

Cool MEMS: Micromachined Thermoelectric Cryogenic Cooler

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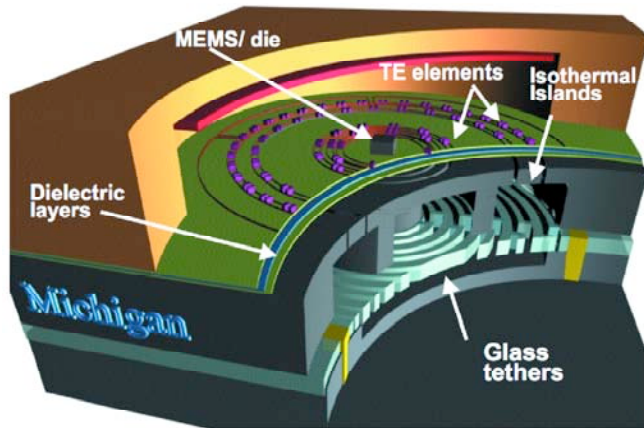


Figure 1 – Cooler showing multi-layer structure.

Thermoelectric cooling is quite attractive for small-size devices because its solid-state operation makes it a robust option for microfabrication and long-term operation. Bismuth telluride and antimony telluride have been chosen as the thermoelectric materials for their good thermoelectric properties in the temperature range being pursued. New techniques for depositing and patterning these materials using wafer-level processing have been developed. In order to reduce power, increase cooling temperature, and improve efficiency, these materials were integrated onto a multi-layer, thermally isolating structure (Figure 1). This structure has provided a measured thermal resistance of $>15000\text{K/W}$. The resulting preliminary cooler (Figure 2) has produced a temperature difference of up to 8K, which is quite consistent with modeling results, and modeling suggests that with further optimization of the thermoelectric material properties, and optimization of structure design, temperature differentials as high as 100K easily could be achieved. ■

Electronic and micromechanical devices/circuits, such as resonant sensors, low-noise amplifiers, and micromechanical resonators, exhibit superior performance when operated at low temperatures. To take advantage of these potential performance gains, low-power microscale cooling systems must be developed that can be integrated easily with a wide variety of microfabricated devices. The goal of this project is to develop microthermoelectric coolers capable of cooling MEMS and electronic devices below 200K, while dissipating less than 100mW of power, all in a chip no larger than a few millimeters on a side.

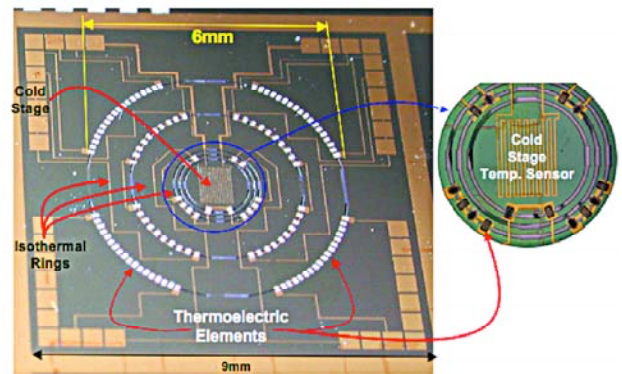


Figure 2 – Fabricated micromachined thermoelectric cooler.