Prospects for High Temperature Cryocooling with Increased SWaP-C Enabled by Advanced DTP Solid-State Thermoelectrics

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Conventional thermoelectric (CTE) systems can provide temperature differences up to 140K, which is not sufficient for most cryocooling applications. Distributed Transport Property (DTP) Thermoelectrics, thermoelectric material systems with properties that vary optimally throughout the material, exhibit significant gains in cooling capacity, efficiency, and maximum temperature difference. Initial empirical test results and numerical modeling indicate that temperature differences greater than 220K are possible with DTP, opening up a broad range of new opportunities for cryocooling applications.
DTP solid state devices present a new and attractive SWaP-C benefit package not attainable with other cryocooling options. In this paper, we show where temperature control systems based on DTP materials can meaningfully impact cryocooling applications such as cryosurgery and cooling of electronic devices. We compare performance and other critical characteristics of CTE, DTP and traditional cryocooler technologies and identify applications where DTP systems create the option of compact solid state temperature control in the higher operating temperature range of cryocoolers.