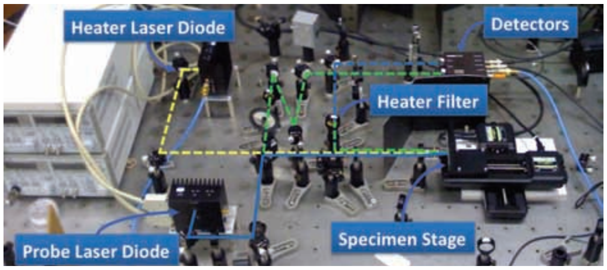
Thermoelectric Measurements

Facilities

The MSEL Thermoelectric (TE) Measurement Facility is composed of an integrated suite of advanced instrumentation to measure thermoelectric and thermophysical properties of bulk and thin film materials. In addition to a commercial system which measures resistivity, Seebeck coefficient, thermal conductivity, Hall coefficient, and heat capacity between 2 K and 390 K, we have developed three custom instrumented tools.

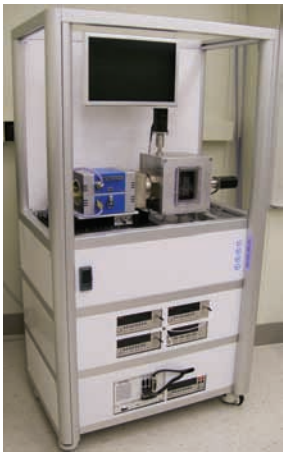
An automated high-throughput TE probe tool has been developed to perform screening measurements of combinatorial TE thin films with continuously variable composition. The tool consists of an array of pressure probes and an automated translation stage that can move a combinatorial film in the x, y, and z directions. This tool can measure both electrical resistivity and the Seebeck coefficient on 1000 distinct sample points within 6 hours.

To complement the TE screening probe, a scanning frequency domain thermoreflectance apparatus was also developed that can rapidly and locally (10 μm spot size) measure the thermal effusivity (from which the thermal conductivity may be calculated) of combinatorial thin films. Combining the data from this apparatus with those data from the TE screening probe, the TE energy conversion efficiency can be calculated as a function of composition of a film.



Combinatorial thermoreflectance apparatus, illustrating the modulated heater and probe infrared laser beam paths.

An advanced high temperature TE measurement apparatus is under development that will concurrently measure resistivity and Seebeck coefficient from 300 K to 1200 K. The apparatus will be capable of *in situ* comparison and evaluation of various contact and measurement methodologies. A unique sample probe also expands the system flexibility with respect to sample size, geometry, and arrangement. Final construction of the apparatus is proceeding according to schedule and, on completion, will be used to certify a Seebeck coefficient standard reference material for use at high temperatures (300 K to 1200 K).



The high temperature TE metrology apparatus under construction.

Significance

The development of greater efficiency TE materials will enable the practical solid-state interconversion of thermal and electrical energy. TE devices remain an integral component for deep-space power generation, small-scale waste heat recovery, and electronic (non-mechanical) refrigeration. In addition, TE devices are environmentally friendly, require minimal maintenance, and reliably offer quiet and compact operation. However, non-standard measurement practices have complicated confirmation of the reported efficiencies of novel TE materials. The instrumentation, standards, and methods developed in the MSEL TE Measurement Facility will enable accurate and precise measurements of novel TE materials.

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