

2.1.4 Summary to: Conductors - Definitions and General Properties

What counts are the *specific* quantities:

- Conductivity σ (or the specific resistivity $\rho = 1/\sigma$).
- current density j .
- (Electrical) field strength E .

- The basic equation for σ is:
 n = concentration of carriers,
 μ = mobility of carriers.

- Ohm's law states:
It is valid for metals, but not for all materials.

$$[\rho] = \Omega\text{m}$$

$$[\sigma] = (\Omega\text{m})^{-1} = \text{S/m};$$

$$\text{S} = \text{"Siemens"}$$

$$\sigma = |q| \cdot n \cdot \mu$$

$$j = \sigma \cdot E$$

σ (of conductors / metals) obeys (more or less) several rules; all understandable by looking at n and particularly μ .

- Matthiesen rule:
Reason: Scattering of electrons at defects (including phonons) decreases μ .

- " $\rho(T)$ rule":
about 0,04 % increase in resistivity per K
Reason: Scattering of electrons at phonons decreases μ .

- Nordheim's rule:
Reason: Scattering of electrons at B atoms decreases μ .

$$\rho = \rho_{\text{Lattice}}(T) + \rho_{\text{defect}}(N)$$

$$\Delta\rho = \alpha_{\rho} \cdot \rho \cdot \Delta T \approx \frac{0,4\%}{^{\circ}\text{C}}$$

$$\rho \approx \rho_A + \text{const.} \cdot [B]$$

Major consequence: You can't beat the conductivity of pure Ag by "tricks" like alloying or by using other materials (Not considering superconductors).

Non-metallic conductors are *extremely* important.

- Transparent conductors (TCO's)
("ITO", typically oxides).
- Ionic conductors (liquid and solid).
- Conductors for high temperature applications; corrosive environments, ..
(Graphite, Silicides, Nitrides, ...).
- Organic conductors (and semiconductors).

No flat panels displays = no notebooks etc. without ITO!

Batteries, fuel cells, sensors, ...

Example: **MoSi₂** for heating elements in corrosive environments (dishwasher!).

The future High-Tech key materials?

Numbers to know (order of magnitude accuracy sufficient)

ρ (decent metals) about 2 $\mu\Omega\text{cm}$.
 ρ (technical semiconductors) around 1 Ωcm .
 ρ (insulators) > 1 $\text{G}\Omega\text{cm}$.

Questionnaire

All Multiple Choice questions to 2.1