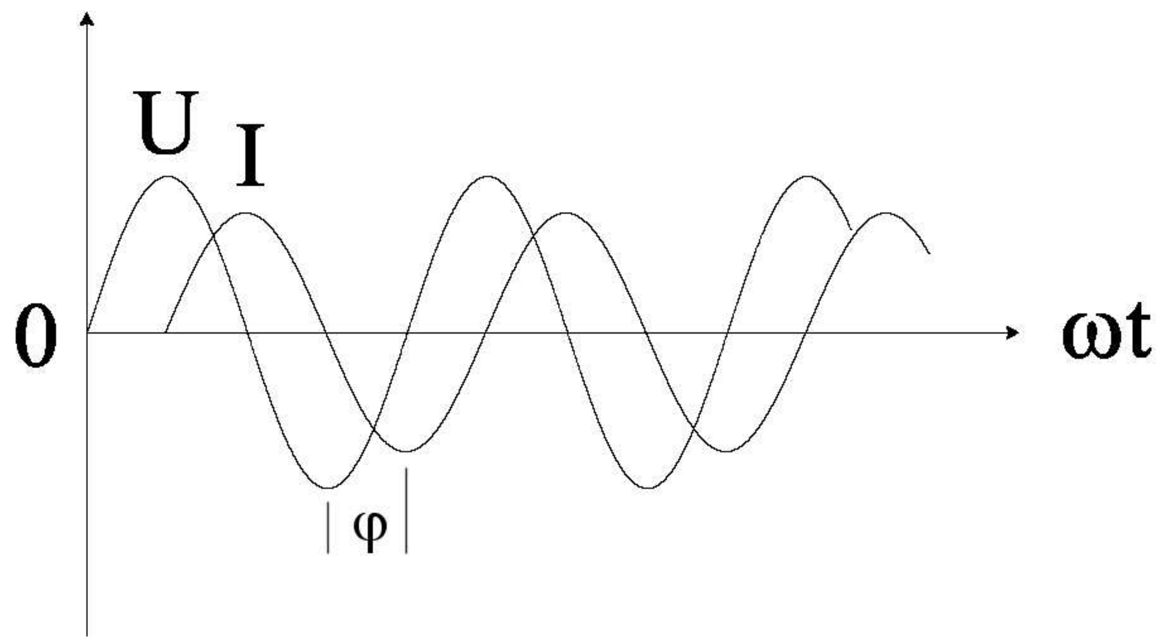
Impedance Spectroscopy

Impedance Spectroscopy

Impedance Z: Resistance of an alternating current circuit, analogous to the ohmic resistance in an direct current circuit.

$$Z(\omega) = \frac{U(t)}{I(t)}$$

Impedance Spectroscopy



$$U(t) = U_0 \cdot \sin(\omega t)$$

$$I(t) = I_0 \cdot \sin(\omega t + \varphi)$$

Impedance Spectroscopy

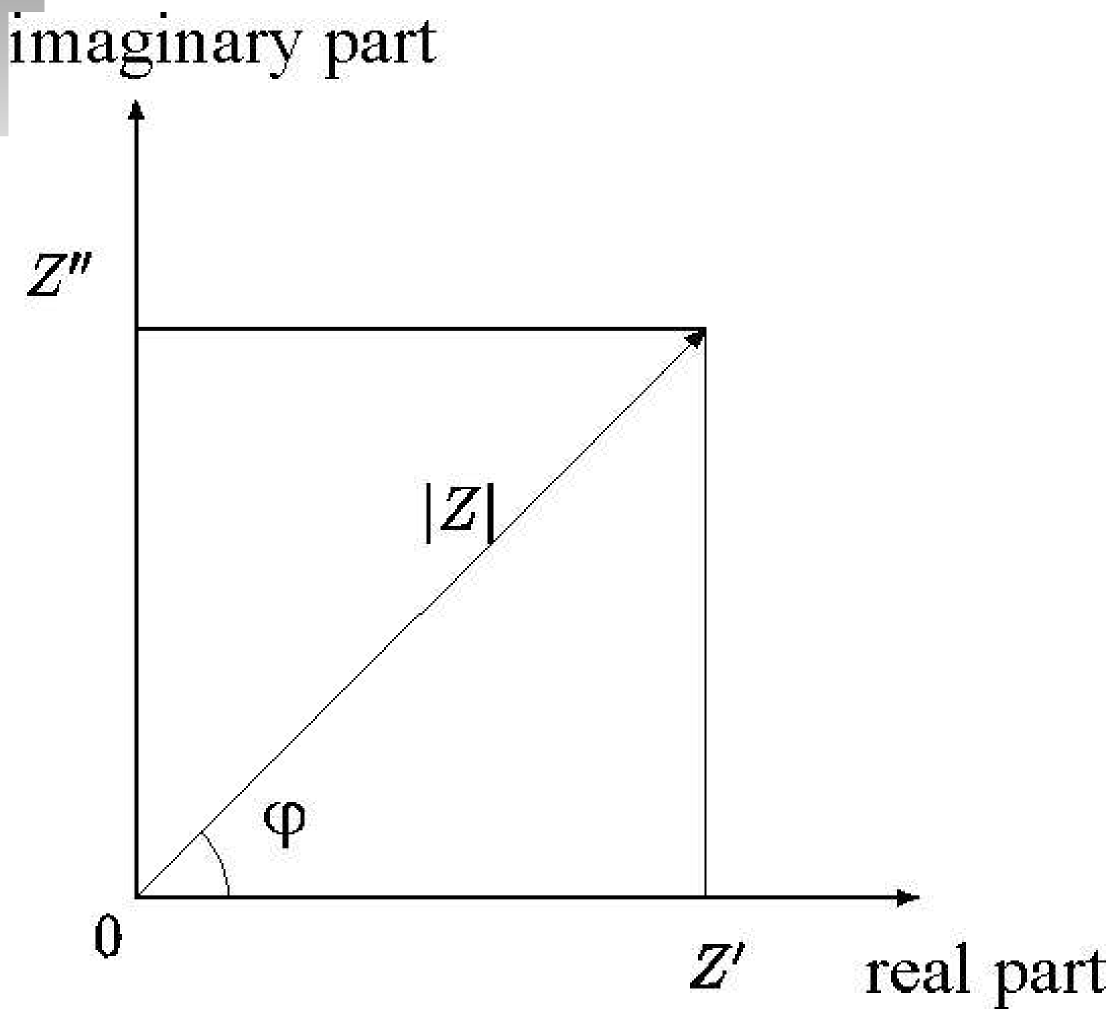
Applying an alternating voltage to a sample and measuring the resulting current.

$$Z^* = |Z| \cdot e^{i\varphi}$$

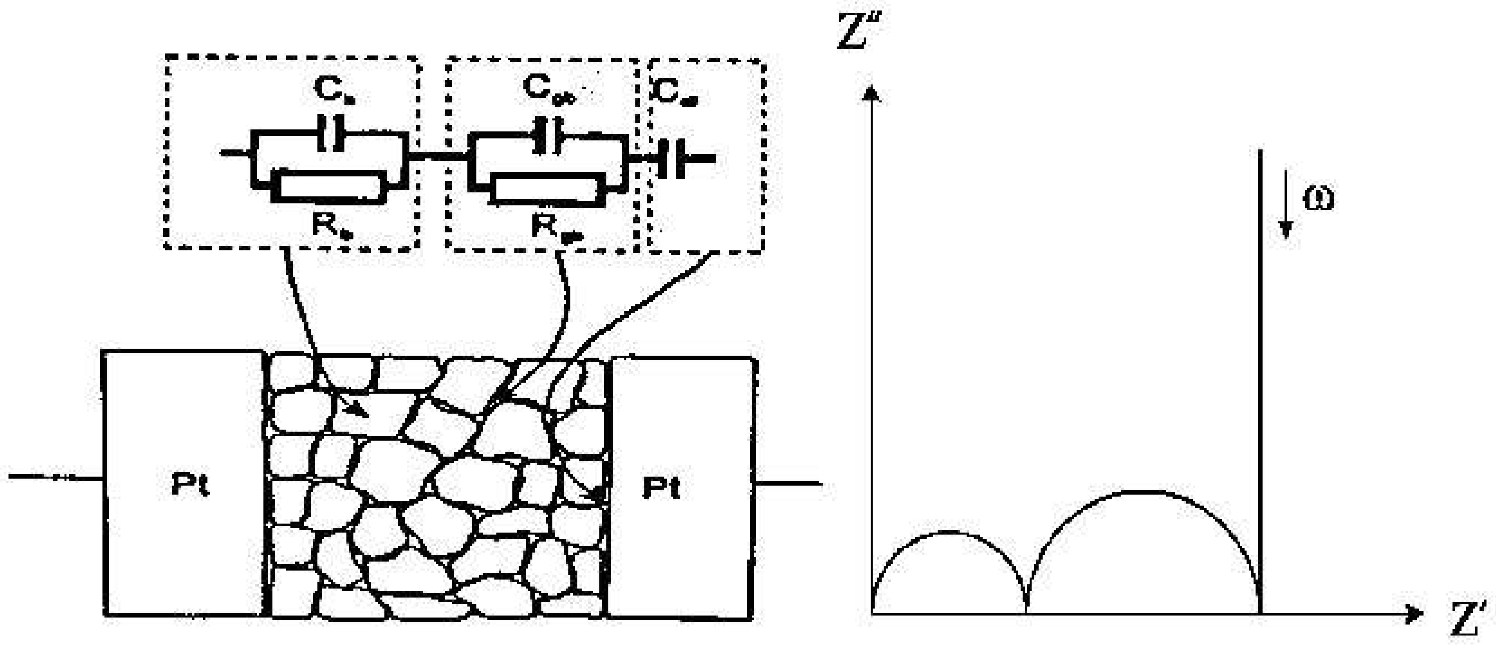
$$Z^* = Z' + iZ''$$

The impedance depends on the circular frequency ω.

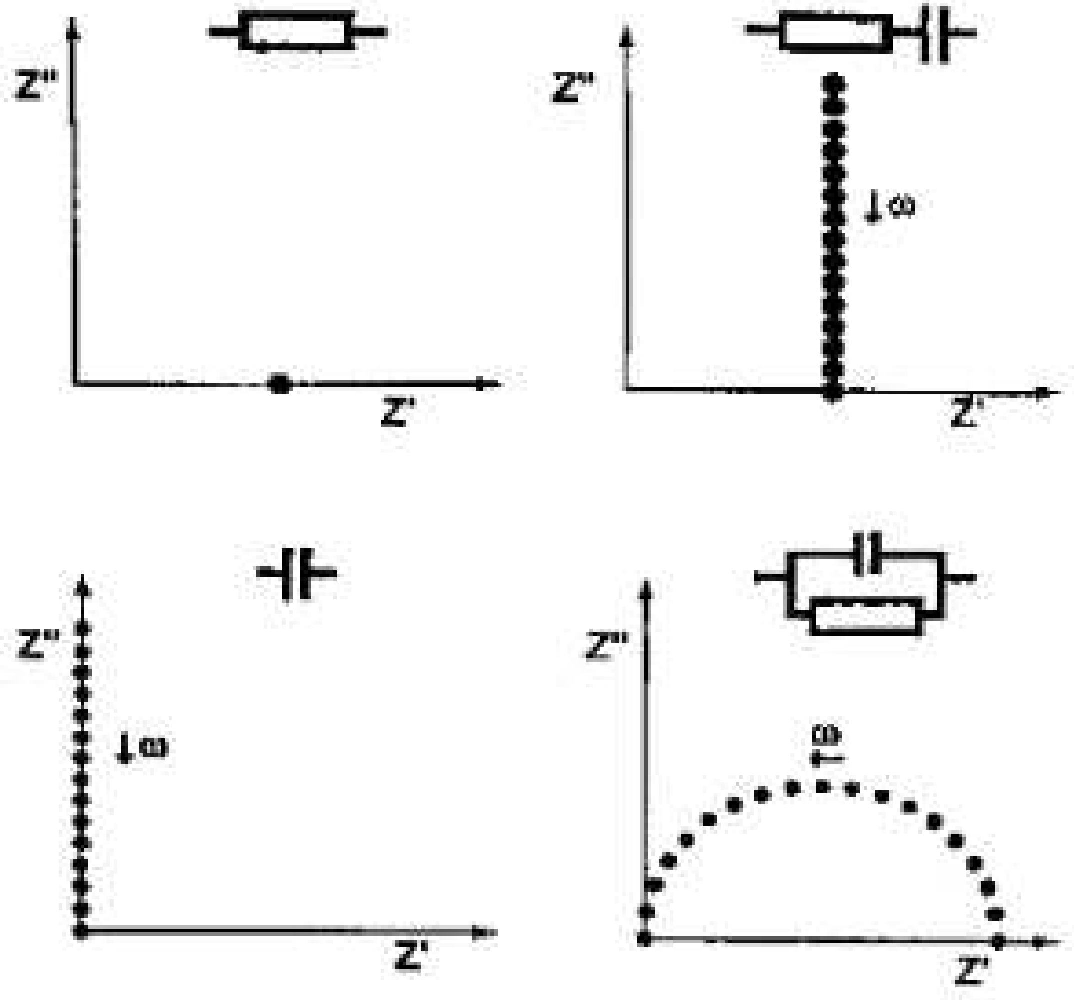
Impedance Spectroscopy

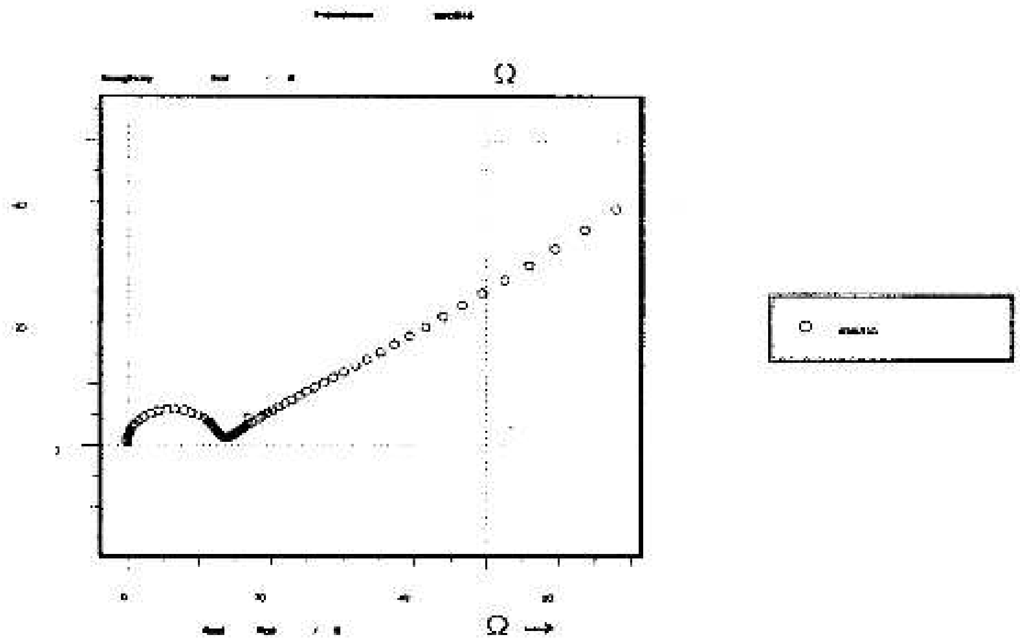


Impedance Spectroscopy



Impedance Spectroscopy



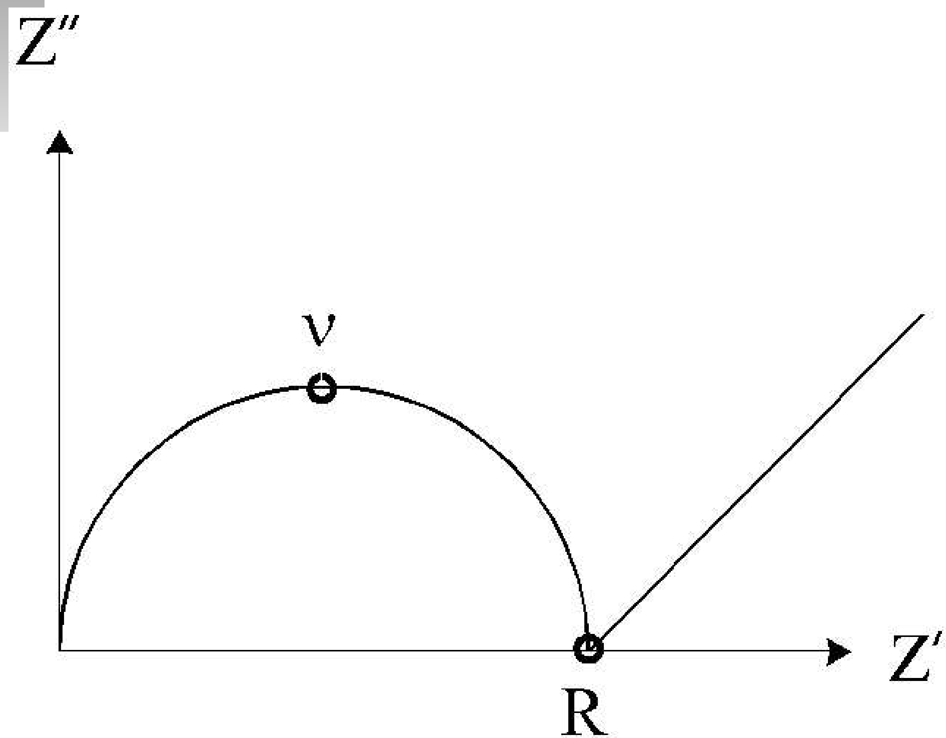


Measurement of AgCl

Spike:
Warburg-Impedance Z_W: Diffusion tries to equalice the concentration of the charge carriers, it is contrairy to the movement in the electric field.
Obversable at low frequencies ω:

$$Z_W = \frac{const}{\sqrt{i\omega}}$$

Impedance Spectroscopy



R: Resistance of the ohmic resistor of one parallel circuit $R = Z'$

$\nu = 2\pi\omega$

Capacity C of the capacitor of one parallel circuit:

$$C = \frac{1}{\nu R}$$

Capacity $[F]$	Interpretation
10^{-12}	Volume of the mainphase
10^{-11}–10^{-8}	Grain boundaries
10^{-7}–10^{-5}	Barrier sample–electrode

conductivity

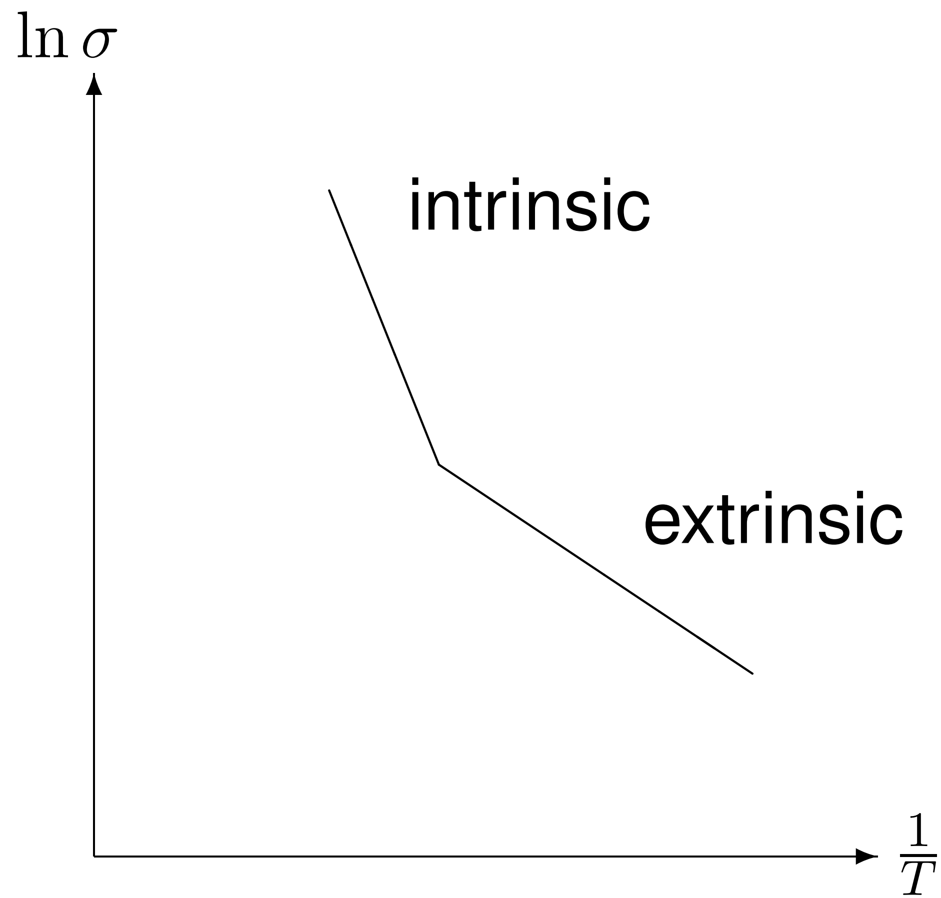
$$\sigma = \sum_i n_i e_i \mu_i = \frac{1}{R} \cdot \frac{l}{A}$$

σ: specific conductivity
n_1: number of charge carrier i
e_i: Charge of the mobile species i
μ_i: mobilty of the charge carrier i
R: ohmic Resistance
l: length of the conductor
A: cross sectional area of the conductor

Arrhenius behavior

$$\sigma = \sigma_0 \exp \frac{-E_A}{kT}$$

Arrhenius behavior



Inonic conductors

Compound	T [°C]	E_A [eV]	σ [$\Omega^{-1}cm^{-1}$]
Na-β-alumina	25	0,16	0,1
α-AgI	146	0,05	1
$RbAg_4I_5$	25	0,07	0,23
doped ZrO_2	1000	1,3	0,05