MIP: PARADIM at Cornell University, DMR-1539918

External User Project – 2021

Transverse Thermoelectrics—A Route to more Efficient Energy Conversion

The direct conversion between heat and electricity that allows for active cooling or the use of waste heat for power generation is enabled by thermoelectric devices.

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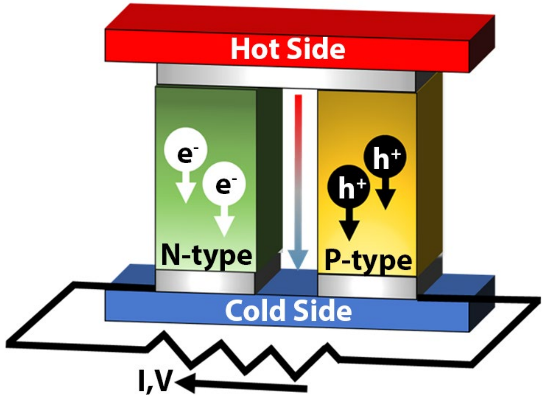
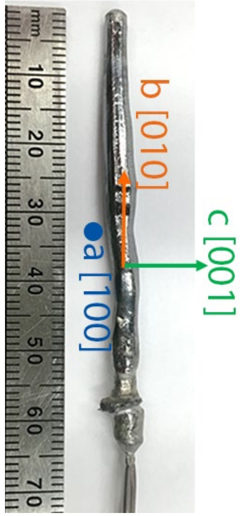
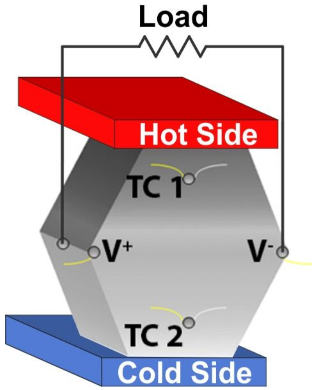
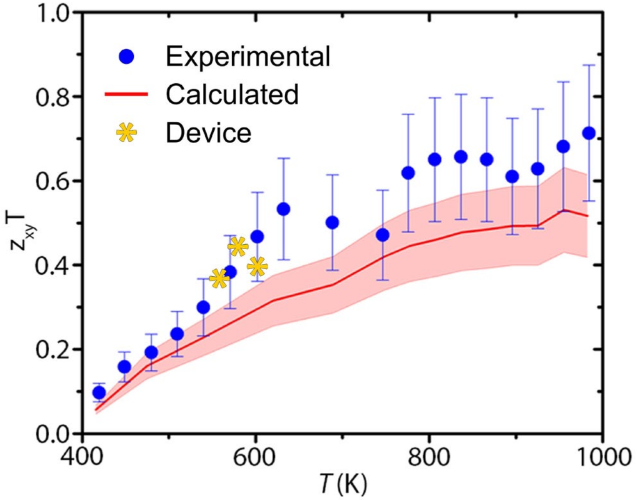
Traditional thermoelectric modules utilize hundreds of pairs of p-type and n-type semiconductors, where heat flows from top to bottom and the electric current meanders through the whole structure. The sheer number of metal-semiconductor contacts causes large efficiency losses compared to the thermoelectric efficiency of the bare semiconductor. Also, the need for stable contacts at the hot side limits operating temperatures and device lifetimes.









In "transverse" thermoelectric devices—developed at Ohio State with the discovery of goniopolarity—a voltage develops perpendicular to the temperature gradient, requiring only one active material and no contacts near the hot side, avoiding a major source of energy loss and device degradation.

The group came to **PARADIM's bulk crystal facility** to grow sufficiently large single crystals of rhenium silicide (Re_4Si_7), a material with record transverse thermoelectric efficiency. Constructing a transverse thermoelectric generator from a single crystal, the group confirmed that the device efficiency (yellow stars) shows no losses compared to the bare material (blue dots) and the calculated efficiency (red curve). The present work establishes transverse thermoelectrics as a viable technology, and rhenium silicide as the "gold-standard" transverse thermoelectric.

M.R. Scudder *et al.*, *Energy Environ. Sci.* **14** (2021) 4009-4017; covered in **NSF Science Nation video**.