expansion (CTE) metals. This design features a simple and demonstrated tunability of the on/off temperature —an innovation among passive thermal switch designs of this nature— making it easily adaptable to various application temperatures without redesign.

This passive cryogenic thermal switch is particularly promising in redundant cryocooler system configurations, offering tunability, a passive nature, and high reliability for a zero-power, easily adaptable solution. A thorough comparison with existing cryogenic thermal switches highlights its unique advantages, making a compelling case for adoption.

One of the primary challenges associated with cryogenic thermal switches is the imperative to minimize thermal parasitic heat loads across an open switch, given the temperature disparity between one end at cryogenic levels and the other near room temperature. This presentation provides a detailed explanation of how this design successfully addresses this challenge, accompanied by a discussion of other encountered hurdles. Key challenges include the tunability of the close temperature, maintaining low open conductance while achieving high closed conductance, minimizing mass while preserving a fast response to temperature changes, and ensuring repeatable long-life performance.

Successful environmental tests have elevated the switch to NASA Technology Readiness Level (TRL) 6, positioning it as a prime candidate for future cryogenic and redundant cryocooler system designs.