
Contactless Electron Mobility Evaluation of Semi-Insulating GaAs and InP Wafers

R. Stibal, S. Müller, W. Jantz

Fraunhofer Institut Angewandte Festkörperphysik

U. Kretzer

Freiberger Compound Materials

Motivation

- Routine GaAs and InP ingot resistivity and mobility evaluation required
- Conventional Hall procedure is
 - slow
 - destructive
- **C**Ontactless **R**ESistivity **M**Apping is (COREMA)
 - fast
 - nondestructive
- But mobility evaluation requires Hall measurement

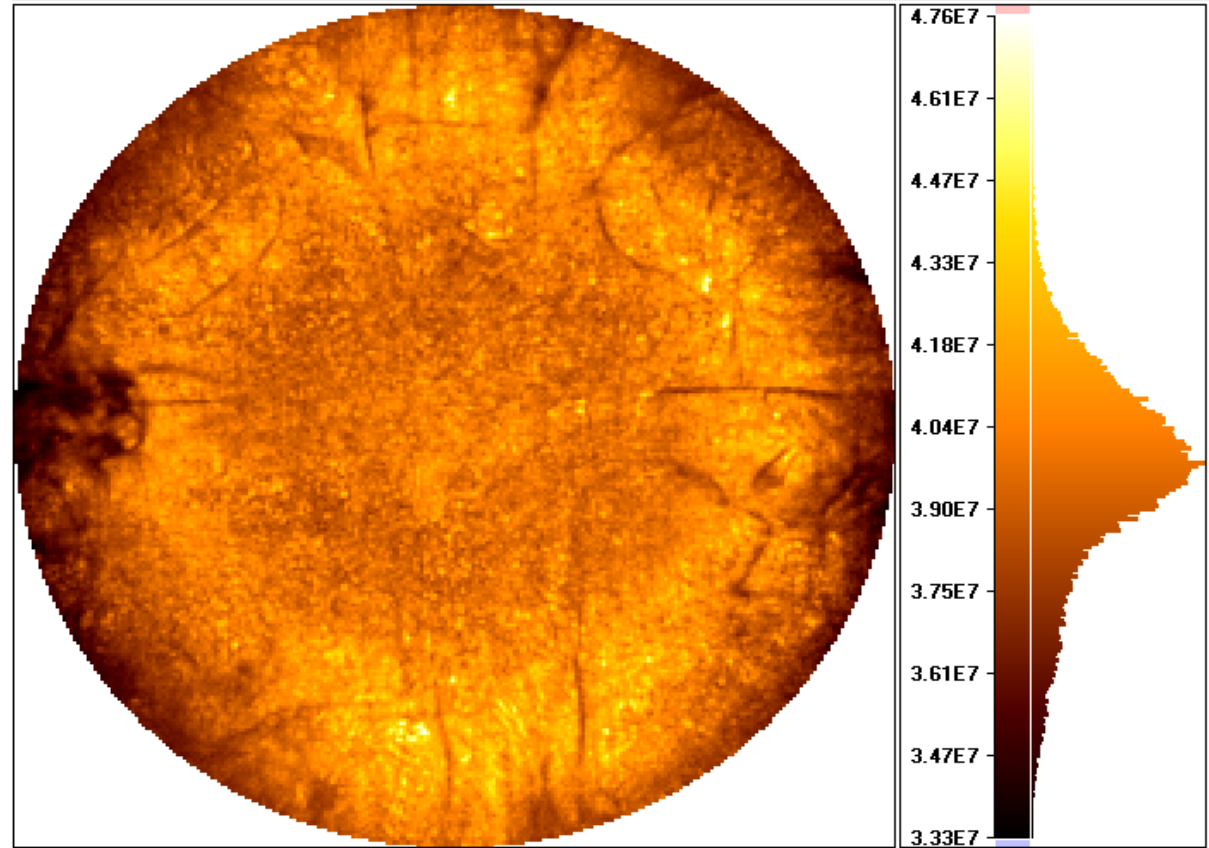
⇒ Upgrade **COREMA** procedure for mobility evaluation !

Contactless Resistivity Mapping COREMA

Resistivity Topogram of
150 mm GaAs Wafer

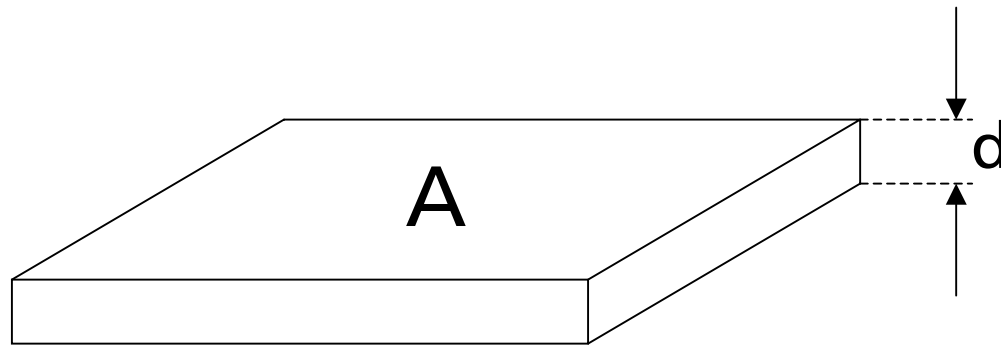
Mean: $3.96E7 \Omega\text{cm}$

Stdv: 4.27 %



Capacitive Resistivity Evaluation (I)

Definition of Resistance and Capacitance



$$R_s = \rho d/A$$

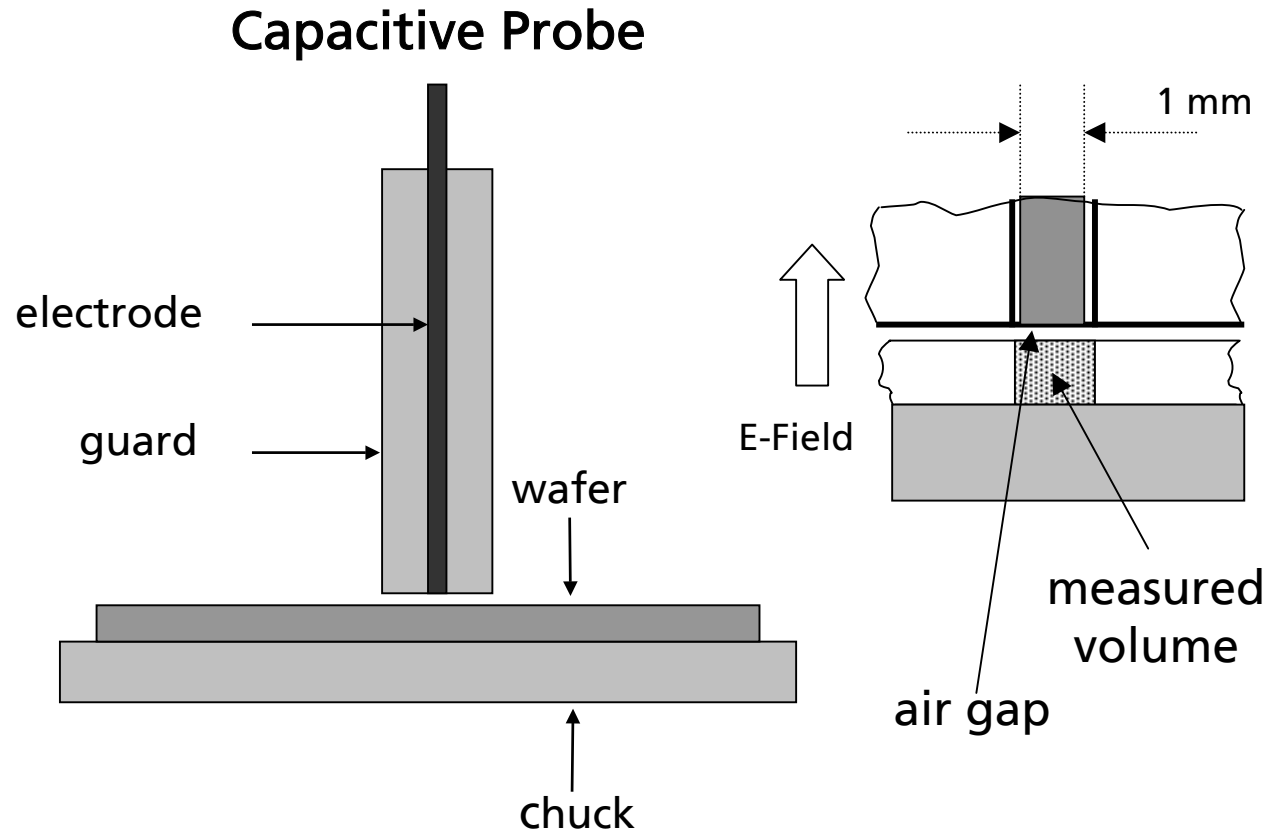
$$C_s = \varepsilon A/d$$

$$R_s C_s = \rho \varepsilon = \tau$$

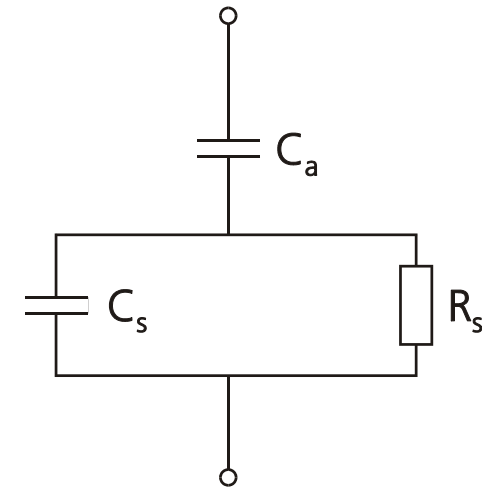
Semi-insulating Semiconductor

$$\rho = \tau / \varepsilon$$

Capacitive Resistivity Evaluation (II)



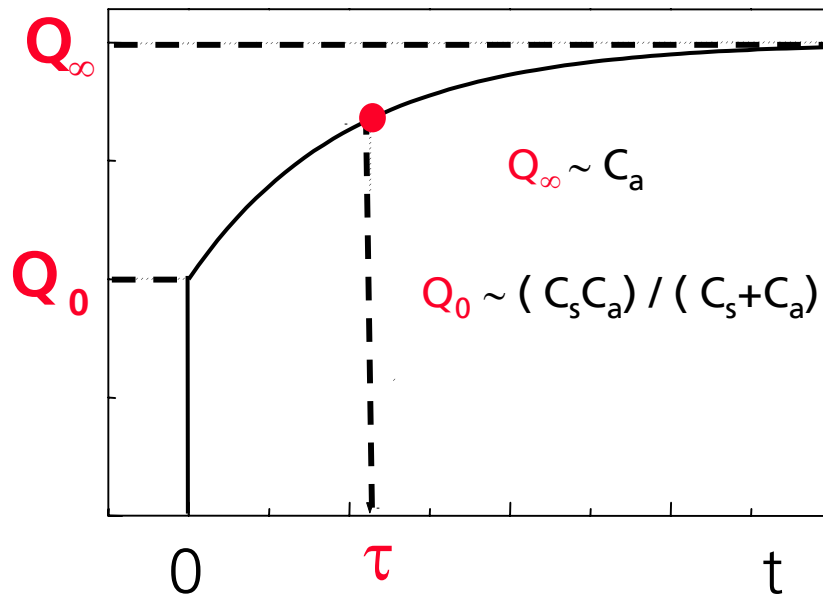
Equivalent Circuit



$$\tau = R_s (C_s + C_a)$$

Capacitive Resistivity Evaluation (III)

Charge Transient after Voltage Step Application



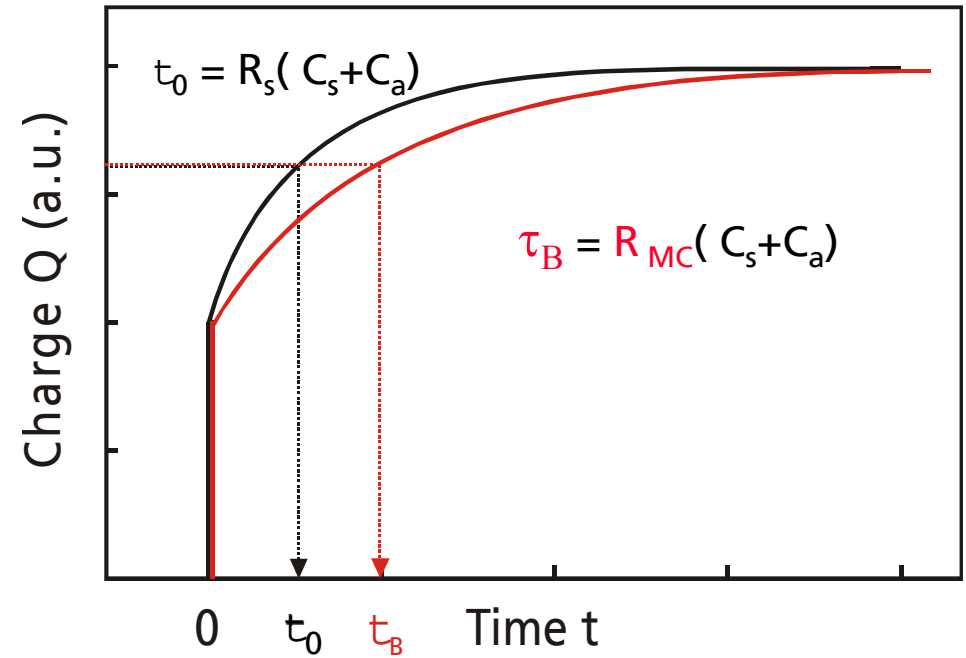
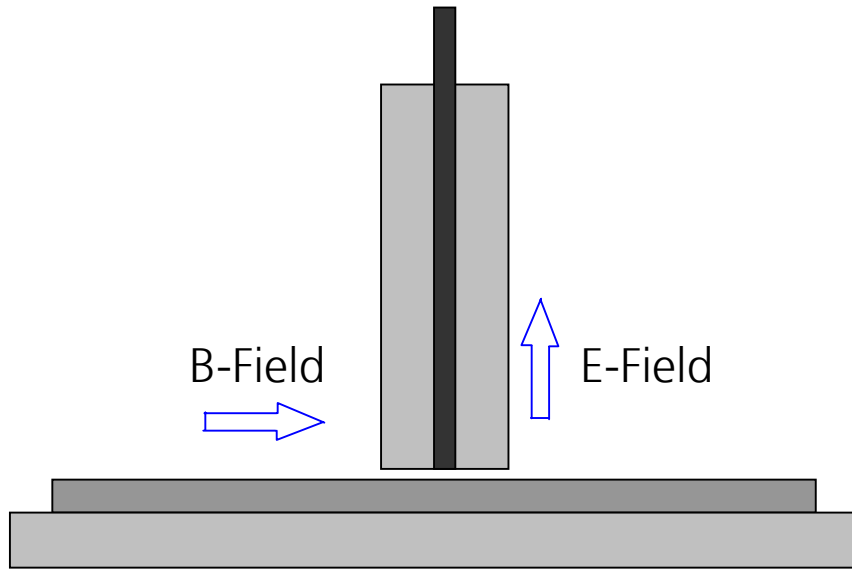
Evaluation of Resistivity

$$\tau = R_s (C_s + C_a)$$

$$\rho = Q_0 \tau (Q_\infty \epsilon \epsilon_0)^{-1}$$

$$\tau \approx 20 \mu\text{sec} @ 10^7 \Omega\text{cm}$$

Capacitive Mobility Evaluation (I)



Capacitive Mobility Evaluation (II)

Drude formula:

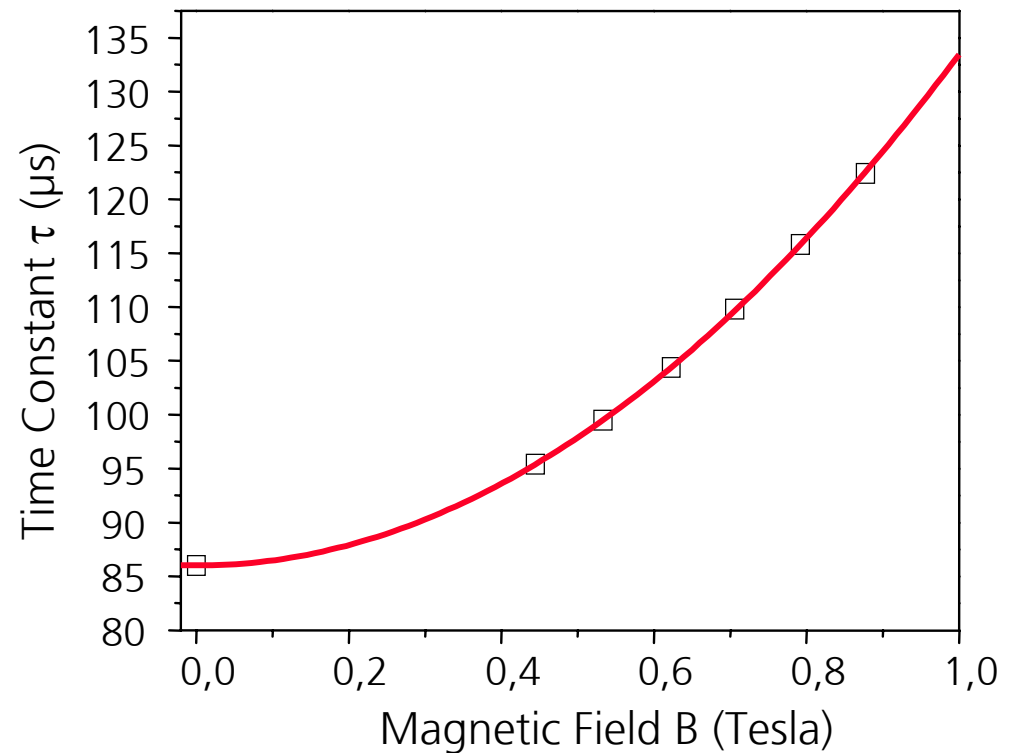
$$\sigma(\mathbf{B}) = \sigma(0) [1 + (\mu\mathbf{B})^2]^{-1}$$

Expected ρ dependence:

$$\rho(\mathbf{B}) = \rho(0) [1 + (\mu\mathbf{B})^2]$$

Expected τ dependence:

$$\tau(\mathbf{B}) = \tau(0) [1 + (\mu\mathbf{B})^2]$$



Capacitive Mobility Evaluation (III)

Measurement of time constant τ at $B = 0$ and $B = 0.843$ Tesla

$$\mu = \frac{\sqrt{\tau(B) / \tau(0) - 1}}{B}$$

Verification of COREMA generated Mobility Data

Comparison with

1. Values measured conventionally with Hall probes
2. Drift mobility values calculated with measured carbon content data (acc. Brooks-Herring formalism)

Correlation (I)

Comparison with Hall Data

Hall Measurement:

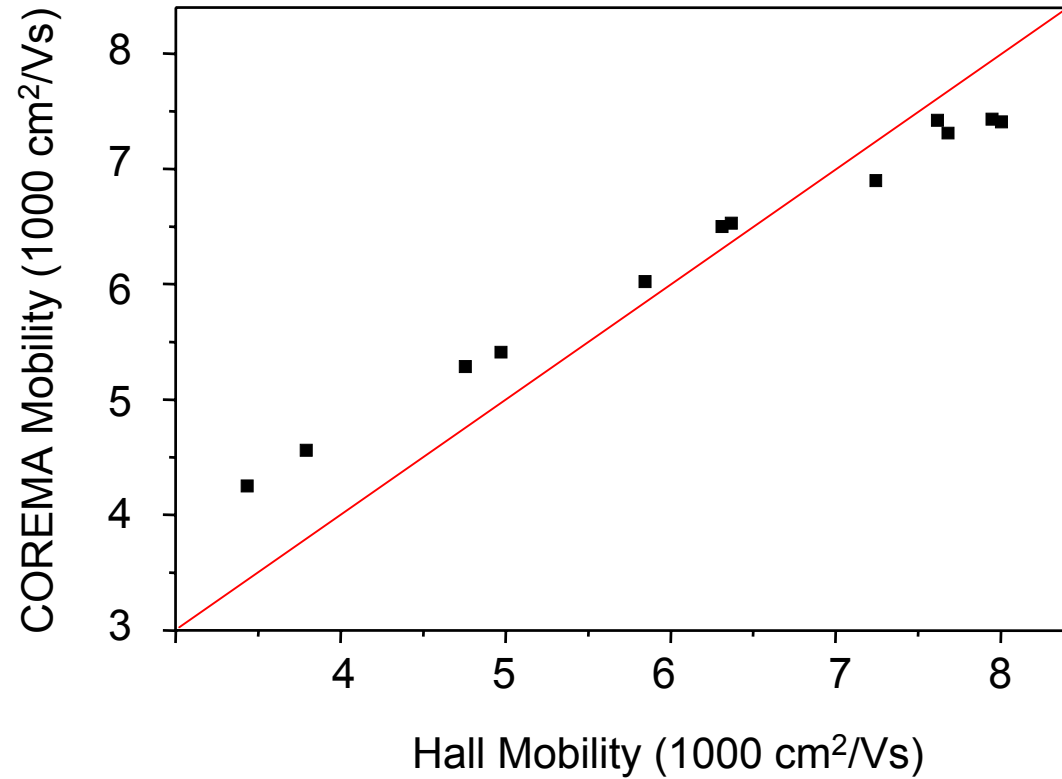
Sample size: 27x27 mm

$B = 0.4357 \text{ T}$

Corema Measurement:

Center of sample: $\varnothing 2.5 \text{ mm}$

$B = 0.843 \text{ T}$



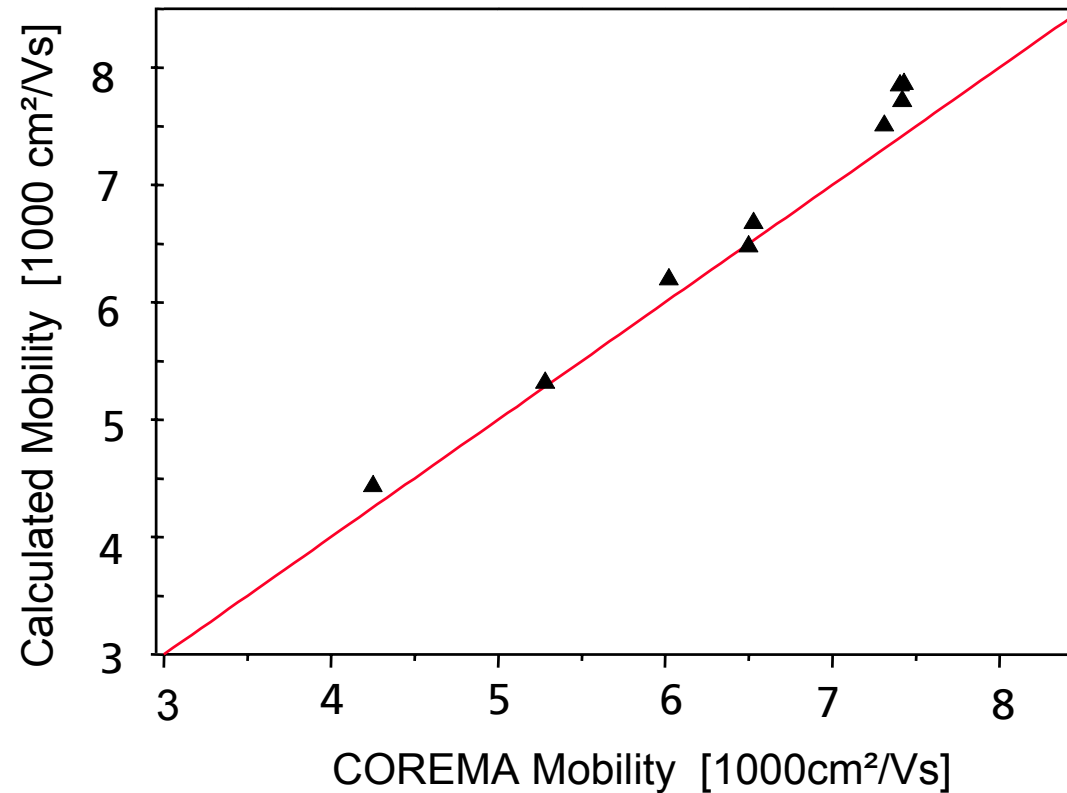
Correlation (II)

Comparison with calculated Drift Mobility

$$\frac{1}{\mu_D} = \left[\frac{1}{8000} + \frac{1}{\mu(Ion)} \right] \frac{V_S}{cm^2}$$

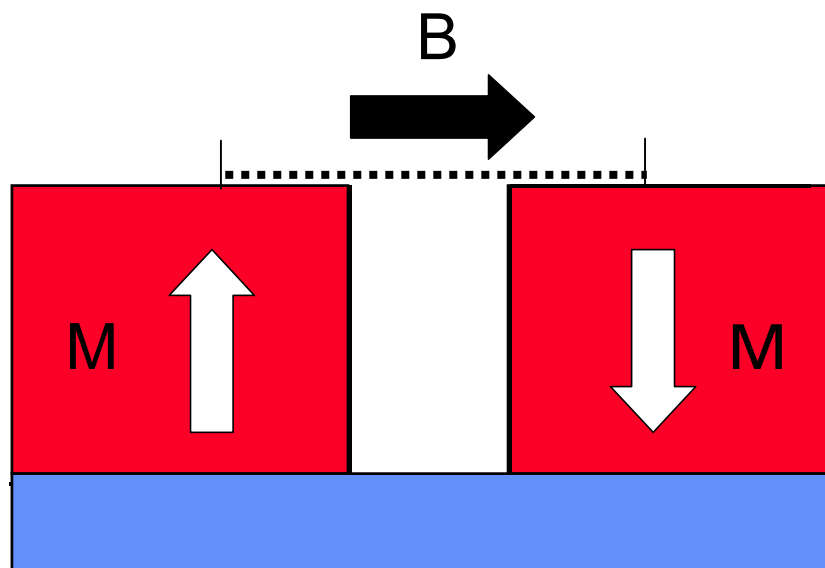
Concentration of ionized scattering centers:

$$[Ion] \cong 2[C]$$

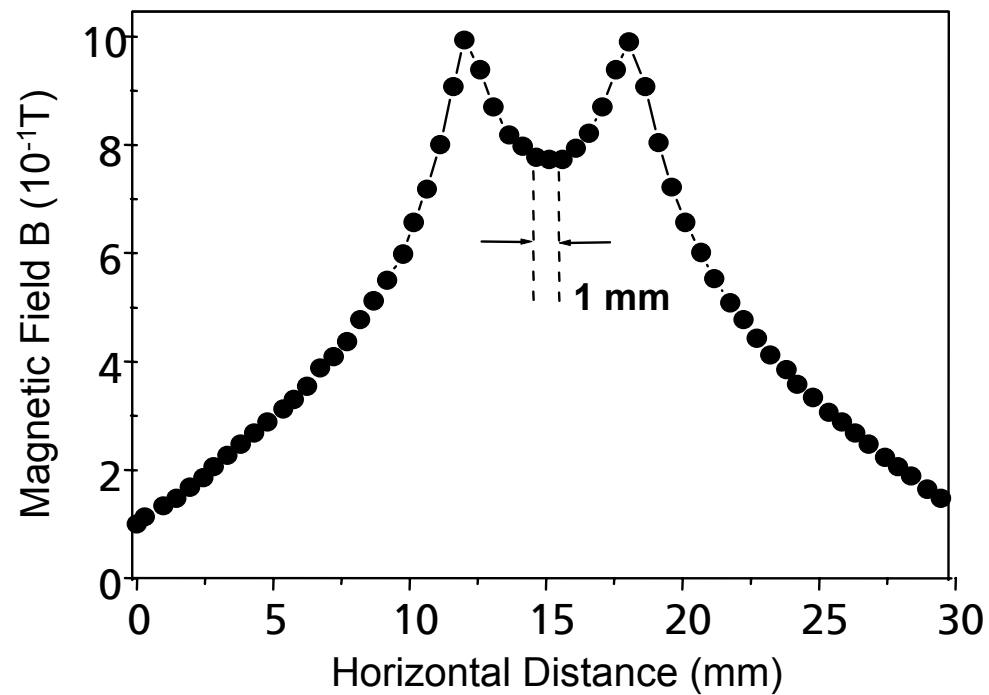


Permanent Magnet System Design

Arrangement of Magnets



Horizontal Field Component



SUMMARY

Contactless Resistivity Mapping (COREMA)

- Wafer $\varnothing \leq 200$ mm
- Resistivity Range $10^5 - 10^{12} \Omega \text{ cm}$
- Repeatability 1%
- Lateral Resolution 1 mm

Contactless Mobility Evaluation (Patent pending)

- Magnetoresistance based Method developed
- Permanent Magnet System designed
- Good Agreement with Hall Data
- Very good agreement with calculated Drift Mobility