2.2.4 Summary to: Conductors - Definitions and General Properties

What counts are the *specific* quantities:

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

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

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.

$$j = \sigma \cdot E$$

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*.

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

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

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

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

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

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