



UiO : Centre for Materials Science and Nanotechnology
University of Oslo

Top-down to know thermoelectrics

Part 3

P-N pairs



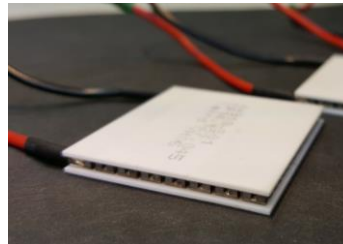
Top-down to know thermoelectrics (TE)

-- From TE applications to Materials

TE industrial applications



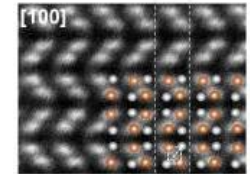
TE modules



TE Pairs



TE Materials



Availability and Installation



Zinc Antimonides

Fabrication



Conducting Oxide

Legs matching



Oxide

Material properties



Silicide

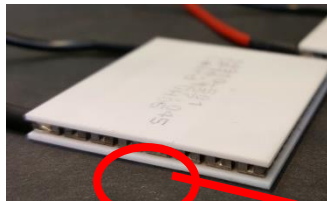


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THERMiO- thermoelectrics workshop

1. June 2017

TE-Pairs and junctions



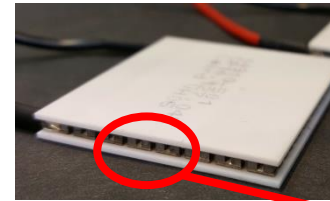
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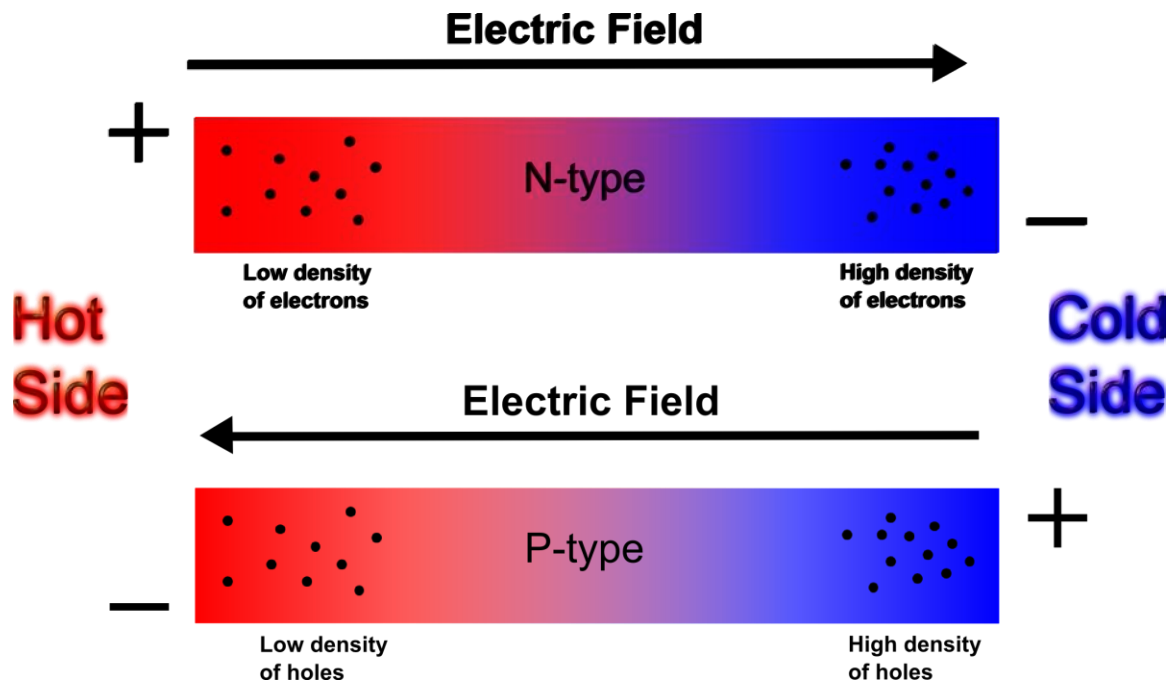
Outline

- Fundamentals
 - P- and N- legs in TEs
 - Interconnects
 - Thermal mismatch
- Science
 - New P- and N-leg pair design
 - Phase stability

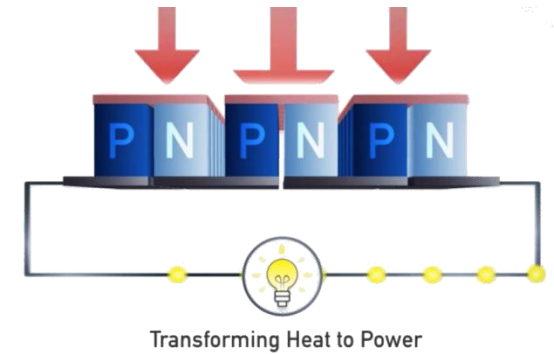


Thermoelectric effect

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

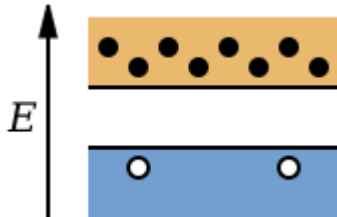


N- & P-type conduction



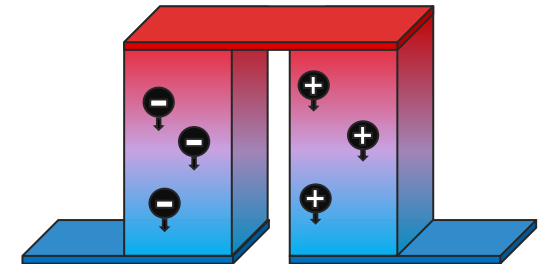
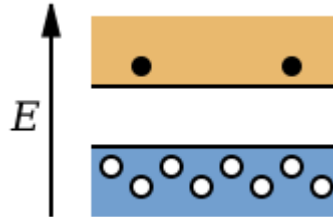
N-type

- Electrons carry charge

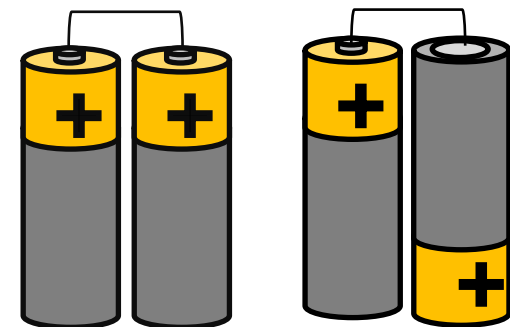


P-type

- Holes carry charge

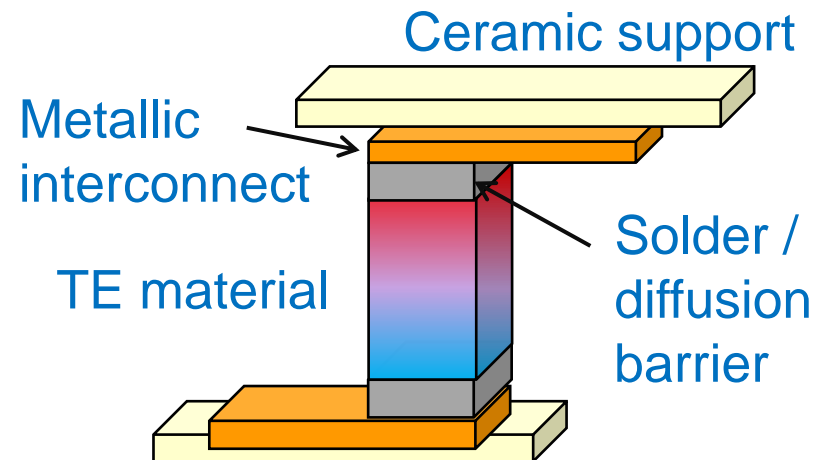
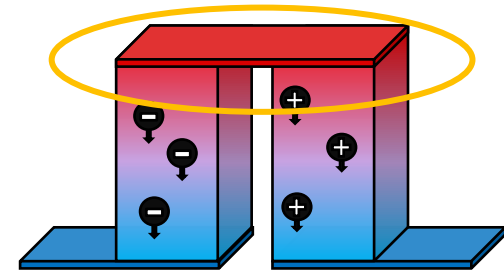


- Only one direction of conduction possible
 - ZT of N- and P-leg add up



Interconnects

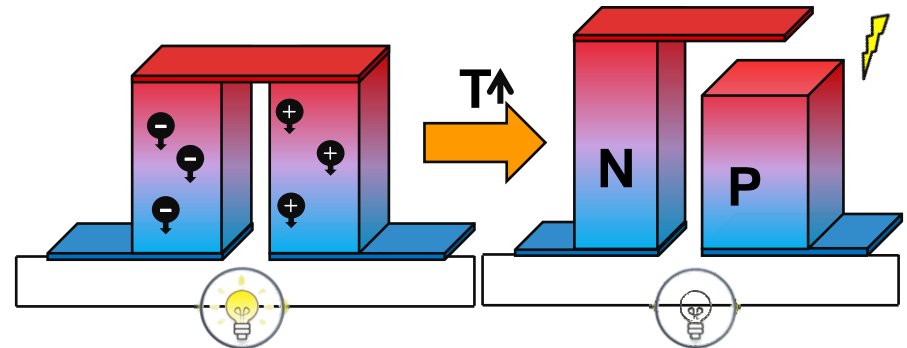
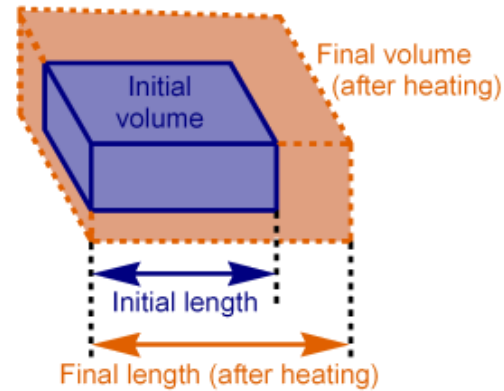
- Electrical contact between N- and P-legs
 - Substrate (Al_2O_3)
 - Metal interconnect (Cu, Mo)
 - Solder (Ag, Pb)
 - (Diffusion Barrier/ Buffer layer)
- Properties
 - Low contact resistance
 - Insulating support
 - Stable
 - Inert
 - Comparable thermal expansion



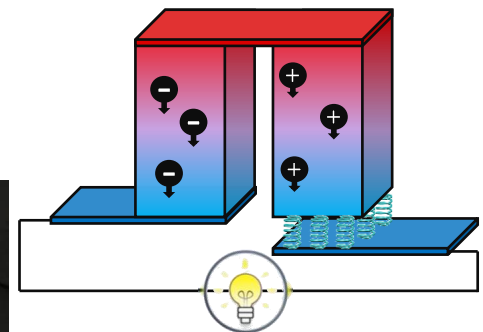
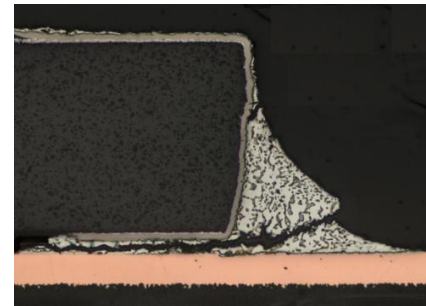
- Ongoing field of research
 - E.g. Cu- ZnSb interface (Henrik)
 - Ceramic interconnect (Reshma)

Thermal mismatch

- Thermal expansion
 - Not equal in all directions
- Thermal mismatch
 - Different expansion of the compartments

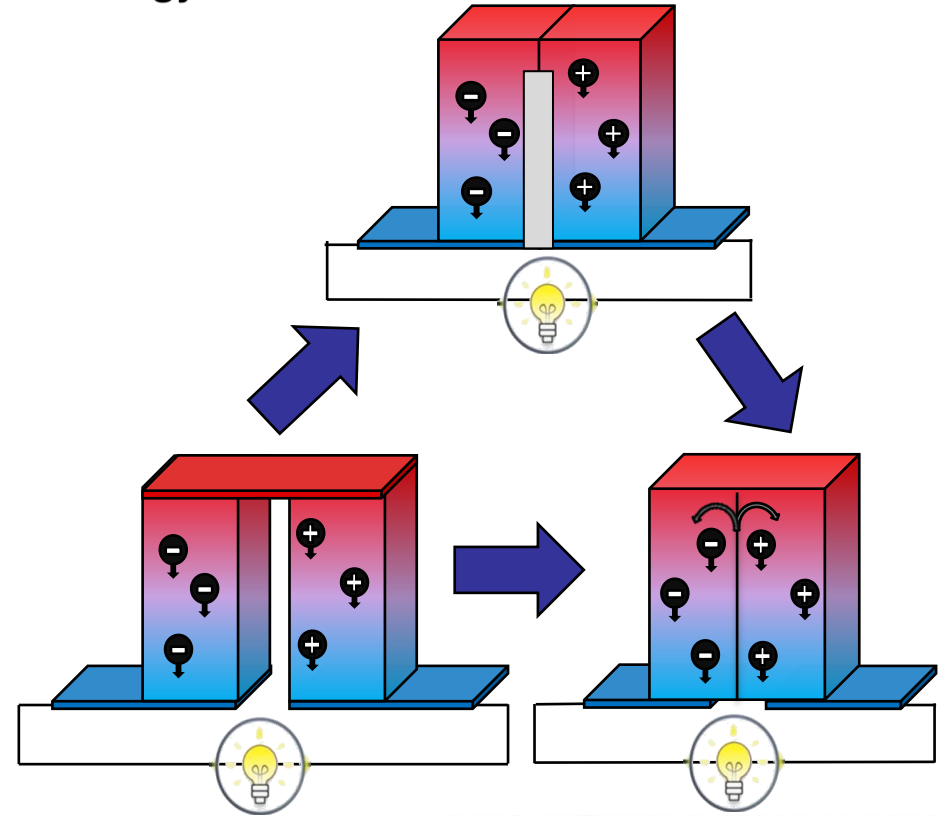


- Loss of contact due to cracking
- Find materials with matching expansion
 - Compensate for expansion



New design

- **Omitting interconnect**
 - Direct p-n junction
 - No metal interdiffusion
 - Easier production
 - Less material
 - Less frail
- **Large are p-n junction**
 - Temperature gradient controls resistance



- **Stability?**
 - Diffusion
 - reactions

