Oxide thermoelectrics

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Thermoelectric materials DIRECTLY CONVERT HEAT INTO ELECTRICITY and vice versa.

Efficiency of thermoelectric materials

Tha efficiency of thermoelectric materials for both power generation and cooling is determined by its Thermoelectric Figure of Merit (ZT)

$$ZT = S^2T/\rho\kappa$$

Max. ZT depends on: **HIGH** Seebeck coefficient (S), temperature (T), **LOW** electrical resistivity (ρ), and **LOW** thermal conductivity (κ).

Optimization of conflicting properties

GOOD thermoelectric material

Electrons free to transport charge and heat

Phonons disrupted from transporting heat

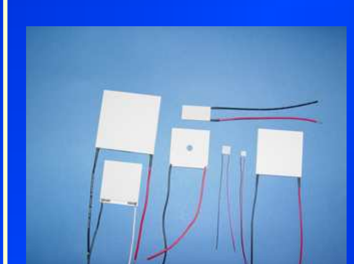
Phonon-Glass Electron-Crystal material (PGEC)

Oxide thermoelectrics

P-type: Na_4CoO_4, $Ca_3Co_4O_9$, etc.
N-type: $(ZnO)(In_2O_3)$, $SrTiO_3$, Al doped ZnO, etc.
Advantages:
- High durability against high temperature and oxidation
- Chemical stability
- Nontoxic
- Light weight
- Small thermal expansion

Applications

Thermoelectric modules



Thermoelectric cooling solutions for electronic telecommunication enclosures, computer cabinets, mini-fridges, and in other enclosed spaces that require specialized climate control.

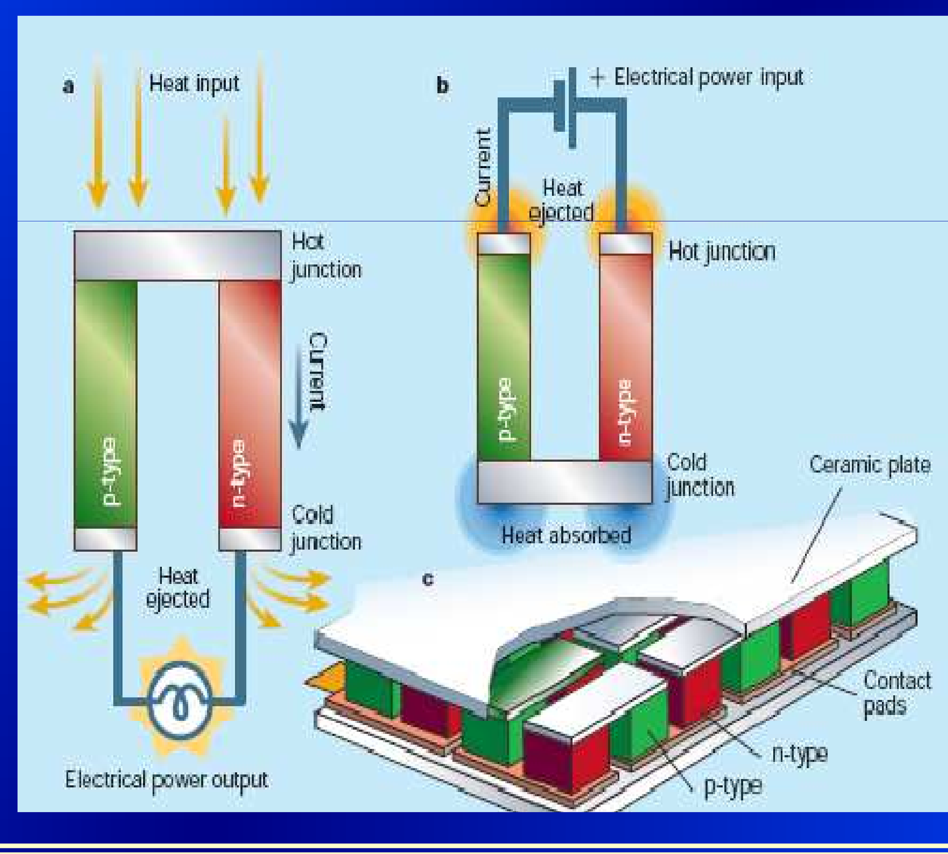
NASA's Cassini Probe to Saturn and Jupiter

A radioisotope thermoelectric generator

Prototype projectors ; concepts: compactness, reduction of fans, and low noise.

Thermoelectric devices

Schematical presentation of typical thermoelectric applications (devices):
a) power generation, and
b) refrigeration device comprising of p-type and n-type semiconducting material.
c) State of the art thermoelectric device containing several thermocouples.

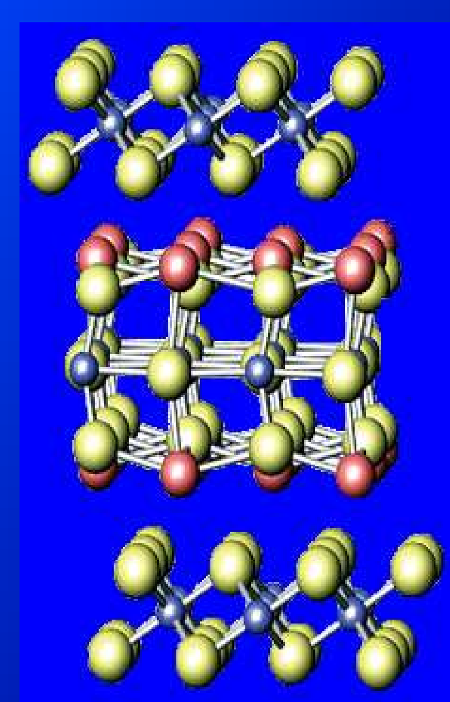


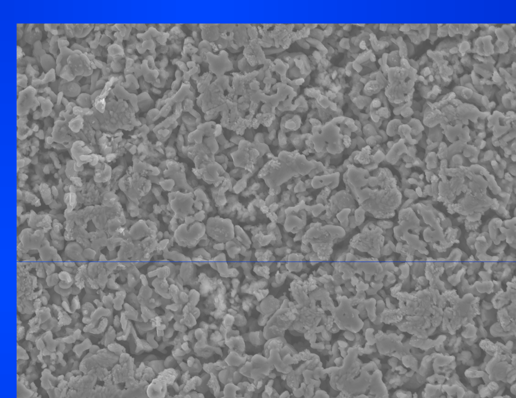
State of the art thermoelectric materials

Conventional materials: Bi_2Te_3, Sb_2Te_3, GeTe, BiSb, PbTe alloy, Zn_3Sb_4, etc.
Limitations:
- Poor chemical stability
- Brittle nature
- Toxic element
- Rare element
- Oxidation

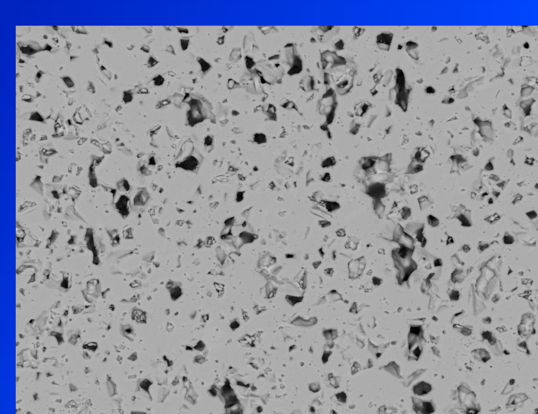
Our work

- Synthesis of thermoelectric material (Na_xCoO_2, $Ca_3Co_4O_9$ and related systems, ceramics in ZnO - In_2O_3 system doped with various dopants)
- Tailoring of thermoelectric characteristics for the best thermoelectric efficiency via:
  - structure
  - microstructure
  - phase optimization
  - with addition of various dopants





Structure of the $Ca_3Co_4O_9$ phase and SEM image of the microstructure.



SEM image of the microstructure of $ZnO\text{-}In_2O_3$ phase .

- Constructing a new measuring system for thermoelectric characterization