Development and Performance Optimization of an N-Type Bi-Sb Thermoelectric Cryocooler

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Traditional thermoelectric devices consist of n-type and p-type thermoelectric legs. Since p-type materials exhibit a low thermoelectric figure of merit at temperatures below 120K, there has been a proposal to construct low-temperature thermoelectric devices incorporating n-type thermoelectric legs and superconducting materials as passive legs. The primary cooling effect is generated by the n-type thermoelectric legs, while the passive legs act as conductors. This enables multiple n-type legs to be connected electrically in series and thermally in parallel, thereby enhancing cooling power. This paper presents the design and fabrication of a prototype for a low-temperature thermoelectric cooler using n-type legs made of Bi-Sb material and passive legs made of high-temperature superconducting material. Initially, based on the actual material properties, we conducted numerical optimizations of the device structure. We designed both a single-arm device containing only n-type legs and a Ð-shaped double-arm device containing both n-type legs and passive legs. To achieve greater cooling power, multiple Ð-shaped double-arm structures were electrically connected in series to construct a low-temperature component device.To assess the actual cooling performance of the device, we manufactured both single-arm and Ð-shaped double-arm devices. Experimental tests were conducted to analyze the effects of input current and warm-end temperature on cooling performance within the 80-120 K temperature range. Additionally, the impact of small transverse magnetic fields on performance was studied. The workshop will include a presentation of the related simulation and experimental findings.