Seebeck measurement

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Thermoelectric effects

Seebeck

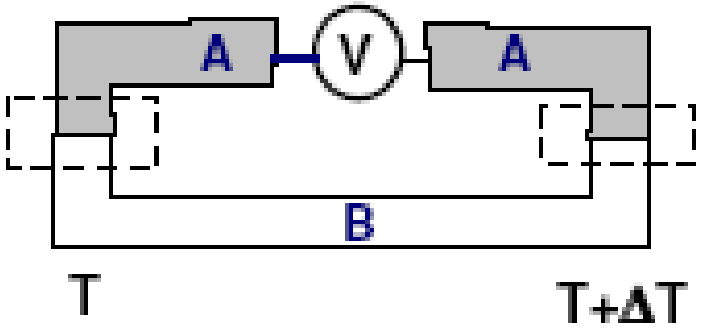
Heat
Temperature

exchange

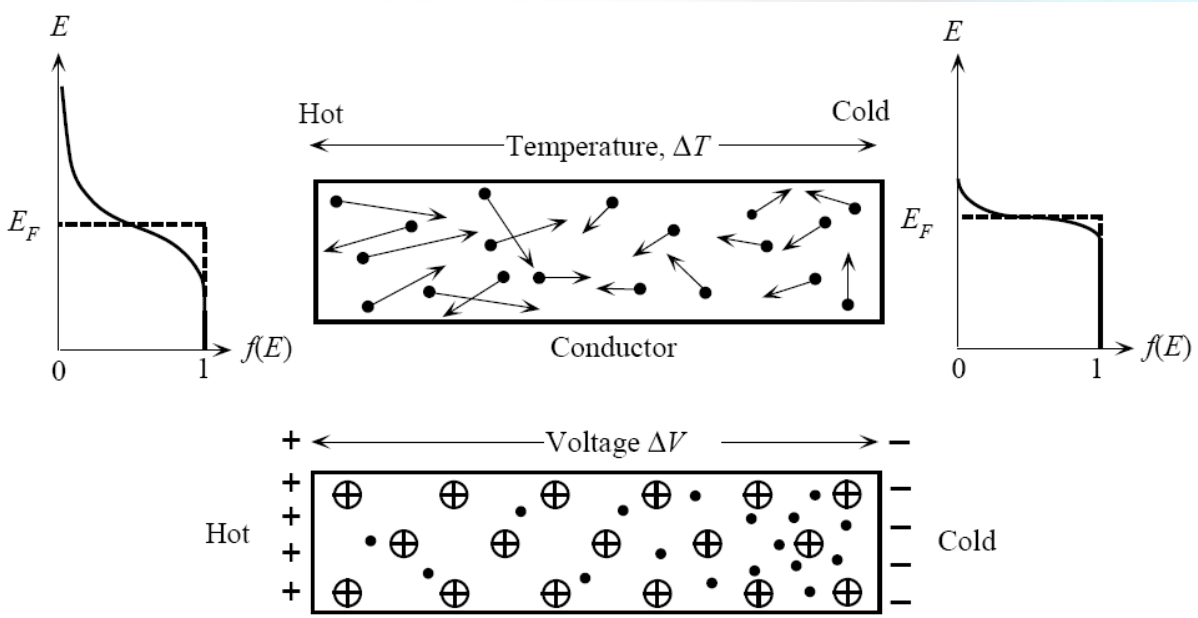
Electricity
Voltage

Peltier

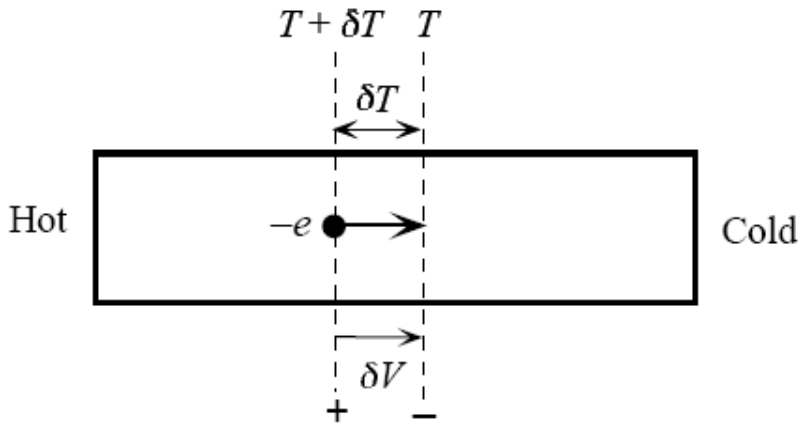
$$S_{AB} = S_A - S_B = (\Delta V / \Delta T)_{Je=0}$$



Physical picture of Seebeck effect



- The temperature gradient causes the flow of charge carriers. A retarding field will be established to prevent further charge pile-up when the system is in equilibrium.
- Conventionally, the sign of S represents the potential of the cold end with respect to the hot end.



Consider a small length δx over which the temperature difference is δT and voltage difference is δV. Suppose that one electron diffuses from hot to cold region across this potential difference.

$$-e\delta V = E_{av}(T+\delta T) - E_{av}(T)$$

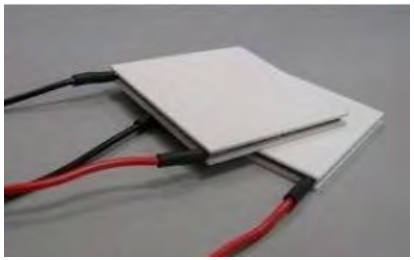
$$-e\delta V \approx \frac{\pi^2 k^2 T \delta T}{2E_{FO}}$$

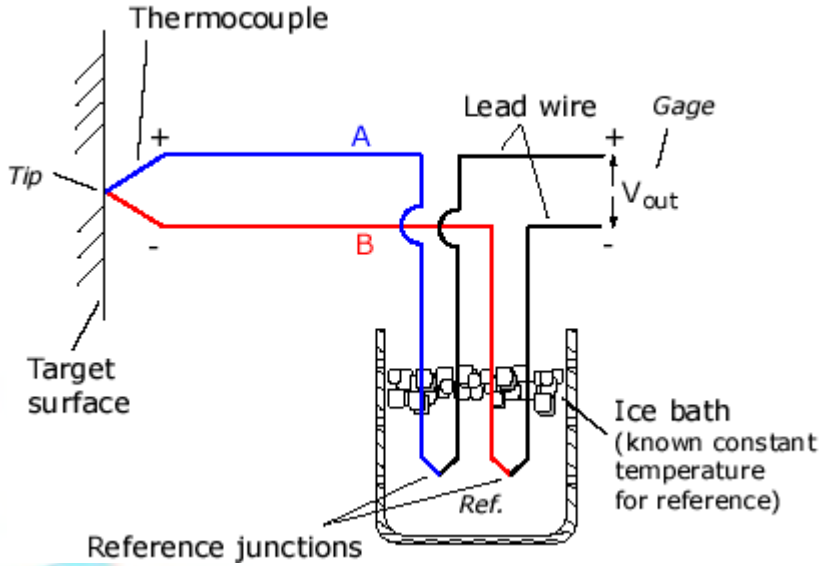
$$S \approx -\frac{\pi^2 k^2 T}{2eE_{FO}}$$

$$E_{av}(T) = \frac{3}{5}E_{FO}\left[1 + \frac{5\pi^2}{12}\left(\frac{kT}{E_{FO}}\right)^2\right]$$

Applications

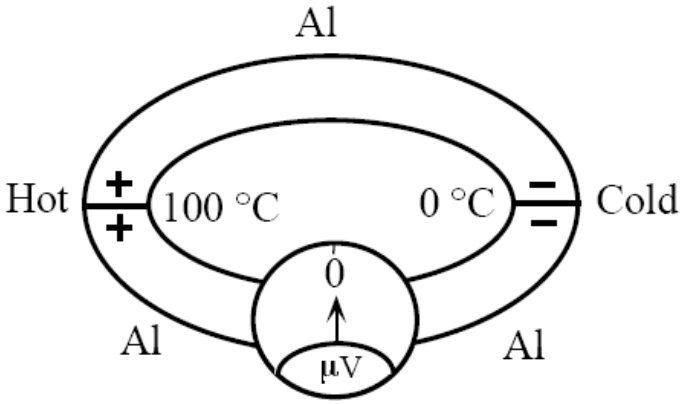
- 發電器（TEG） Seebeck
- 製冷器（TEC） Peltier
- 熱電偶（Thermocouple）



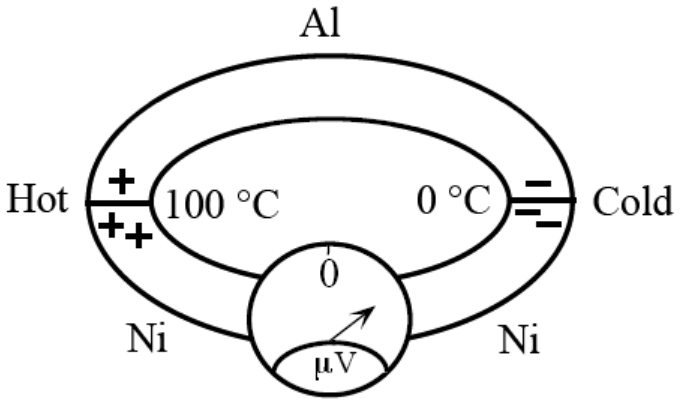


$$V_{\text{out}} = (S_A - S_B)(T_{\text{Tip}} - T_{\text{Ref}})$$

$$\Rightarrow T_{\text{Tip}} = T_{\text{Ref}} + \frac{V_{\text{out}}}{S_A - S_B}$$

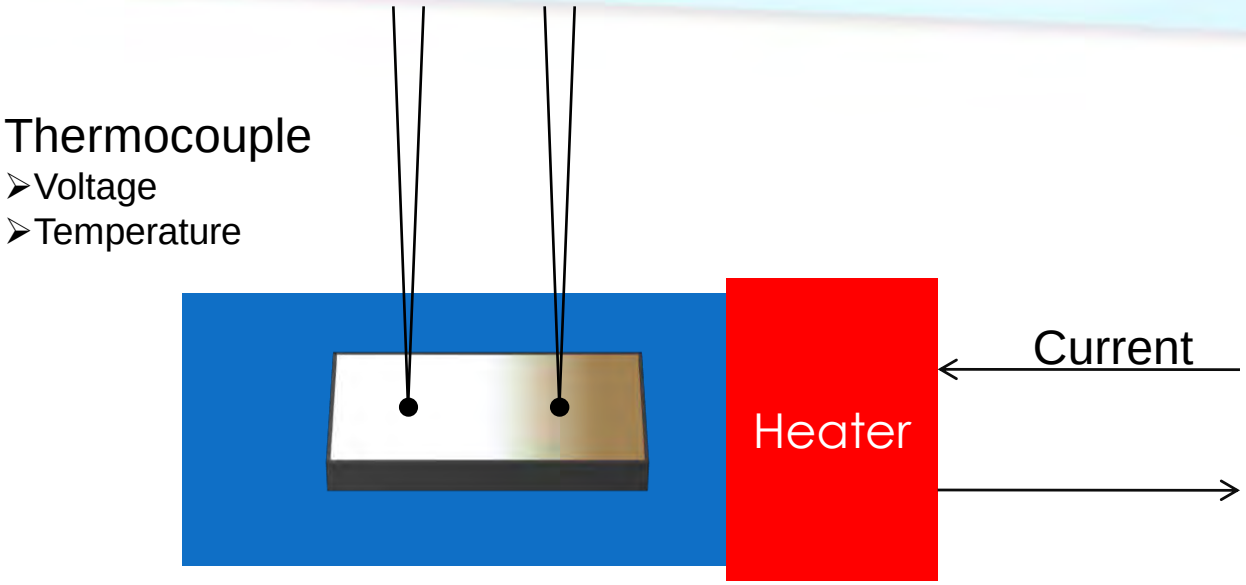


$\Delta V = 0$



$\Delta V \neq 0$

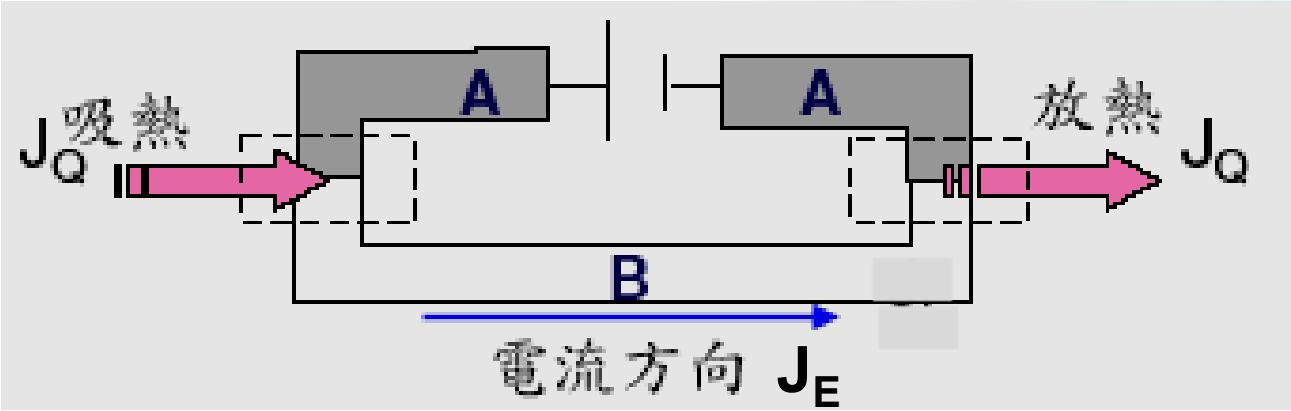
Measurement



Seebeck coefficient of some Material

	Al	Cu	Fe	Ni	Pt	Se	Si	Te	Bi	Ge
Seebeck (μV/K)at 0°C	3.5	6.5	19	-15	0	900	440	500	-72	300

Peltier Effect



當一電流通過以上電路，一介面端會吸熱，另一介面端會放熱；若改變電流方向，則吸熱端與放熱端亦隨之互換

“熱” ⟷ “電” 可逆

Peltier coefficient is defined as

$$\pi_{AB} = J_Q / J_E = \text{熱流/電荷流}$$