2.1.4 Summary to: Conductors - Definitions and General Properties

What counts are the *specific* quantities:

- Conductivity σ (or the specific resistivity ρ **= 1/** σ.
- current density $\boldsymbol{j}$.
- (Electrical) field strength · ***E***.

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

The basic equation for σ is:
n **=** concentration of carriers,
$\boldsymbol{\mu}$ = mobility of carriers.

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

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

$$j = \sigma \cdot E$$

σ (of conductors / metals) obeys (more or less) several rules; all understandable by looking at ***n*** and particularly $\boldsymbol{\mu}$.

Matthiesen rule:
Reason: Scattering of electrons at defects (including phonons) decreases $\boldsymbol{\mu}$.

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

"$\rho(T)$ rule":
about **0,04 %** increase in resistivity per **K**
Reason: Scattering of electrons at phonons decreases $\boldsymbol{\mu}$.

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

Nordheim's rule:
Reason: Scattering of electrons at **B** atoms decreases $\boldsymbol{\mu}$.

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

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).

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

Ionic conductors (liquid and solid).

Batteries, fuel cells, sensors, ...

Conductors for high temperature applications; corrosive environments, ..
(Graphite, Silicides, Nitrides, ...).

Example: **$MoSi_2$** for heating elements in corrosive environments (dishwasher!).

Organic conductors (and semiconductors).

The future High-Tech key materials?

Numbers to know (order of magnitude accuracy sufficient)

ρ(decent metals) about **2** µ**Ωcm**.
ρ(technical semiconductors) around **1 Ωcm**.
ρ(insulators) > 1 GΩcm.

Questionaire

All Multiple Choice questions to 2.1