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 $\underline{\boldsymbol{j}}$.
- (Electrical) field strength · $\underline{\boldsymbol{E}}$.

[ρ] = Ωm
[σ] = (Ωm)$^{-1}$ = S/m;
S = "Siemens"

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

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

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

$$\underline{\boldsymbol{j}} = \sigma \cdot \underline{\boldsymbol{E}}$$

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***.

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

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

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

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

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

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 μΩcm**.
ρ(technical semiconductors)
around **1 Ωcm**.
ρ(insulators) > 1 GΩcm.

Questionaire

All Multiple Choice questions to 2.1