Thermoelectric

2018146033 임 민수
2018146067 이 진영
2018146085 임 찬혁
2018146107 이 지수

- History , overview, and introduction
- Theory of Thermoelectric
- Experiment
- Application

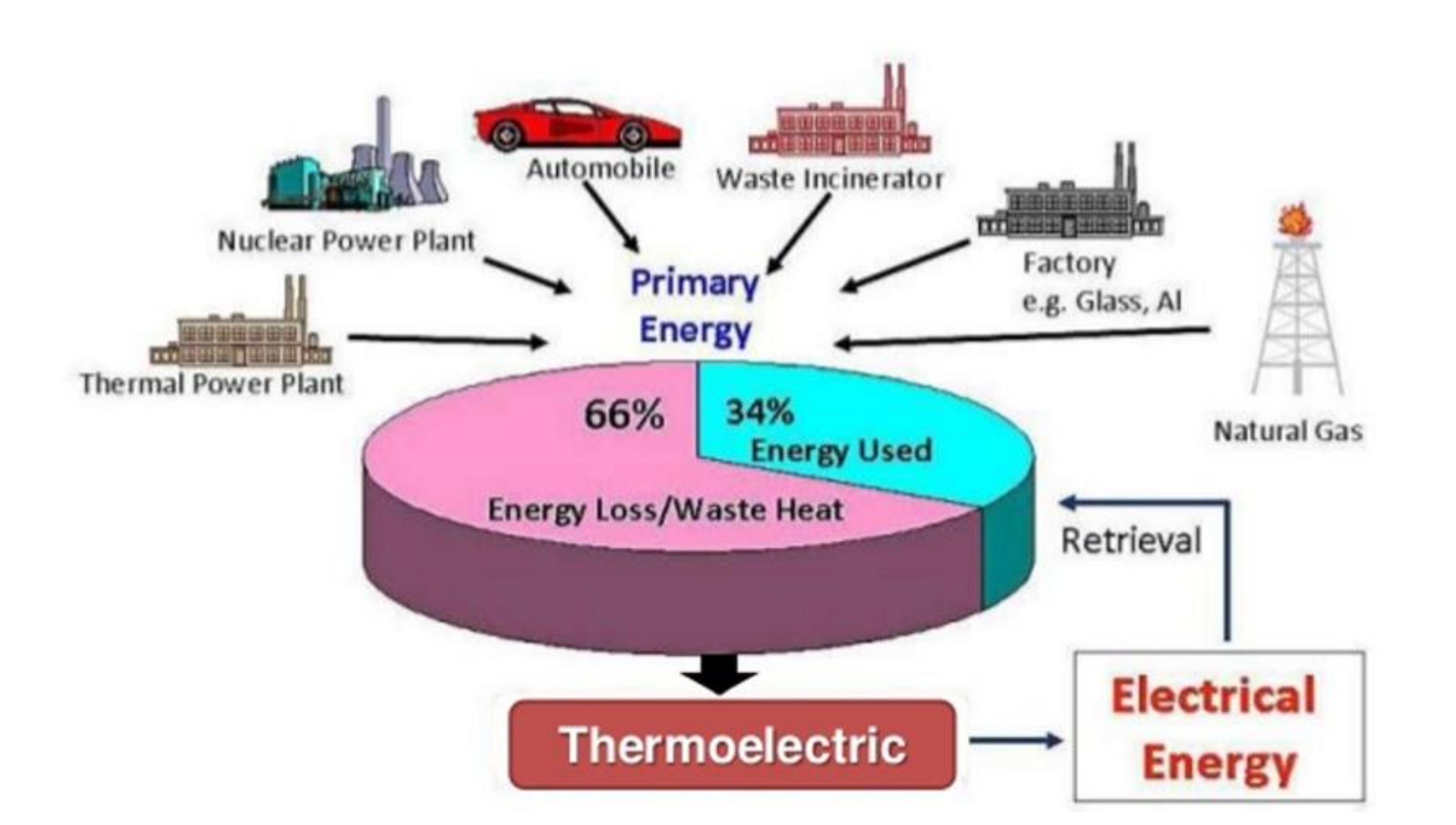
History

임민수

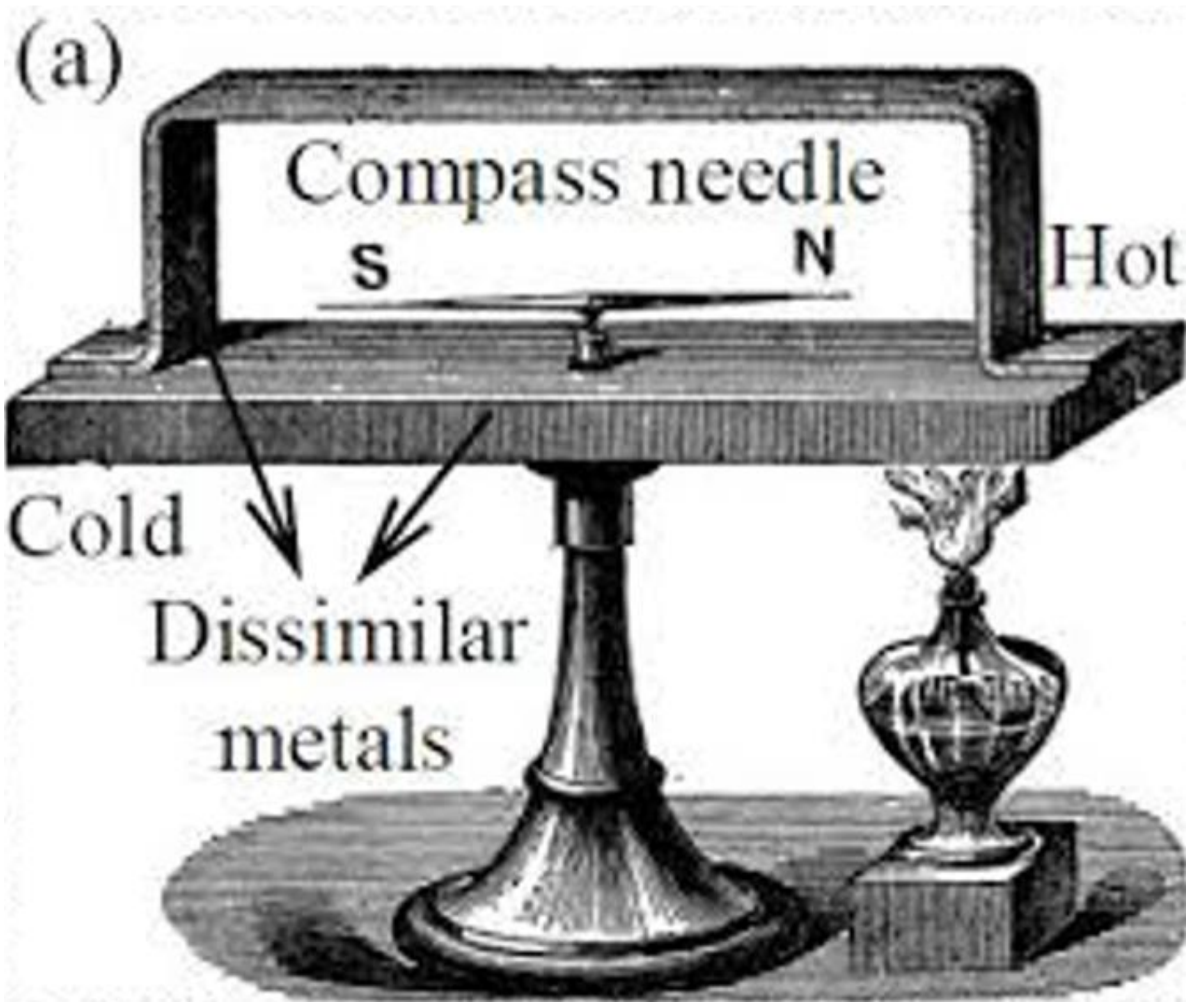
[Second Industrial revolution]

[Climate Change]

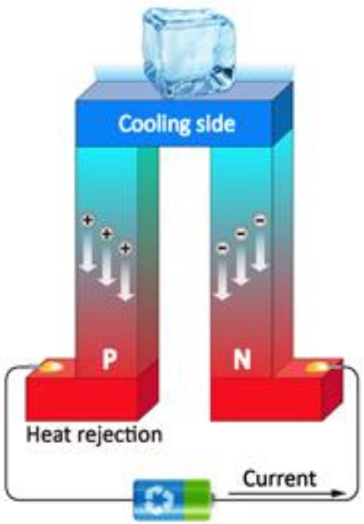
Waste Heat to electricity

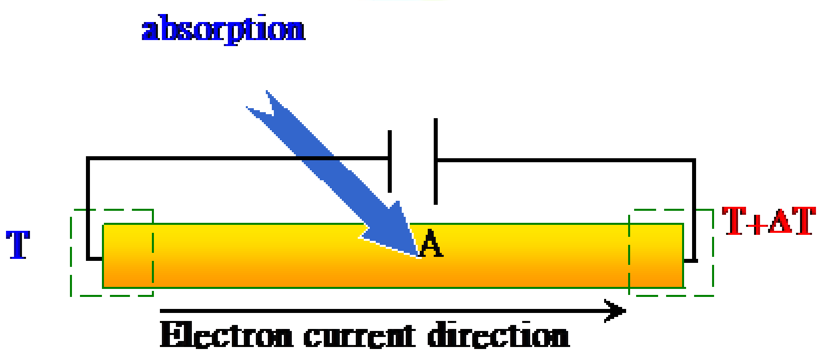


Seebeck Effect



Peltier Effect & Thomson Effect





[Peltier Effect]

[Thomson Effect]

Theory

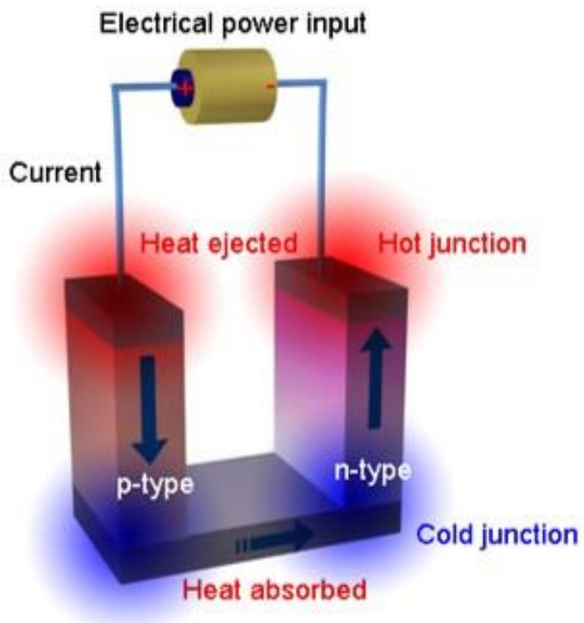
이진영

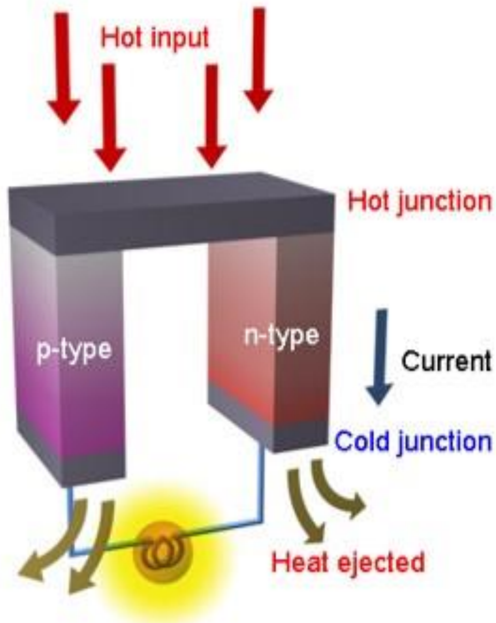
THERMOELECTRICITY : The direct conversion of heat into electricity

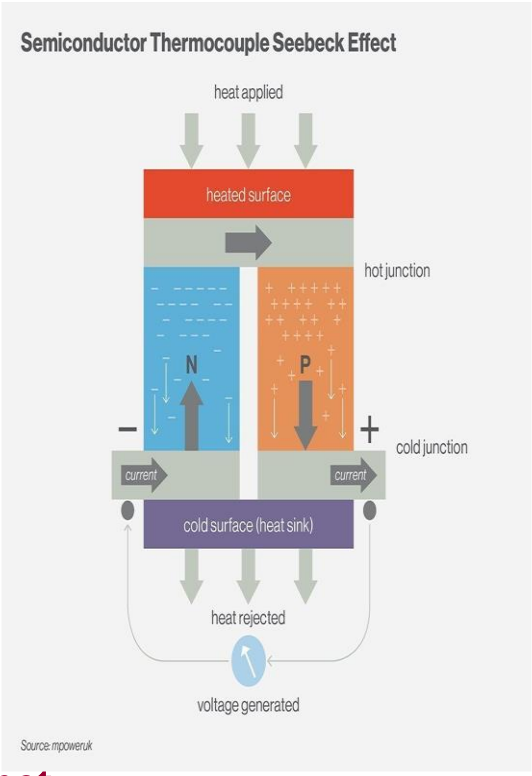
THERMOELECTRIC EFFECT

- PELTIER EFFECT
- SEEBECK EFFECT
- THOMSON EFFECT

THERMOELECTRIC EFFECTS







Peltier effect

(1843)

Seebeck effect

(1821)

THERMOCOUPLE

Thermoelectric Cooling & Thermoelectric Power Generation

$$Cooling\ Efficiency = \frac{T_C[(1+ZT_M)^{1/2} - \frac{T_H}{T_C}]}{(T_H - T_C)[(1+ZT_M)^{1/2}+1]}$$

$$Power\ Efficiency = \frac{T_H - T_C}{T_H} \frac{\sqrt{1+Z_M(T_H+T_C)/2}-1}{\sqrt{1+Z_M(T_H+T_C)/2}+(T_C/T_H)}$$

ZT : Performance Criteria of Thermoelectrical Materials

Power Factor : σS^2

Seebeck Coefficient

Conductivity

Temperature

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

Thermal Conductivity

$ZT \sim 3$ for desired goal

Difficulties in increasing *ZT* *in bulk materials:*

$\sigma \uparrow \Leftrightarrow S \downarrow$ *and* $\kappa \uparrow$

$S \uparrow \Leftrightarrow \sigma \downarrow$

STRATEGY TO INCREASE ZT

- DOS(Density of State) ENGINEERING

Mobility of carrier
"LOW DIMENSION"

↓

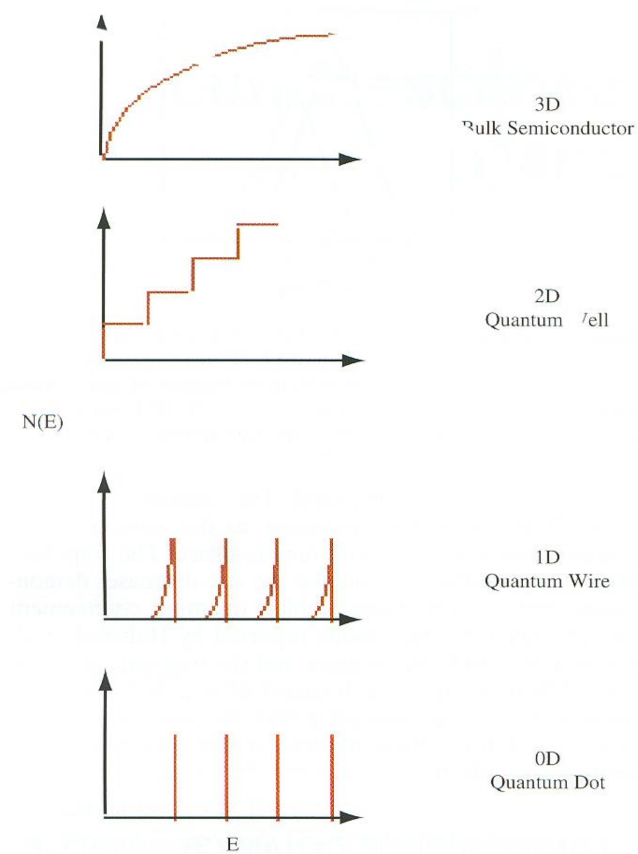
DOS(Density of State)
INCREASING

↓

S(Seebeck Coefficient)
INCREASING
without σ change

↓

ZT INCREASING

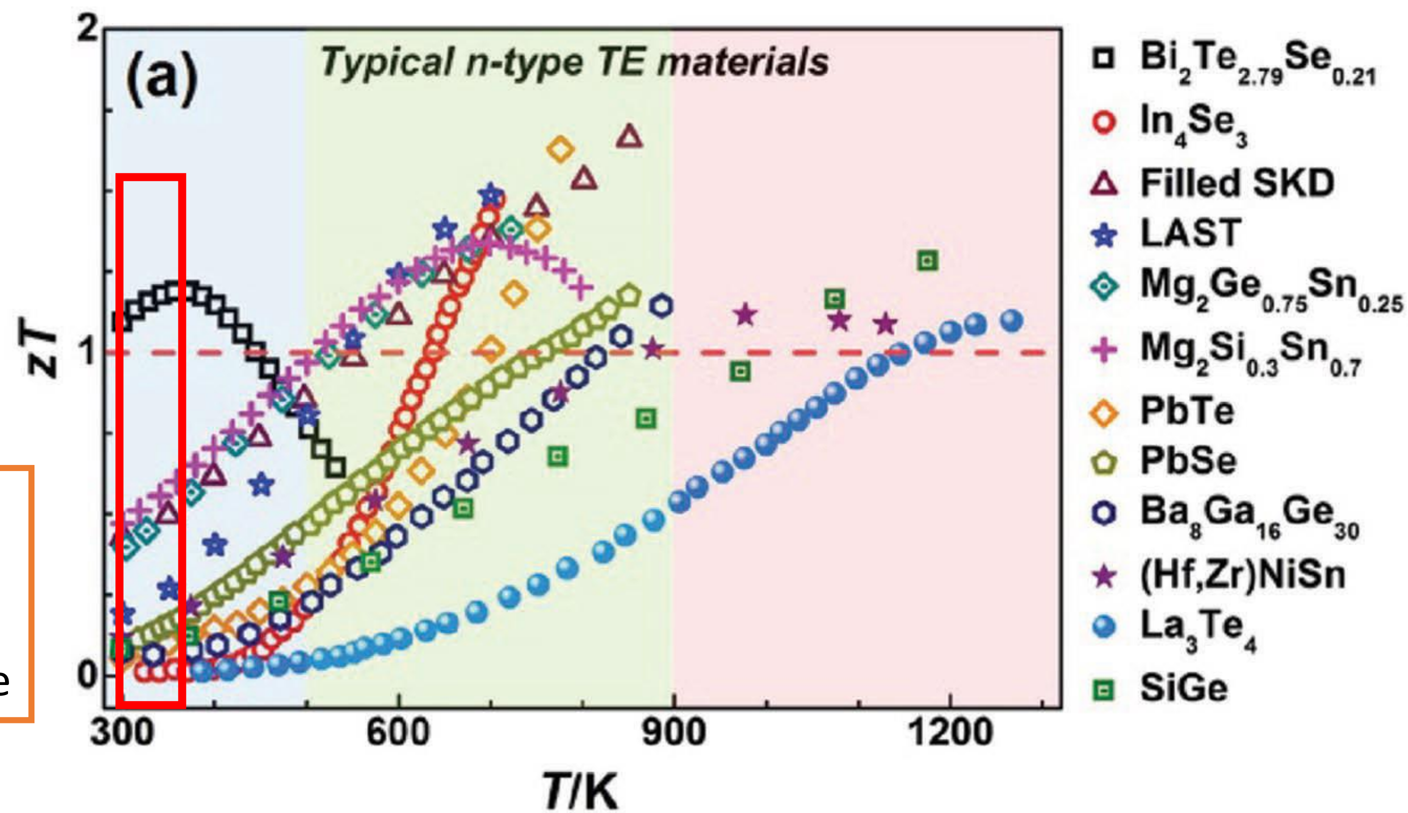


Experiment

임찬혁

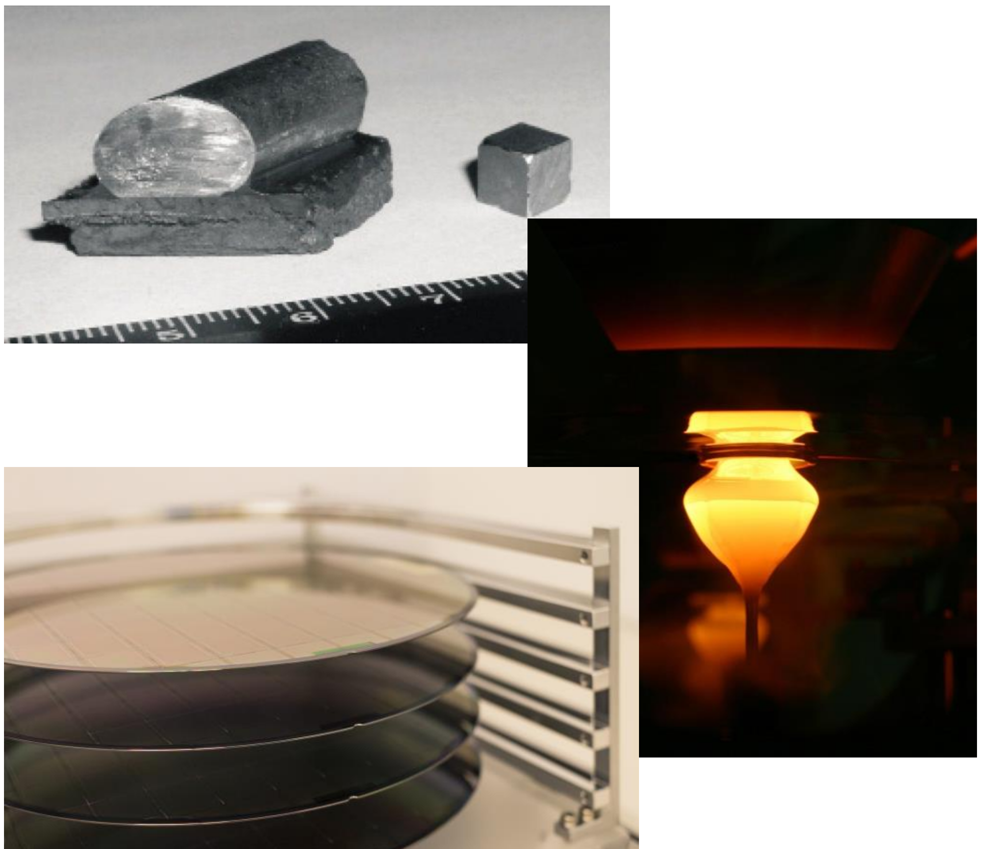
TE materials

Contents | History | Theory | Experiment | Application



Bi-Te :
High zT at
ordinary
temperature

Bi-Te : ZONE MELTING



[Crystal Growth]

↓

[Slicing]

↓

[Coating]

↓

[Dicing]

Bi-Te : HOT EXTRUSION

Yield ↑

Cost ↑

[High Temperature]

[Pressing Out]

Hot Press

Application

이지수

Thermoelectric Application

Thermoelectric Cooling (TEC)

Thermoelectric Generation (TEG)

[Qc (Cooling capacity)

$$= \alpha T_C I - \frac{1}{2} I^2 R - K\Delta T$$]

Heat absorption by Peltier effect

Joule thermal effect due to the current flow

Reversed heat by the temperature difference

Coefficient of performance

$$\left[\ \mathrm{COP} = \frac{Q_C}{P} = \frac{\alpha T_C I - \frac{1}{2} I^2 R - K\Delta T}{\alpha I \Delta T + I^2 R}\ \right] \propto \mathbf{ZT}$$

[Low power & small size]

[High capacity Semiconductor Diode, Laser, and Power Amplifier Connection System]

[Flat type large optoelectrics]

Heat density ↑

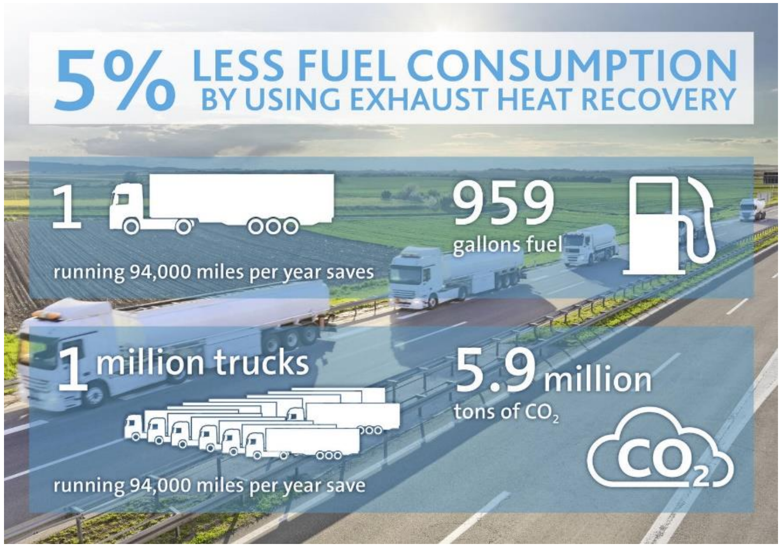
Number of applied module ↓

For vehicles

Smaller Devices

TEG Efficient ∝ ZT

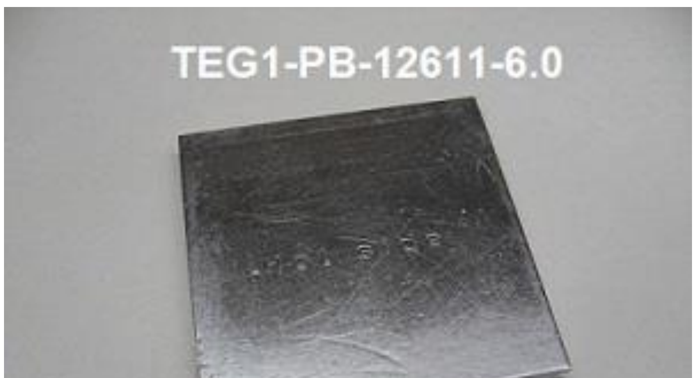
- transport waste heat



- industry waste heat

Transportation Waste Heat

FUEL CONSUMPTION



Bi-Te thermoelectric generator

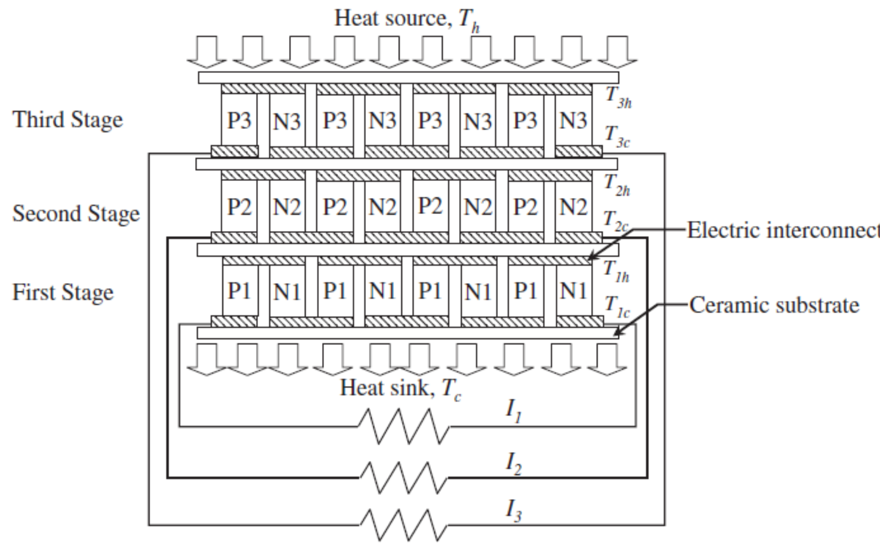


Fig. Schematic diagram of a general cascaded TEG.

Low grade heat!

- Bi-Te
- Flexible modularization technology

→ Wearable devices, wireless sensors,..

THANK YOU