# Topographie des spezifischen Widerstands semi-isolierender SiC-Substrate

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# Übersicht

- Motivation
- COntactless REsistivity MApping (COREMA)
- Bewertung von lokal inhomogenem Material
- Widerstandstopogramme von SiC Substraten
- Zusammenfassung



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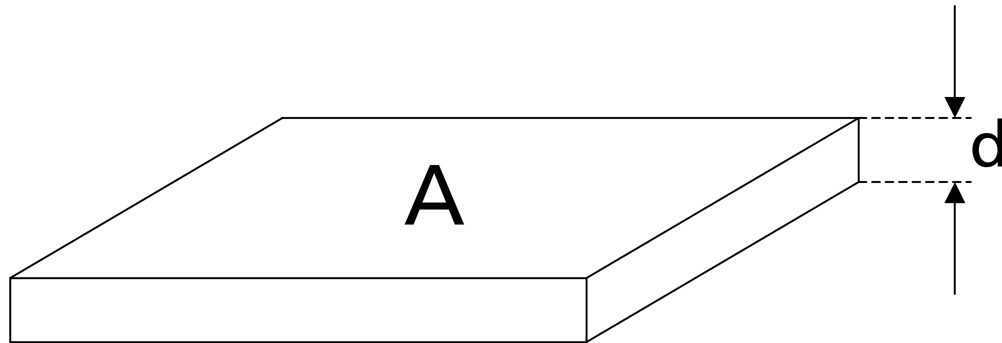
# Motivation

- **Weltweit wird an der Entwicklung von (SI) SiC Wafern mit Durchmesser bis zu 100 mm gearbeitet**
- **Kontaktfreie, ortsaufgelöste Widerstandsmessung an SiC Substraten ist aus mehrfachen Gründen erwünscht**
- **COntactless REsistivity MApping (COREMA) wird industriell zur Charakterisierung von SI GaAs und InP Substraten eingesetzt**
- **Weiterentwicklung des COREMA - Systems für die Bewertung von SiC Substraten erscheint aussichtsreich**

# Neue Anforderungen

- **Erweiterung des Messbereiches auf $1x10^5$ – $1x10^{12}$ Ωcm**
- **Automatisierte Messung von lateral inhomogenem Material**
- **Bewertung von *lokal* inhomogenem Material**

# Capacitive Resistivity Evaluation (I)




$$R_s = \rho\, d/A$$

$$C_s = \varepsilon\, A/d$$

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

**Semi-insulating semiconductor**

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



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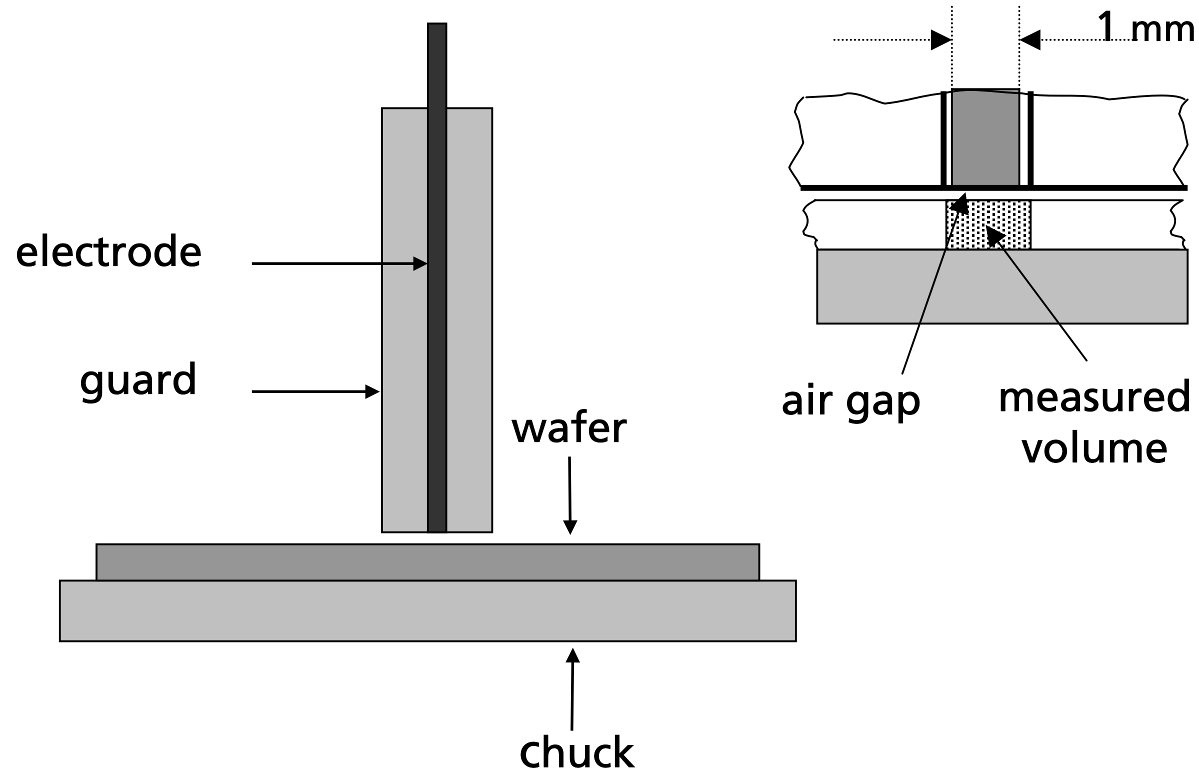
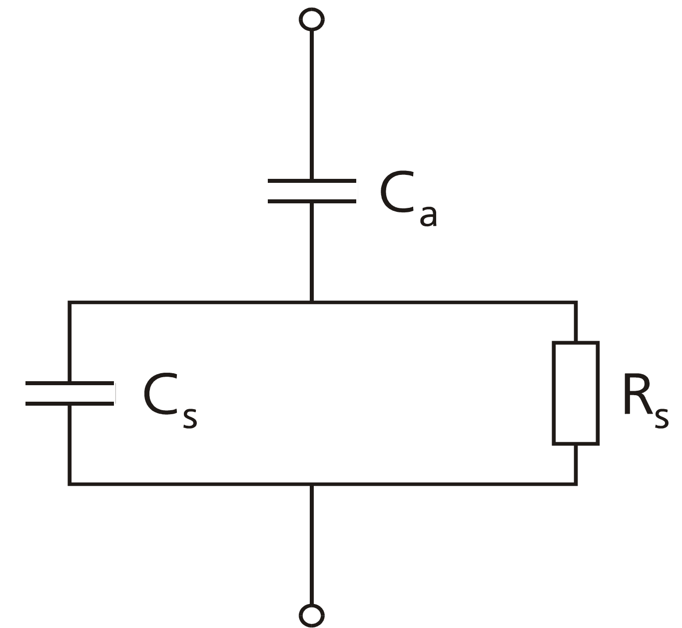
# Capacitive Resistivity Evaluation (II)

## Capacitive Probe




## Equivalent Circuit




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

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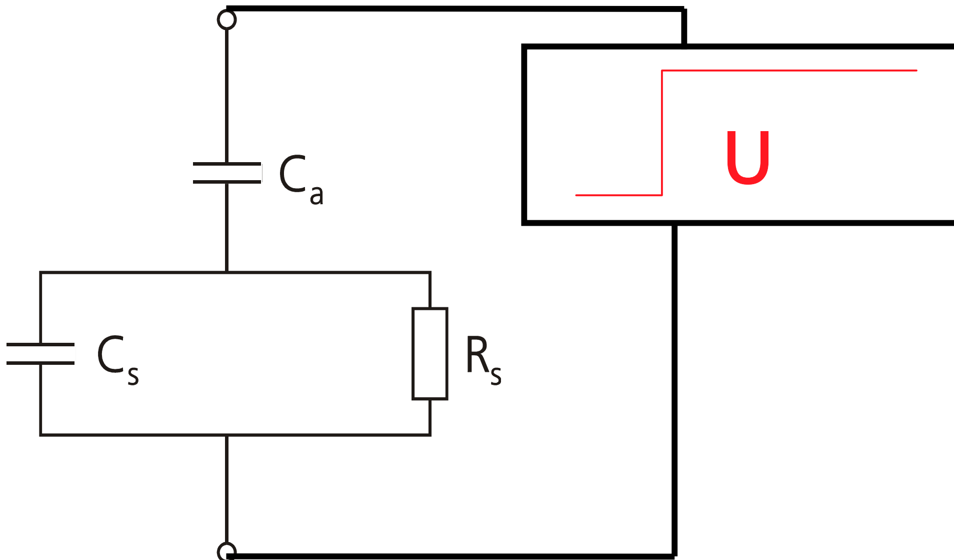
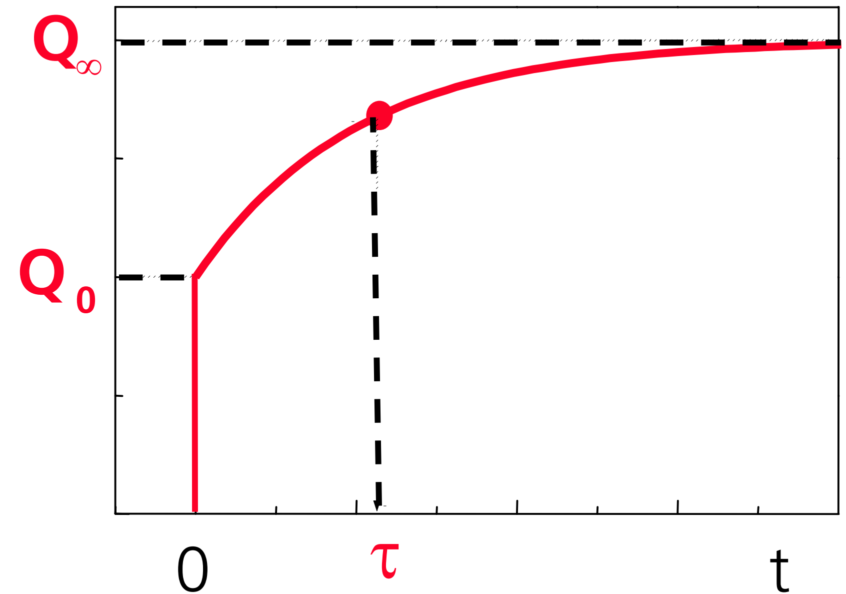
# Capacitive Resistivity Evaluation (III)

## Equivalent Circuit




## Charge Transient after Voltage Step Application




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

$$\rho = Q_0 \, \tau \, (Q_\infty \, \varepsilon \, \varepsilon_0)^{-1}$$



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# IAF - COREMA - 2000

Specifications

Range   $1x10^5 – 1x10^{12}$ Ωcm

Wafer ∅ ≤ 200 mm

Probe ∅ ≤ 1 mm

Repeatability   1%

Speed  100 ms @ 1E7 Ωcm

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# SiC SUBSTRATE RESISTIVITY TOPOGRAPHY (I)

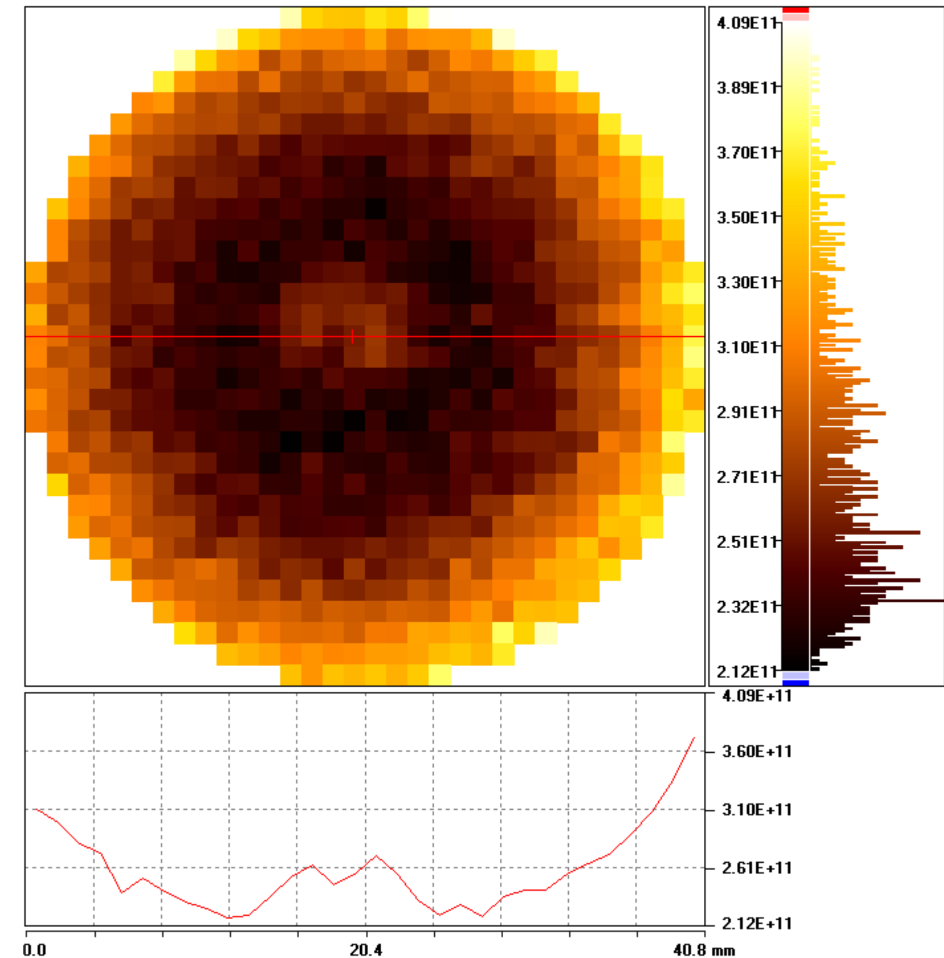
2" Wafer

$\rho$: 2.12 x$10^{11}$ - 4.09 x$10^{11}$ $\Omega$cm

Mean: 2.75 x$10^{11}$ $\Omega$cm

Stdv: 14.7%

Very homogeneous Material



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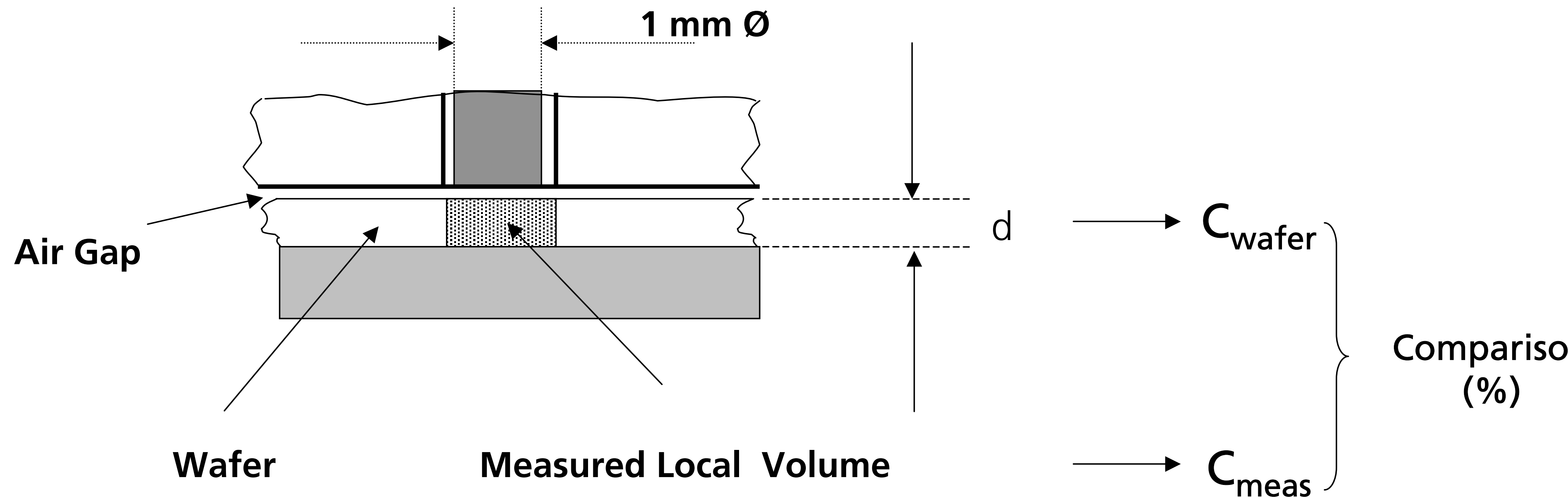
# Evaluation of local Homogeneity (I)



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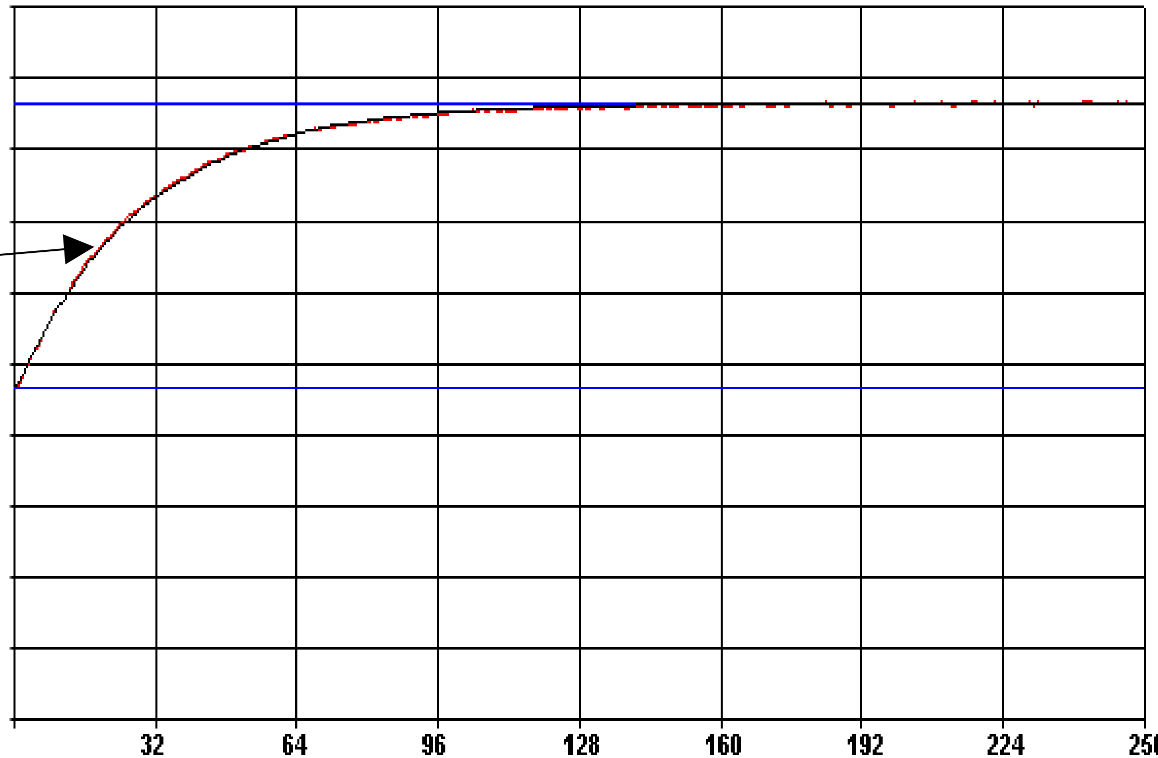
# Evaluation of local Homogeneity (II)

Measured values

$Q_\infty$

Fit

$Q_0$




Datapoints

Resistivity Topogram

Theoretical values

$Q_\infty^*$

$Q_0^*$

Expected Transient

$Q_0 = Q_0^*$

Volume of resistive Material = 100% (homogeneous)

Volume Topogram

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# Evaluation of local Homogeneity (III)

Measured values

Theoretical values

Fit

$Q_\infty$

$Q_0$

$Q_\infty^*$

$Q_0^*$

Expected Transient

$Q_0 > Q_0^*$

32 64 96 128 160 192 224 256

Data points

Volume of resistive Material < 100% (inhomogeneous)

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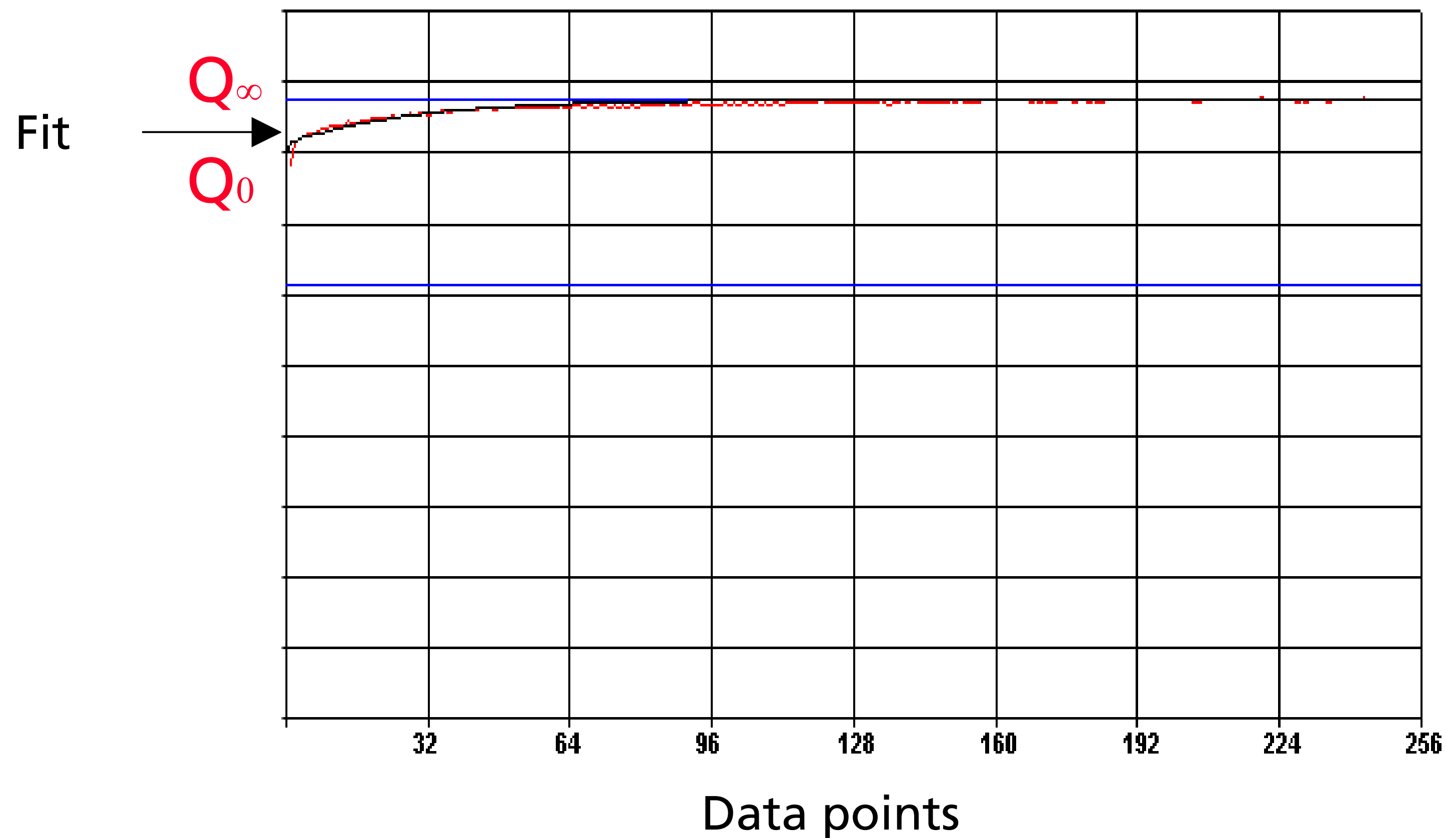
# Evaluation of local Homogeneity (IV)

Measured values

Theoretical values




$Q_\infty^*$

$Q_0^*$

Expected Transient

$Q_0 \gg Q_0^*$

Volume of resistive Material < < 100% (inhomogeneous)



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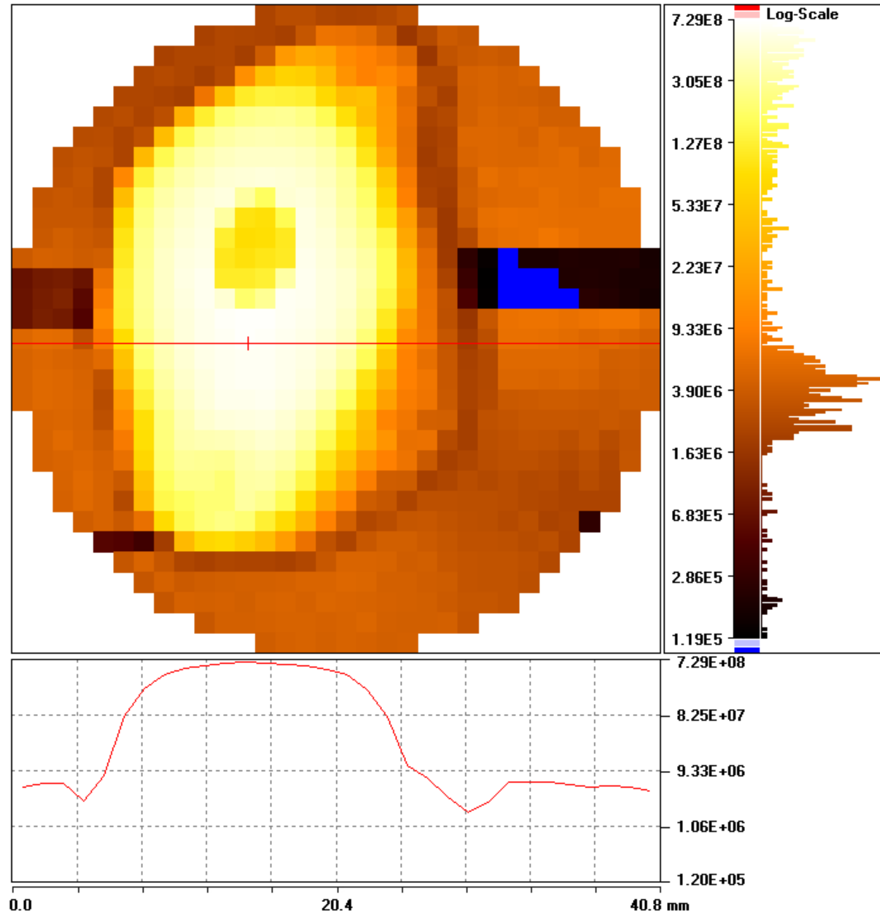
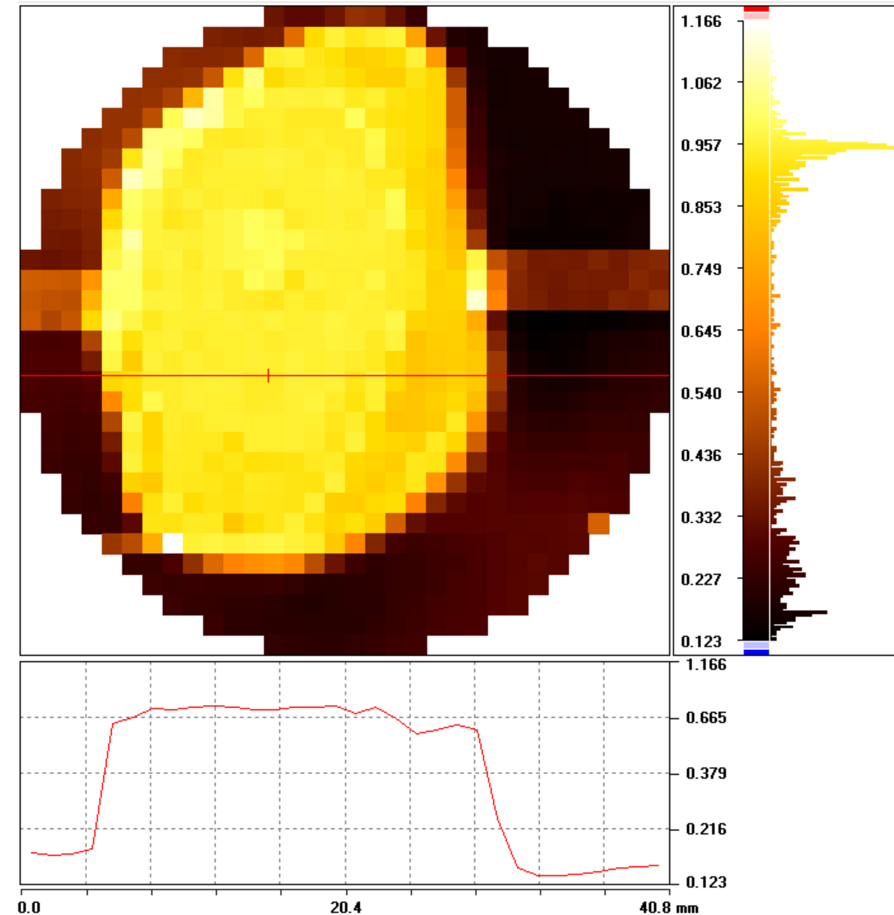
# SiC SUBSTRATE RESISTIVITY TOPOGRAPHY (II)




Mean: 1.13 x$10^8$ $\Omega$cm
Stdv: 168 %




Mean: 62%
Stdv: 54%



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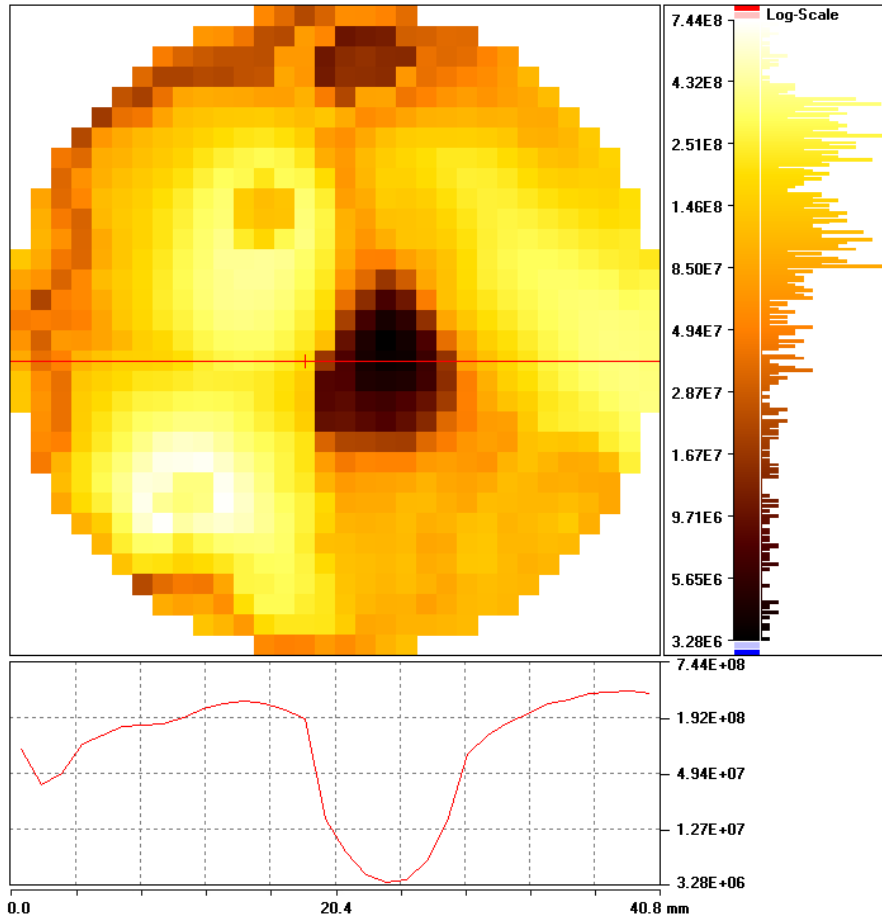
# SiC SUBSTRATE RESISTIVITY TOPOGRAPHY (III)

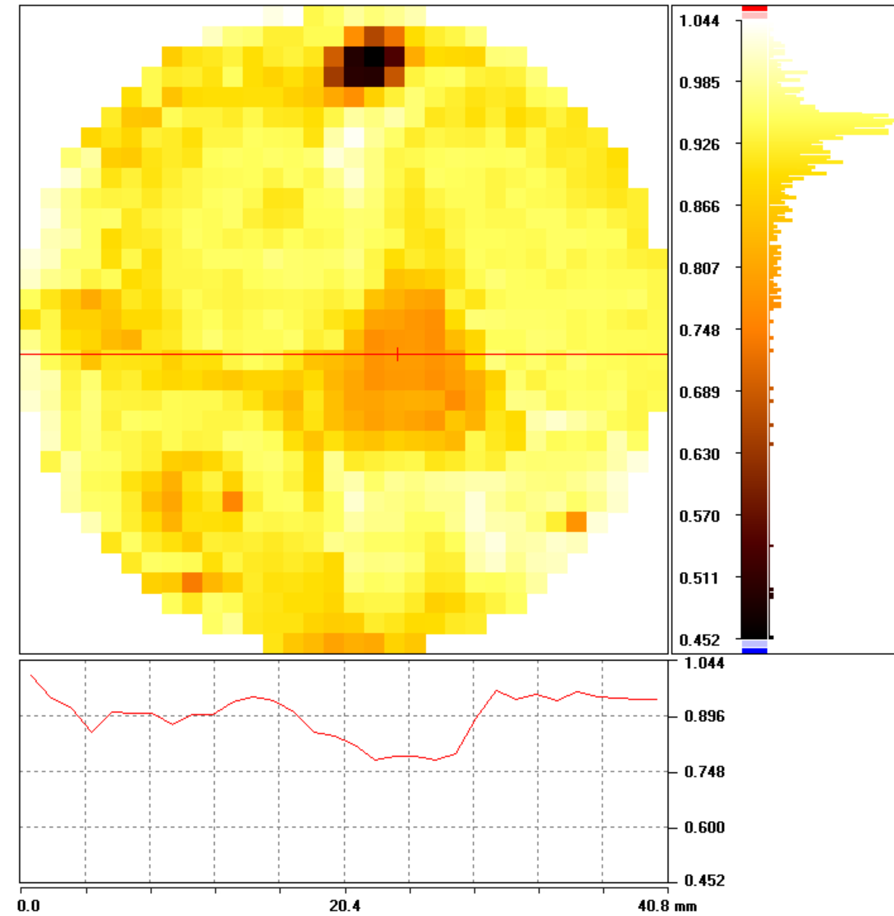
Resistivity




Mean: $1.72 \times 10^{8}\ \Omega\text{cm}$

Stdv: 75 %

Volume




Mean: 92.4%

Stdv: 6.76%



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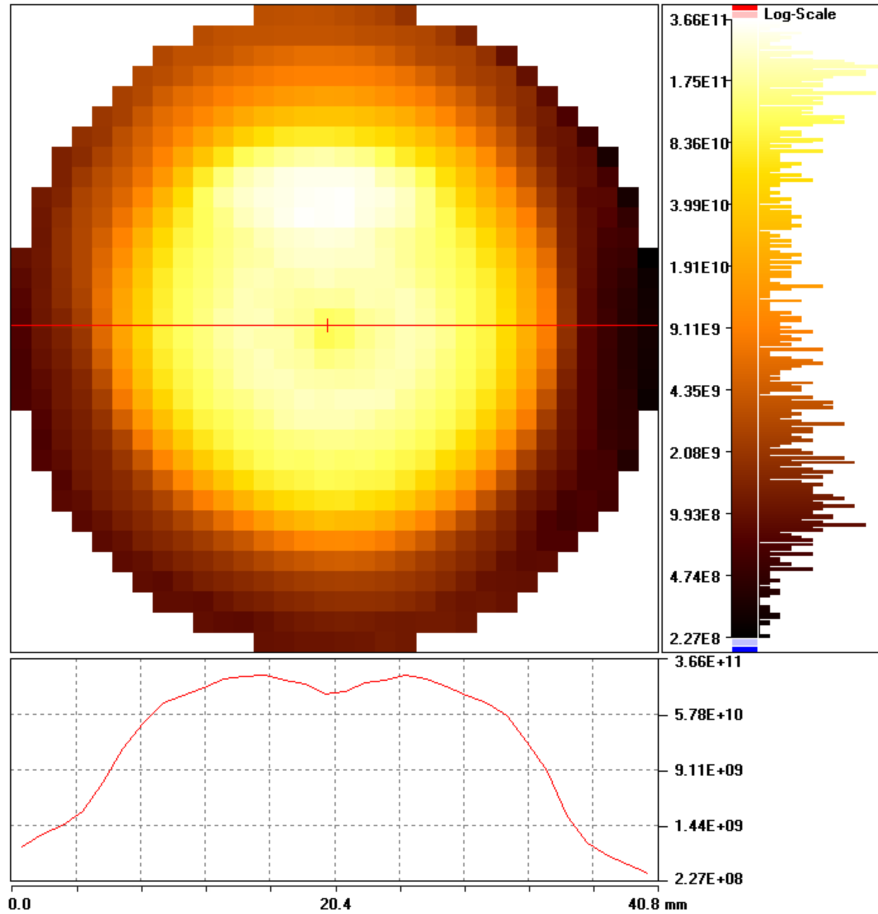
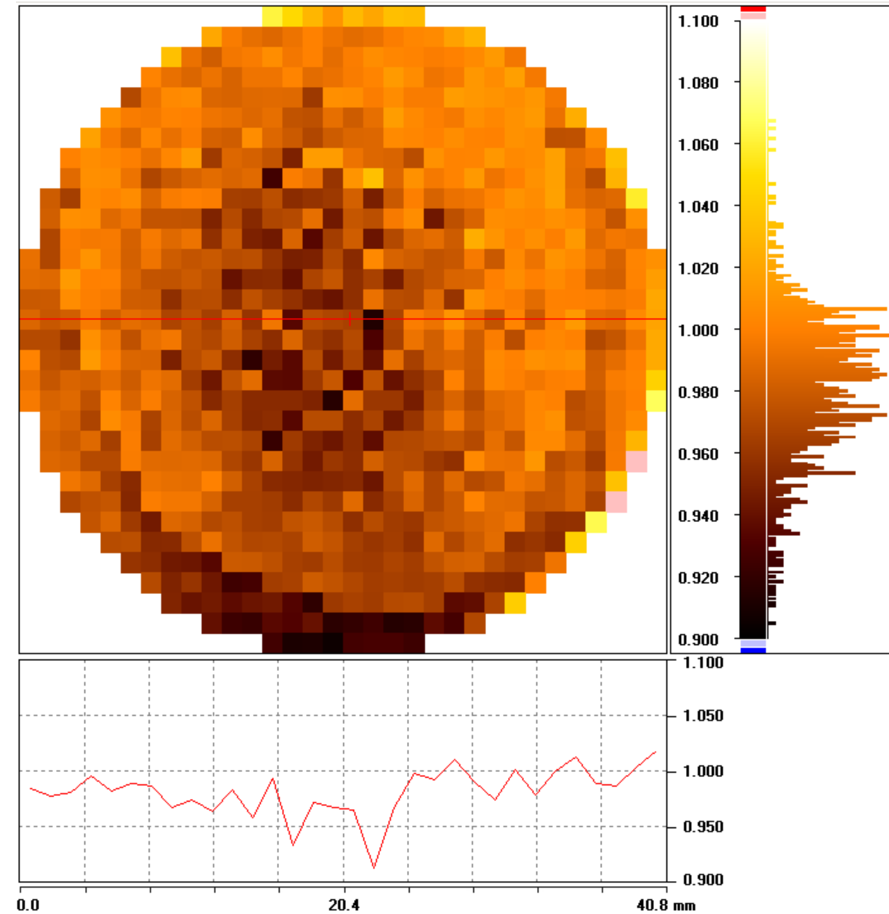
# SiC SUBSTRATE RESISTIVITY TOPOGRAPHY (IV)



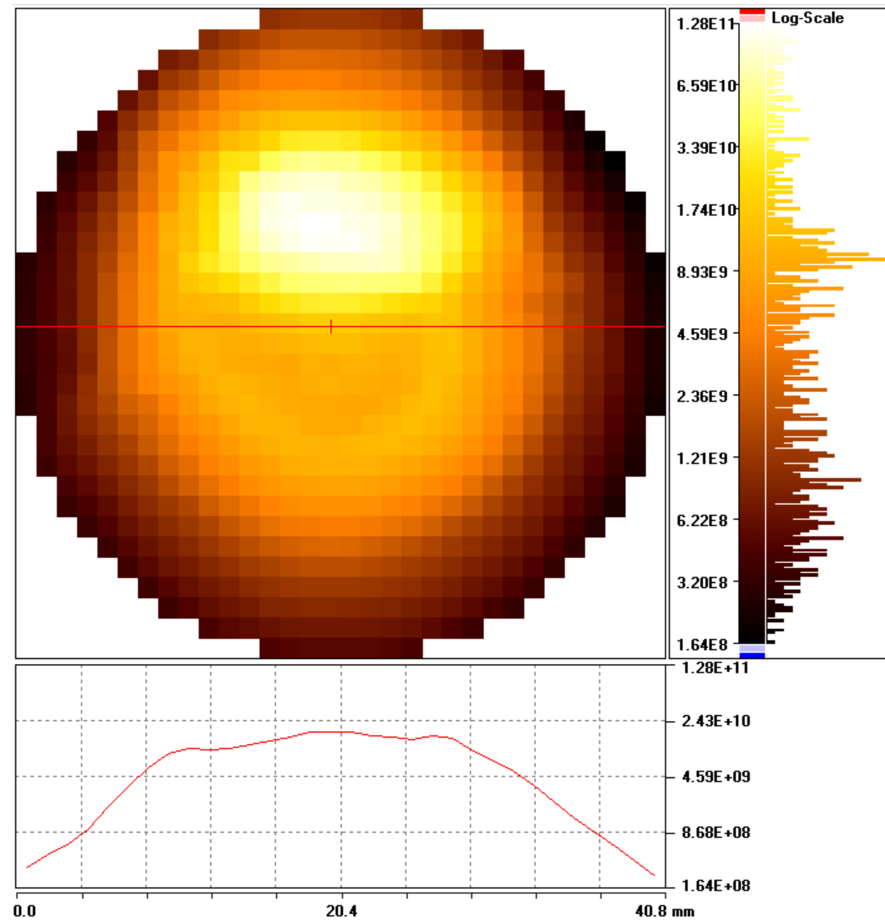

Mean: 5.82 x$10^{10}$ Ωcm
Stdv: 143 %




Mean: 98.2%
Stdv: 2.54%

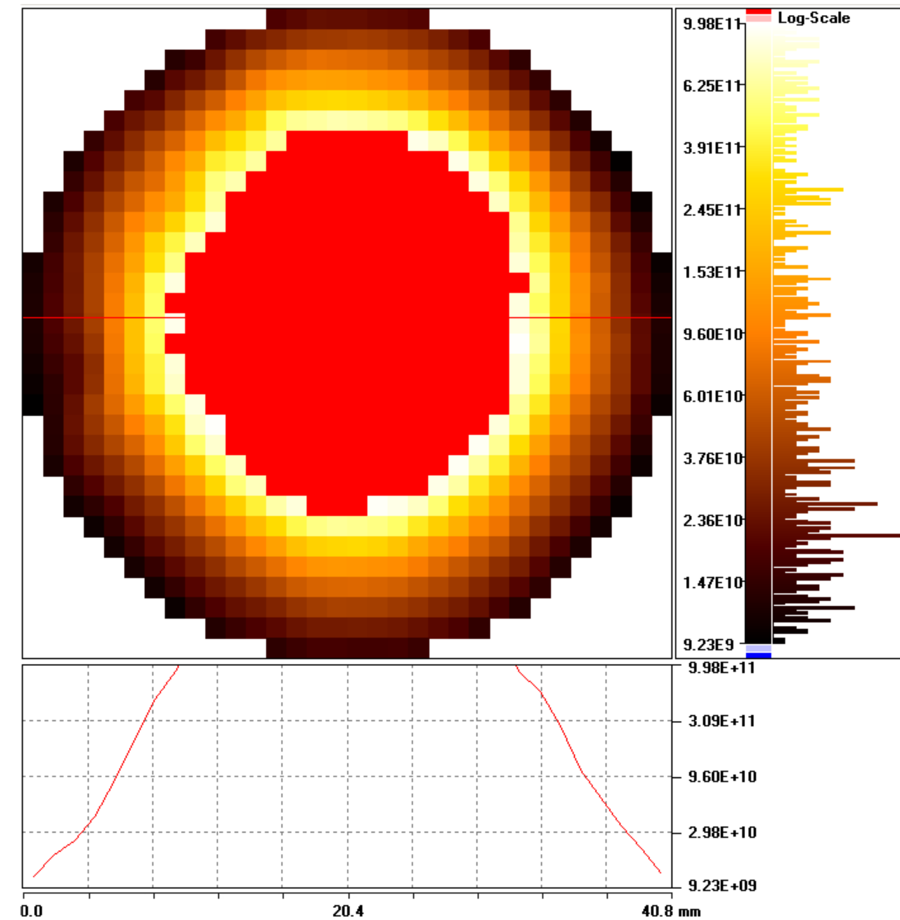
# SiC SUBSTRATE RESISTIVITY TOPOGRAPHY (V)

Resistivity (3 h darkness)




Mean: 1.12 x10$^{10}$ $\Omega$cm

Resistivity ( >48 h darkness)




Mean: 1.65 x10$^{11}$ $\Omega$cm

# Zusammenfassung

- Kapazitive Widerstandsmessung im Bereich $1 \times 10^5$ bis $1 \times 10^{12}$ $\Omega$cm
- Topografie semi-isolierender SiC Substrate
- Bestimmung des Volumen-Anteils bei lokal inhomogenen Material