

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 $\cdot E$.

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

$$j = \sigma \cdot E$$

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 .

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

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

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

● 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: MoSi₂ 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 $\mu\Omega\text{cm}$.
 ρ (technical semiconductors)
around 1 Ωcm .
 ρ (insulators) > 1 $\text{G}\Omega\text{cm}$.**

Questionnaire

All Multiple Choice questions to 2.1