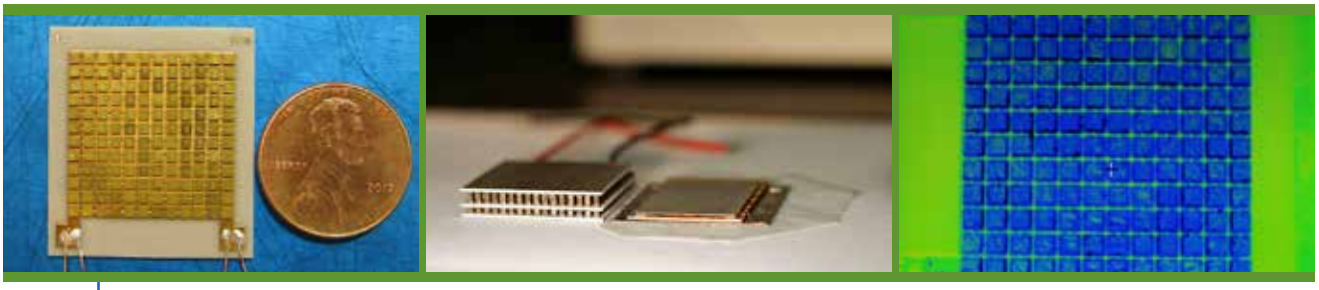
Active Thermal Management



RTI International is one of the world's leading thermoelectric (TE) R&D laboratories and has a long track record of successful TE-related materials and device development. RTI's TE research portfolio ranges from fundamental materials science to device physics, technology development, and applications. Our lead in thin-film TE materials for high heat flux thermal management resulted in a breakthrough innovation that has led to record levels of heat flux pumping.

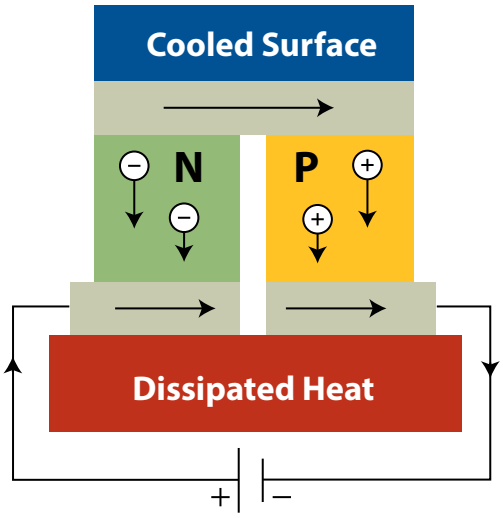
Active Thermal Management

In today's high-performance electronic components, the generated heat loads result in unacceptably high junction temperatures and reduced component lifetimes. This issue affects everything from quantum cascade lasers to servers in data centers to electronic engine control units in military aircraft. Government, industry, and academia are currently searching for reliable, effective means to address this issue.

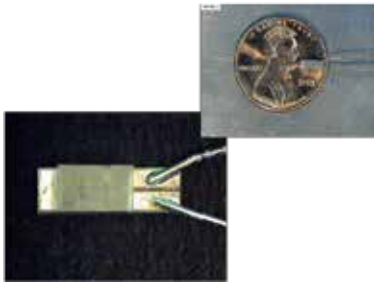
TE devices may be a promising technology for this application. TE cooling operates via the Peltier effect, a phenomenon in which a temperature difference is created by applying a voltage between two electrodes connected to a semiconductor (e.g., Bi_2Te_3 or a related material). The primary advantages of TE devices compared to competing cooling technologies, such as Stirling coolers, are that TE devices are smaller, lighter, and have no moving parts. Several commercial manufacturers mass-produce this type of TE device, which is made of bulk materials with millimeter-scale thicknesses.

RTI, however, is one of only a few groups worldwide producing *thin film–based* TE materials and devices. Our thin-film superlattice (TFSL) materials have been engineered for enhanced electrical conductivity and reduced thermal conductivity, which is necessary for high-performance TE materials.

RTI's thermoelectric coolers (TECs) are composed of 5–20 µm thick TFSL elements that have an orders-of-magnitude lower thermal mass than conventional bulk devices and, therefore, can move larger amounts of heat with a quicker response. The response time of a typical TFSL device is on the order of 10s of µsec, whereas ~1 mm thick bulk TE devices exhibit much longer response times, on the order of seconds.



TE devices provide reliable, compact cooling capability with no moving parts



RTI's TFSL three-couple module size compared to a penny.

The thin-film couple's small size also enables the ability to pump high heat fluxes. When the heat-pumping characteristics of a series of RTI thin film–based TECs were measured, a maximum heat pumped per unit area Q_{max}/A >250 W/cm^2 @ ΔT_{TEC}=0K was demonstrated. **This value is 25 times higher than that typically observed in commercial, off-the-shelf (COTS) bulk TECs and more than three times better than COTS thin-film devices.**

Additionally, RTI's small couples can be well-matched to the size of typical hot spots in electronic devices. Individual couples can also be combined into larger arrays and sized to match the cooling requirements of a given application. In one example, a 3-mm thick, three-stage cascade module using this technology produced a combined ΔT of 87.6°C.

This advanced TE technology is particularly relevant for wafer-level microsystem integration because the continuing miniaturization of electronic microsystems will require newer and more advanced thermal management solutions.

RTI Offers These Capabilities

- Epitaxial growth, fabrication, and characterization of high-performance semiconductor TE materials
- Nanoscale TE materials development
- Custom TE cooling and power generation device design and fabrication
- Thermal modeling and analysis

Applications of these lightweight, high-heat flux pumping devices include microprocessor hot-spot cooling, power transistor hot-spot cooling, focal plane array cooling, and low-noise amplifier and laser diode cooling.

Working with RTI

RTI is a nonprofit research institute and ITAR-registered organization that works with a diverse base of commercial clients, government agencies, and academic institutions, supporting our clients through application-driven technology development programs, custom prototyping, and small-volume production. We also partner with external organizations for joint proposals in a variety of government and defense programs.

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