CHARACTERIZATION OF RARE EARTH-DOPED III-V THERMOELECTRIC MATERIALS

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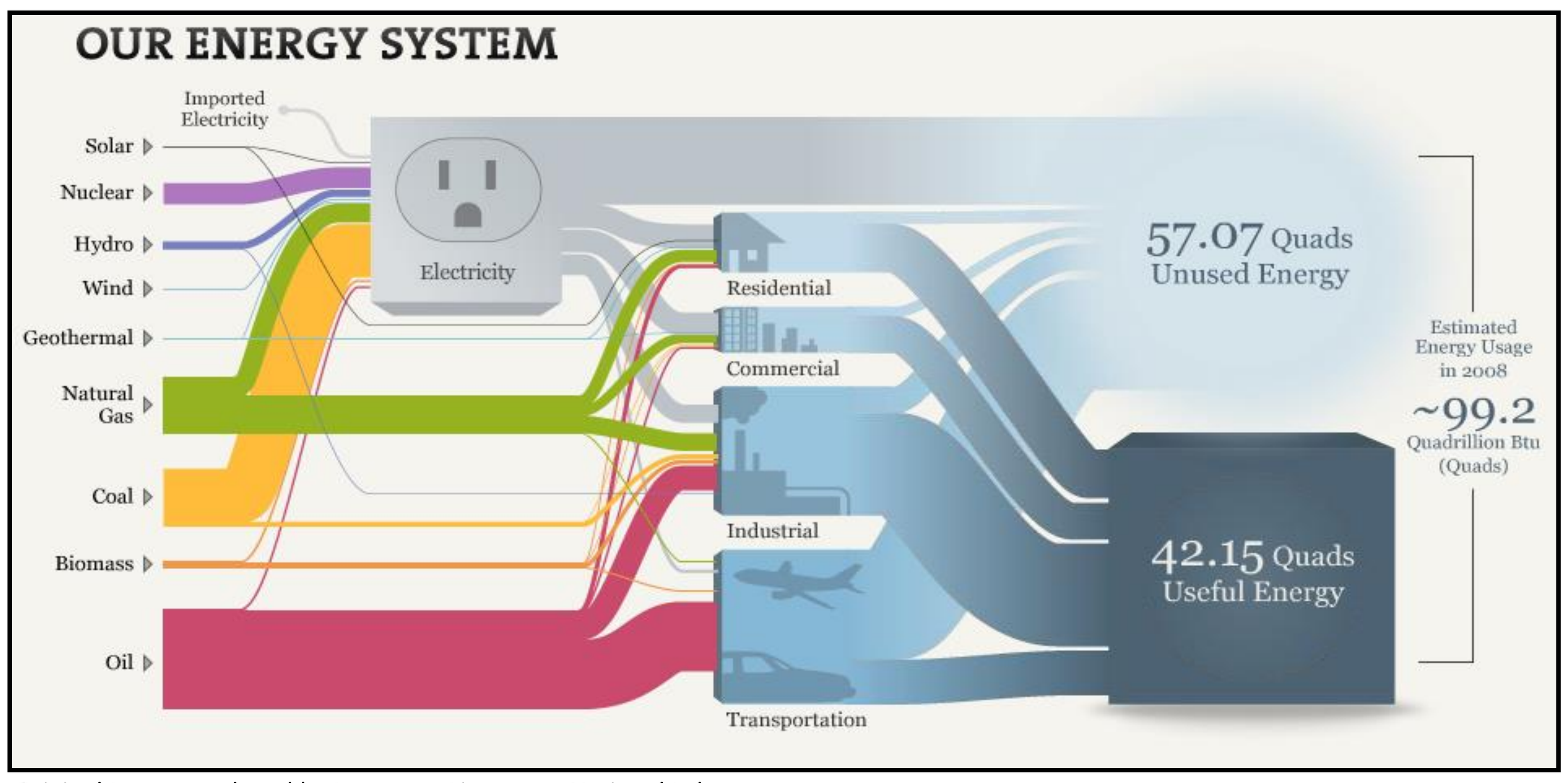
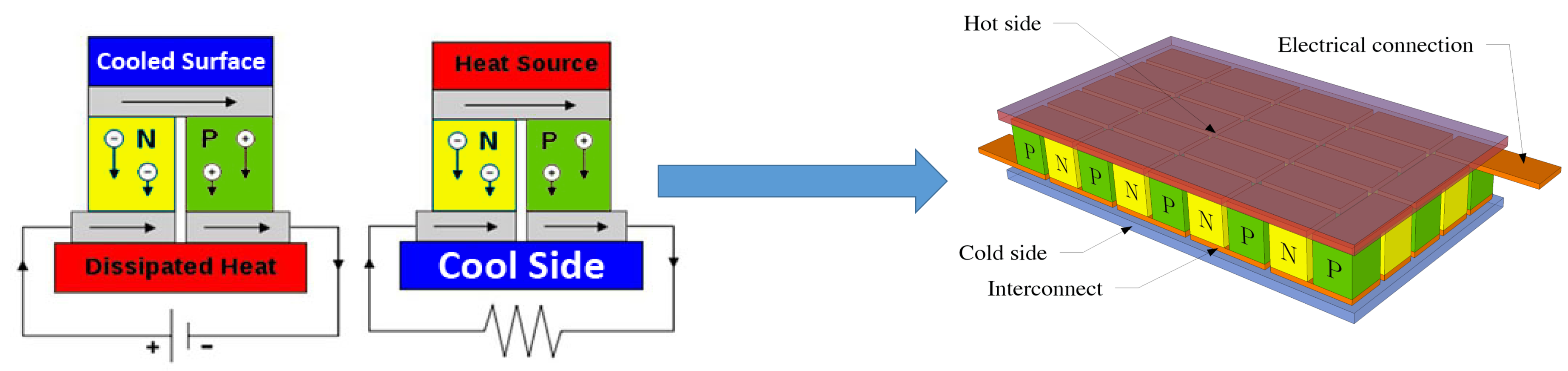
Energy Efficiency: We Lose More Than We Use



Original Image produced by Lawrence Livermore National Laboratory

Thermoelectric Devices

- Convert waste heat into usable electricity
- Hot charge carriers move to the cold side, producing a current
- Solid-state, robust, and require little maintenance



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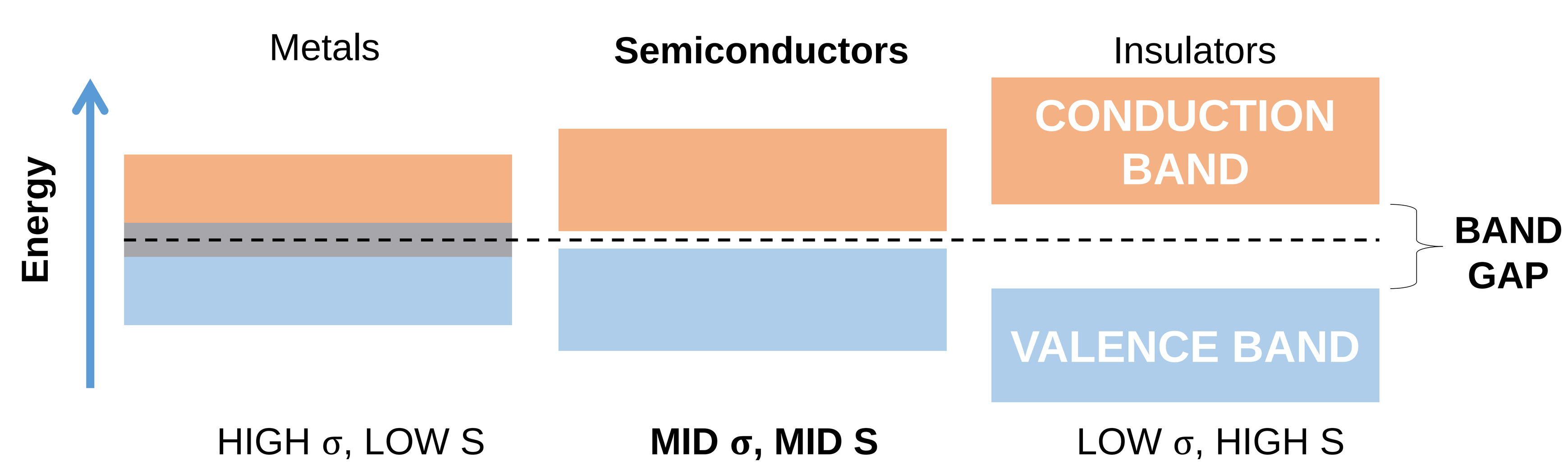
Semiconductors and the Thermoelectric Effect

The Thermoelectric Figure of Merit (ZT)

$$ZT = \frac{S^2\sigma}{\kappa}T$$

"Power Factor" $S^2\sigma$ — MAXIMIZE

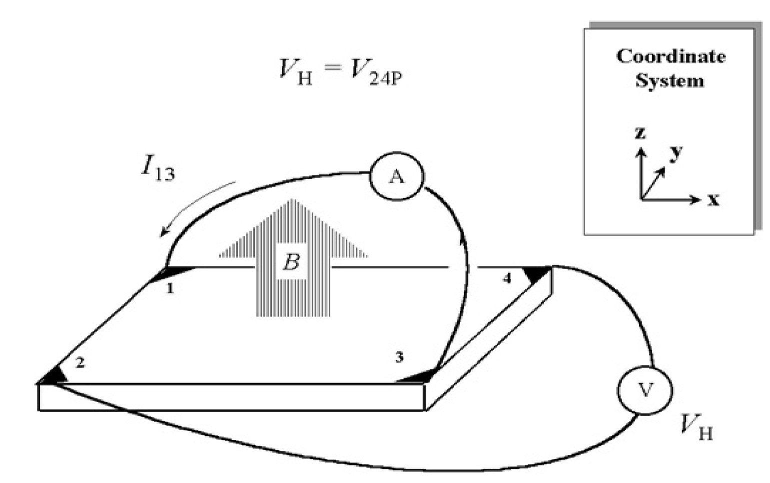
- Thermal conductivity (LOW)
- Seebeck coefficient (HIGH)
- Electrical conductivity (HIGH)



Hall Measurement

- Material conductivity (σ)
- Carrier concentration (n)
- Carrier mobility (μ)

$$\sigma = nq\mu$$

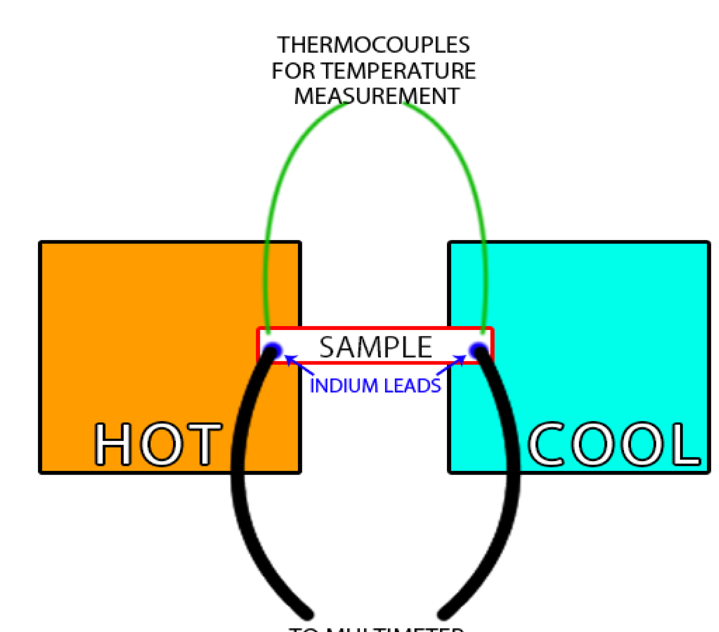


Van der Pauw Technique
Source: http://tau.nanophys.kth.se/cmp/hall/node5.html

Seebeck Measurement

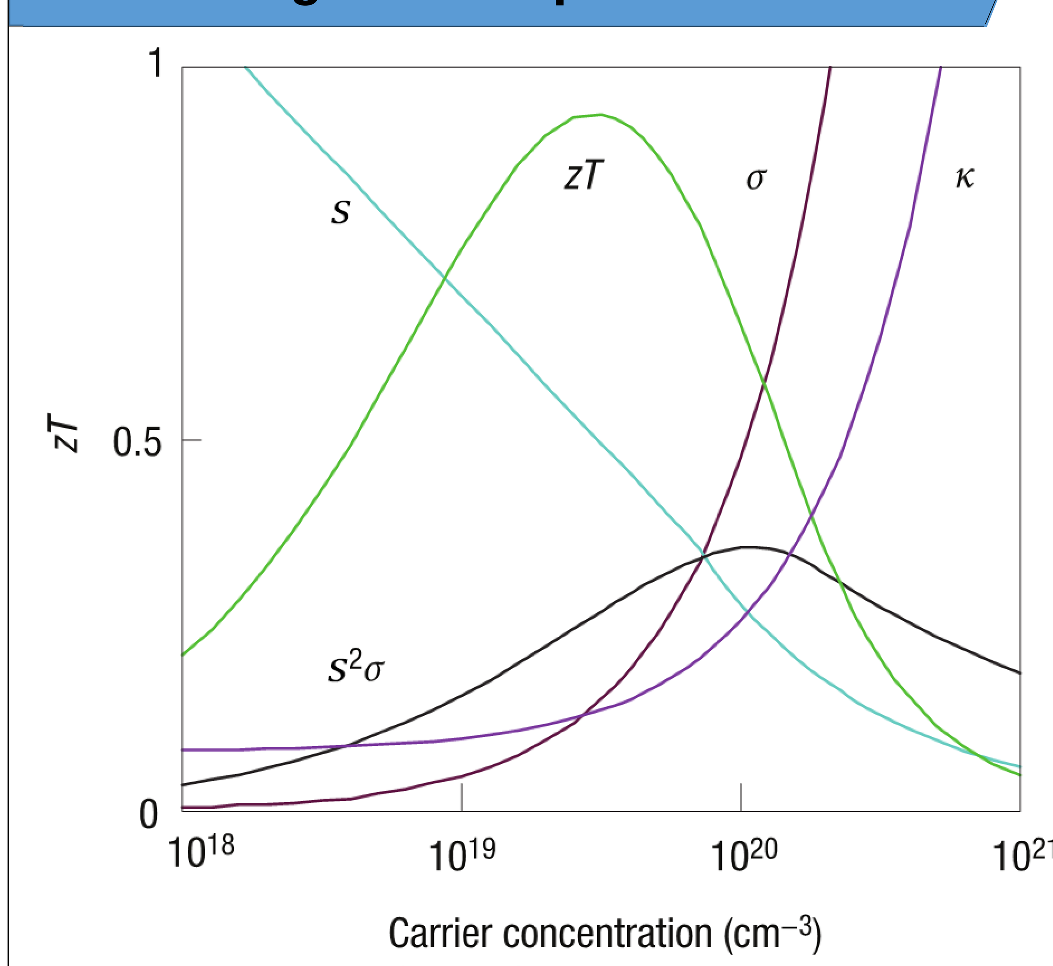
- Change in voltage induced by a temperature difference
- Positive for p-type material
- Negative for n-type material

$$S = \frac{\Delta V}{\Delta T}$$



Seebeck Measurement Apparatus

Balancing the Components of ZT

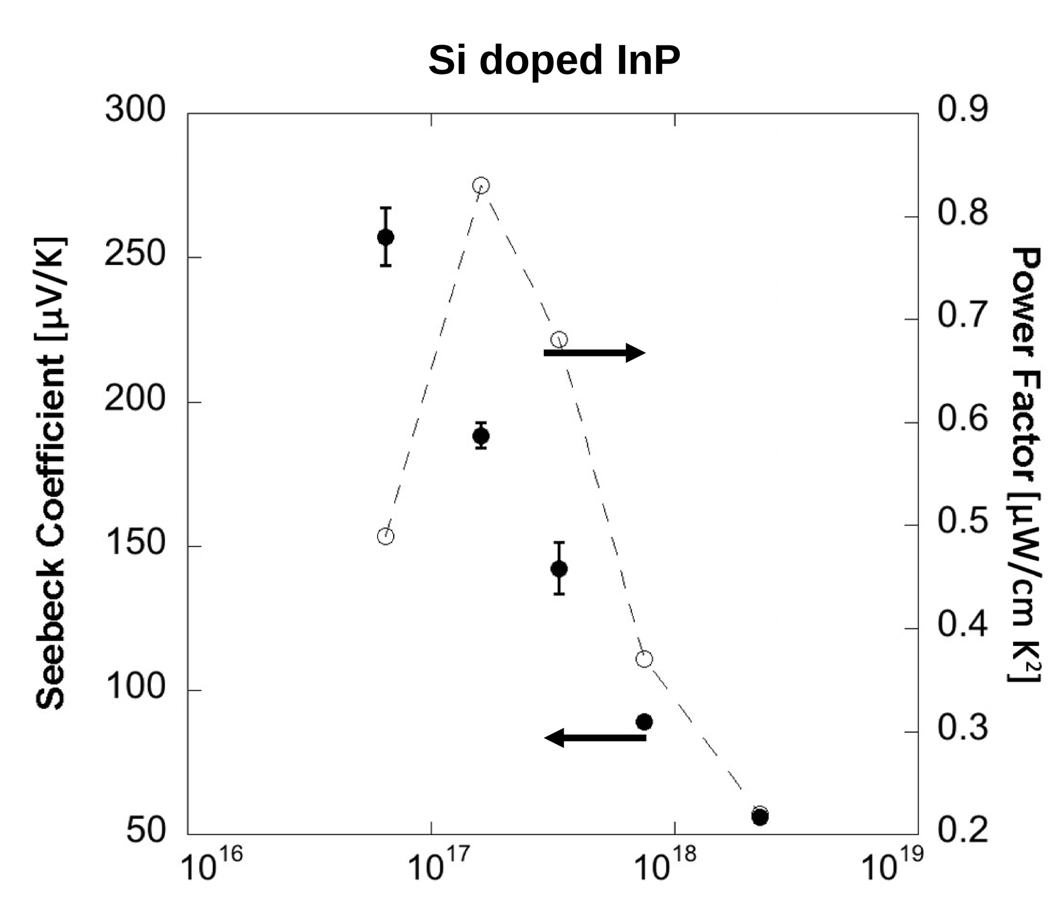


Snyder GJ, Toberer ES. Nat Mater 2008;7:105.

Inverse relationship between *S* and *n* indicates a balance is needed to maximize the power factor.

This optimal power factor can be achieved by varying the dopant concentration in the material.

Experimental results of Si doped InP will serve as a baseline for comparison with rare earth doped material.



Future Work and Expectations

The next steps are to grow series of Er:InP, Si:InAsP and Er:InAsP at different Si and Er concentrations. This will allow us to make direct comparisons between the binary compound, InP, and the ternary compound, InAsP, as well as any differences in the incorporation and ionization behavior of Er compared to Si in these materials. The ternary alloy InAsP is expected to have significantly lower thermal conductivity due to alloy scattering, however, the added lattice complexity may reduce the maximum doping concentration that it is possible to achieve.

Acknowledgements

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