Dielektrische Verschiebungsdichte

E → 1) wird von Ladungen erzeugt

→ 2) übt auf Ladungen Kräfte aus

$\operatorname{div} \vec{E} = \frac{\rho}{\varepsilon_0}$ ⟶ zweiten Feldvektor $\vec{D}$

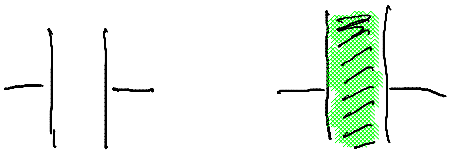
$\operatorname{div} \vec{D} = \rho$

$\vec{D} = \varepsilon_0 \vec{E}$ im Vakuum

Verschiebungsdichte

Dielektrizitätskonstante

ε des Isolators



C_0 $\quad$ C

$$\boxed{\varepsilon = \frac{C}{C_0}}$$

Dielektrikum $\equiv$ Isolator

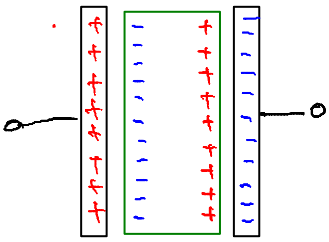
"durch"

$$C = \varepsilon \varepsilon_0 \frac{A}{d}$$

Glas $\varepsilon \sim 5 \div 10$

Wasser $\varepsilon \sim 80$

Luft $\varepsilon \sim 1{,}00058$



$+Q_0$ $\quad$ $-Q_0$

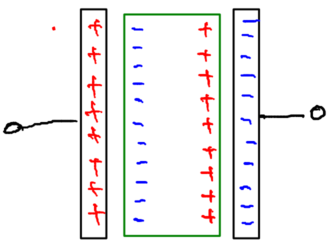
Vakuum $E_0 = \frac{U_0}{d}$

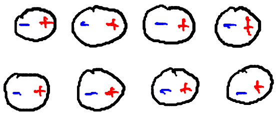
$$\underbrace{U_D = \frac{U_0}{\varepsilon} \; ; \; E_D = \frac{E_0}{\varepsilon}}_{\text{mit Dielektrikum}}$$

$$Q_D = \frac{Q_0}{\varepsilon}$$

Polarizationsladung $Q_p = Q_0 - Q_D$

$$Q_p = Q_0 \left(1 - \frac{1}{\varepsilon}\right) = A \varepsilon_0 E_0 \frac{\varepsilon - 1}{\varepsilon}$$





$+Q_0$ $\quad$ $-Q_0$ $\rightarrow$

äußeres Feld E_0 $\longrightarrow$

$\longleftarrow$ Gegenfeld durch Polariz.

$\longrightarrow$ Restfeld $\vec{E}_D$

Volumenelement $dV = dA \cdot dl$

Dipolmoment $dp = dQ_p \cdot dl = dA \varepsilon_0 E_0 \frac{\varepsilon - 1}{\varepsilon} dl$

$$= \varepsilon_0 E_0 \frac{\varepsilon - 1}{\varepsilon} dV$$

$$\boxed{d\vec{p} = \varepsilon_0 \vec{E}_0 \frac{\varepsilon - 1}{\varepsilon} dV}$$

$$\boxed{d\vec{p} = \varepsilon_0 \vec{E}_0 \frac{\varepsilon - 1}{\varepsilon} dV}$$

$$= \varepsilon_0 E_0 \frac{\quad}{\varepsilon} dV$$

$$\vec{P} = \frac{d\vec{P}}{dV} = \frac{\varepsilon - 1}{\varepsilon} \varepsilon_0 \vec{E}_0$$

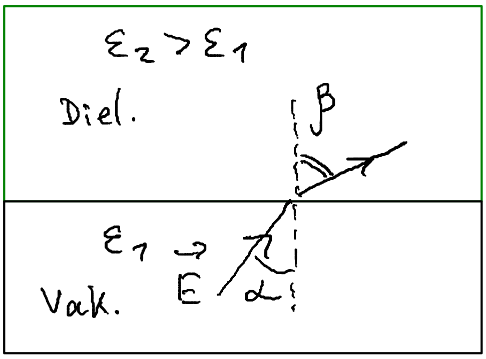
$$E_D = \frac{E_0}{\varepsilon} \quad \Rightarrow \quad \vec{P} = (\varepsilon - 1) \varepsilon_0 \vec{E}$$

dielektrische Suszeptibilität $\chi_p = (\varepsilon - 1)\varepsilon_0$

$\vec{D}$-Feld $\rightarrow$ nur für "wahren" Ladungen

$\hookrightarrow \vec{D} = \varepsilon \varepsilon_0 \vec{E}$

$$\boxed{\vec{D} = \varepsilon_0 \vec{E} + \vec{P}}$$



$$E_\perp^{Diel.} = \frac{\varepsilon_1}{\varepsilon_2} E_\perp^{Vak}$$

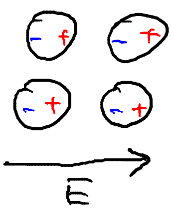
$$E_\parallel^{Diel} = E_\parallel^{Vak}$$

für $\vec{D}$ das Umgekehrte

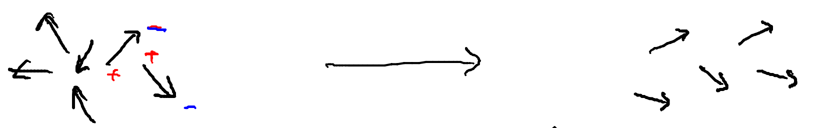
Mechanismen der diel. Polarisation

1) Verschiebungspolarisation

z. B. Atome



2) Orientierungspolarisation



z.B. polare Moleküle $\vec{E}$

Wasser, Säuren hängt wie T^{-1} von der Temp.

Die elektrische Feldenergie im Dielektrikum

Die Energie $W_{el} = \frac{1}{2} C U^2$

Energiedichte $w_{el} = \underbrace{\varepsilon \frac{\varepsilon_0}{2} E^2} = \frac{1}{2} E D$

Elektrostriktion

Piezoeffekt

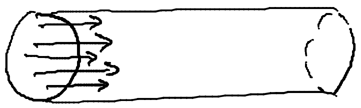
Der elektrische Strom

Die Stromstärke $I = \frac{dQ}{dt}$

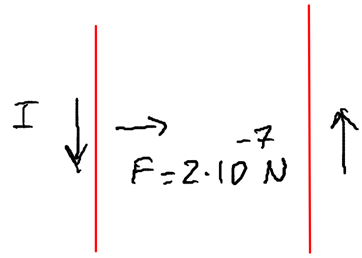
Ampere $[I] = 1\,A$

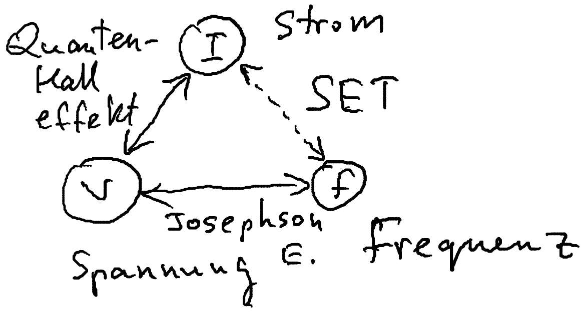
$mA = 10^{-3}\,A$

$\mu A = 10^{-6}\,A$

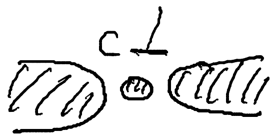


A





SET = single-electron-tunneling

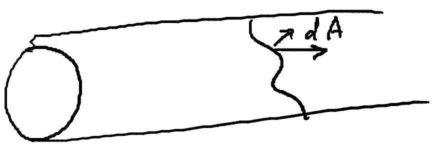


SET-transistor

Energie $W \sim \frac{e^2}{2C}$

$\underline{I = e \cdot f}$ $\qquad 10^{-6}\,e$

Stromdichte $j \implies I = \int_A \vec{j} \cdot d\vec{A}$



Ladungsträger

Elektronen e^-

Ionen $-$ $+$

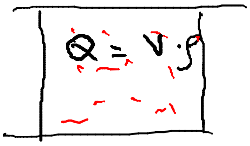
→ Elektronische Leiter (z.B. Metalle, Halbleiter)

→ Ionen-Leiter (z.B. Elektrolyte)

→ gemischte (z.B. Plasma
Gas)

Ladungen q (z.B $q = -e$) $\qquad Q = \underbrace{nq}_{\rho}$

$$V = \vec{A} \cdot \vec{v}\,\Delta t$$



$$\boxed{\vec{j} = \rho \cdot \vec{v}}$$