Micro Thermoelectric Cryogenic Cooler for MEMS

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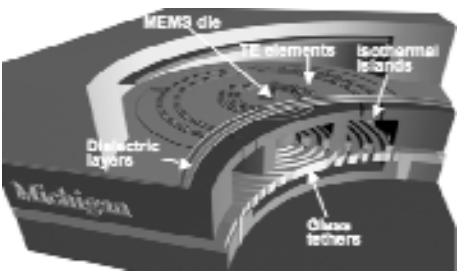
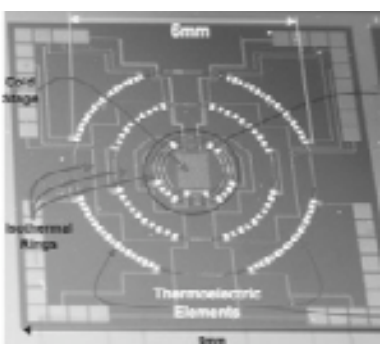


Schematic view of a TE cooler.

A micro thermoelectric cryogenic cooler can have a major impact on critical military, medical, and consumer applications including substantial performance improvement of existing systems such as infrared detectors for military applications. Additionally, the quality factor of MEMS resonators improves drastically as a function of temperature, just as the thermal noise in circuits, such as low-noise amplifiers and sensor buffers, reduces significantly with temperature. Although not commonly used at the macroscale, thermoelectric cooling becomes appealing at the microscale, where its maintenance free, solid-state operation, and small size are more important features than raw efficiency. The ultimate goal of this project is to develop a micro thermoelectric cryogenic cooler capable of achieving a temperature of 160K, with heat-lift of a 5mW, in a volume of less than 0.2cc, and using less than 100mW of power. To achieve the project goal, a multi-stage cooler is being implemented using a design that emphasizes thermal isolation techniques and high-quality thermoelectric materials to achieve maximum efficiency. Recently, the first generation of coolers was fabricated using a thermally isolating design capable of achieving a total thermal resistance of up to 15000K/W. Thin film Bi2Te3 and Sb2Te3 with ZT between 0.3 and 0.4 were used as the thermoelectric materials, and the resulting cooler generated temperature differentials up to 4K. Future work will focus on improving cooling through improved design of the thermoelectric elements, as well as on vacuum packaging and MEMS device integration. This project is supported by the MCC program of the Defense Advanced Research Projects Agency under grant number W31P4Q-06-1-001.



Fabricated 5-stage cooler.