Percolation and Localization in ultrathin silver films

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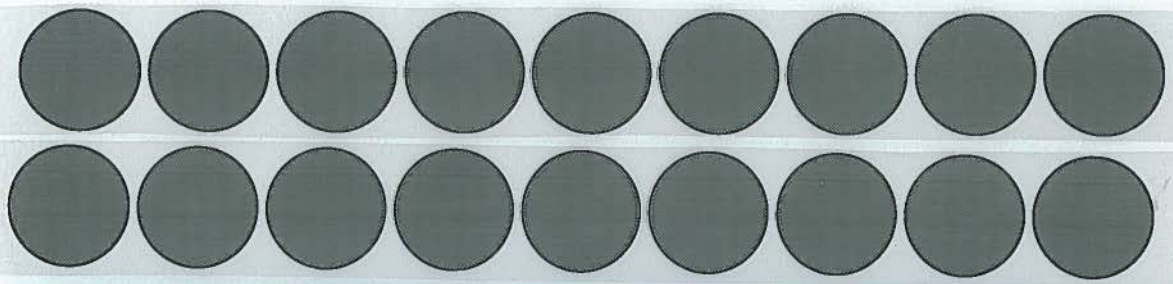
Si(111)-7x7



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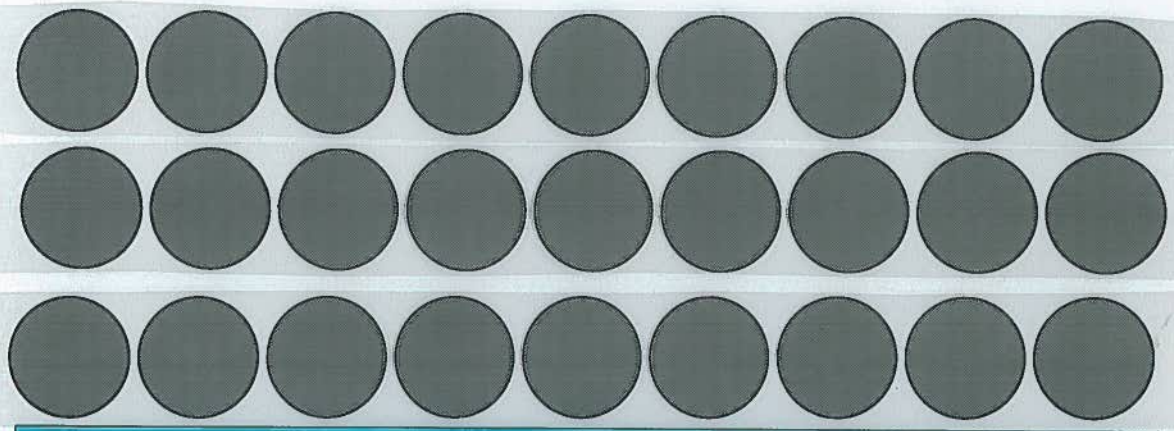

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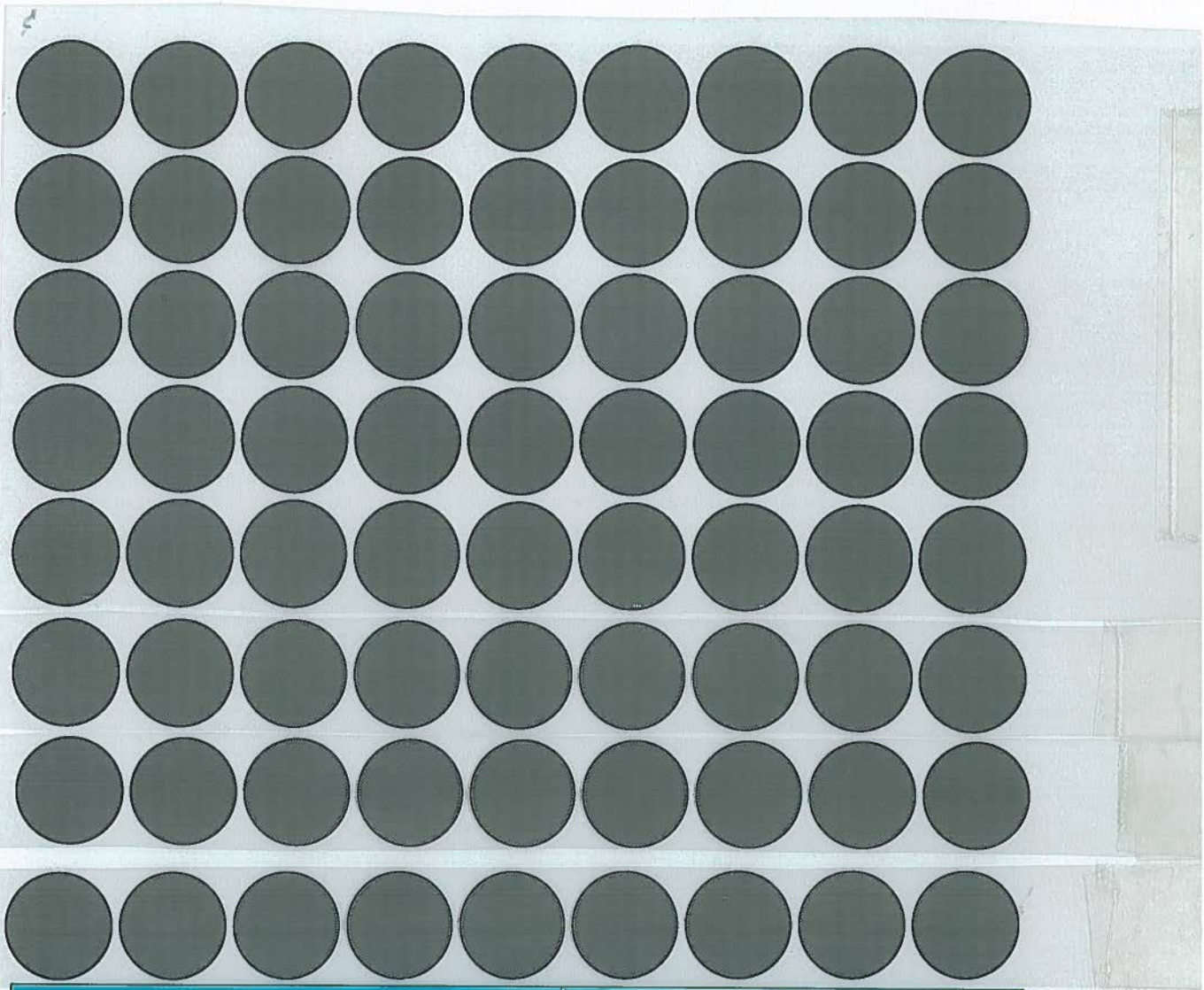
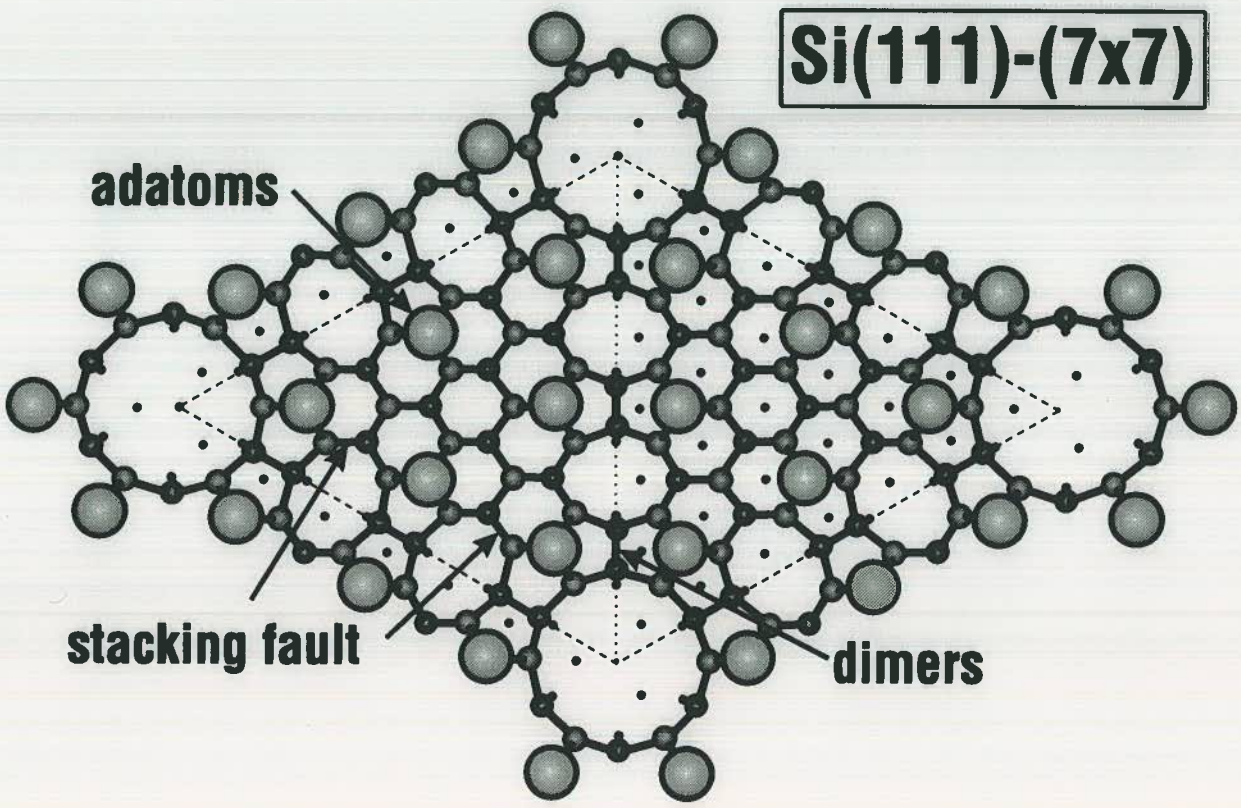


Si(111)-7x7

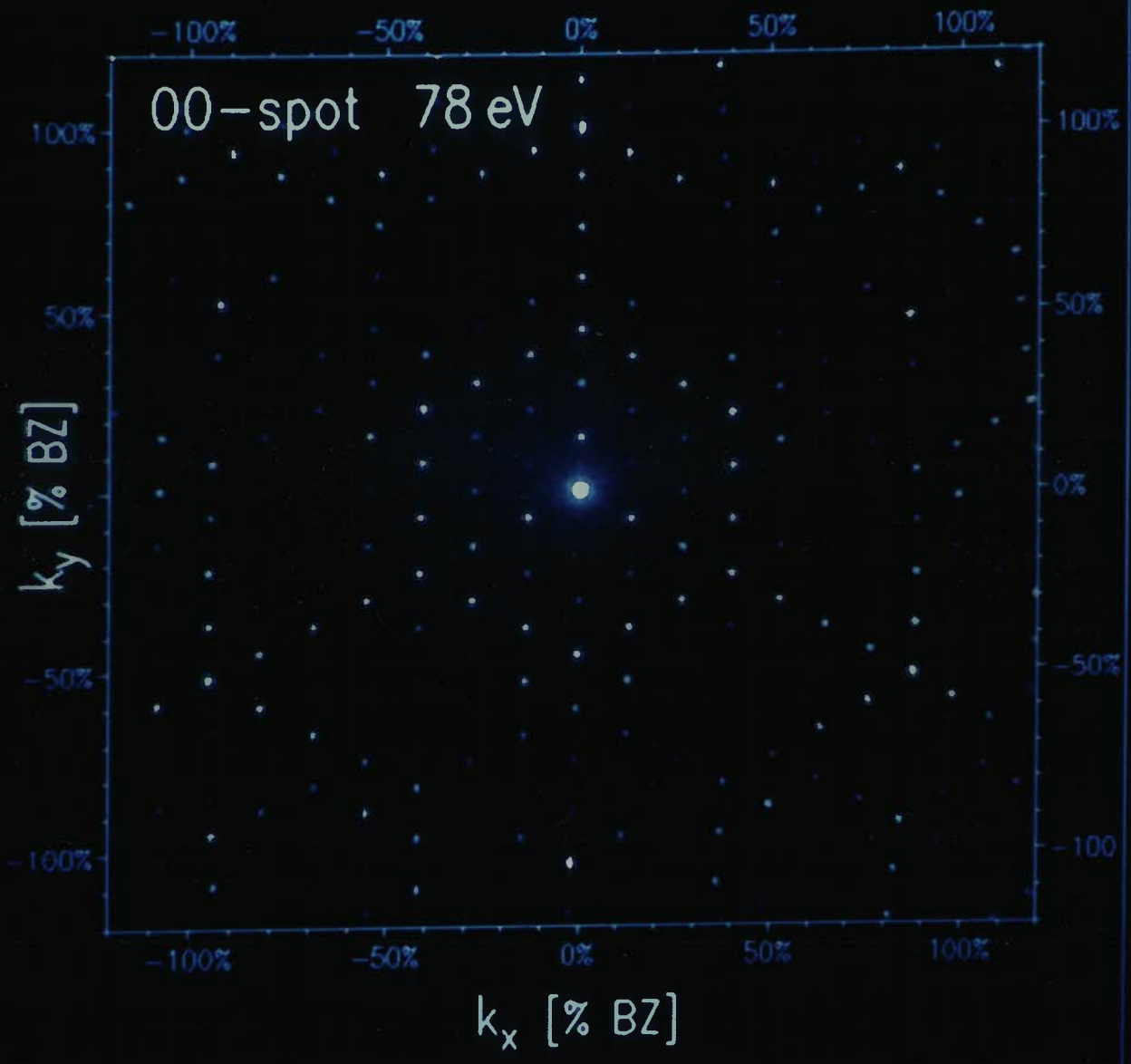
Substrate

Si(111)-7x7

- single crystalline
- atomically flat (LEED, STM)
- no contamination (Auger)
- high resistivity (6000 Ωcm)



Si(111) - (7x7) - Substrate Surface



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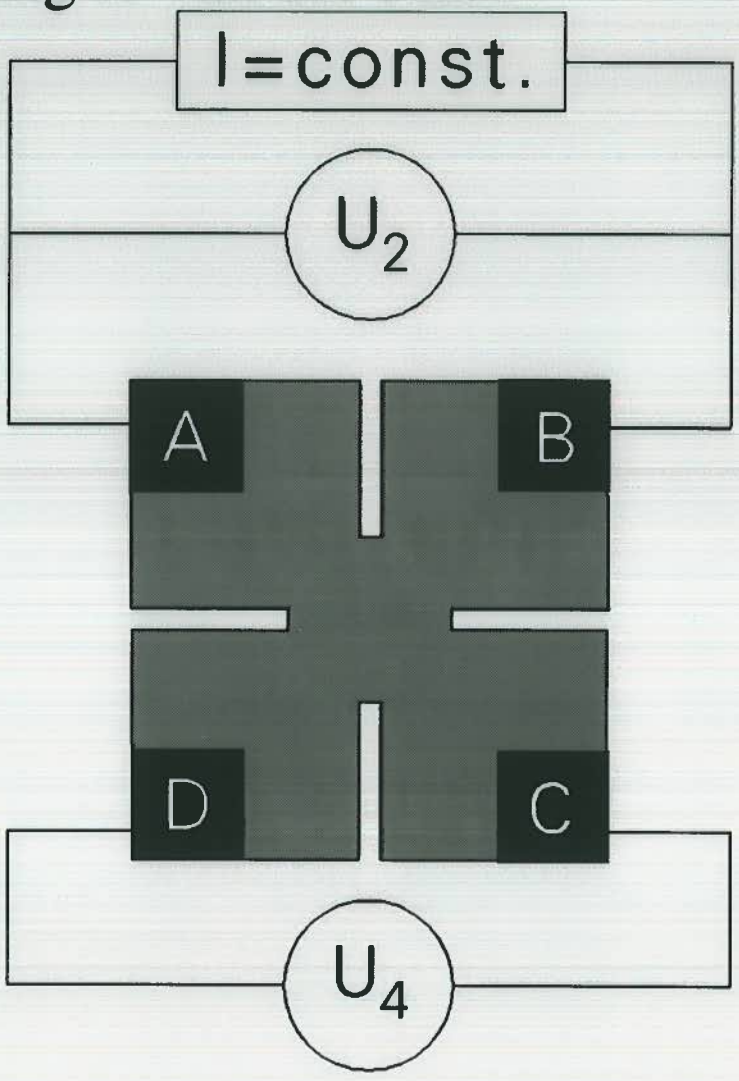
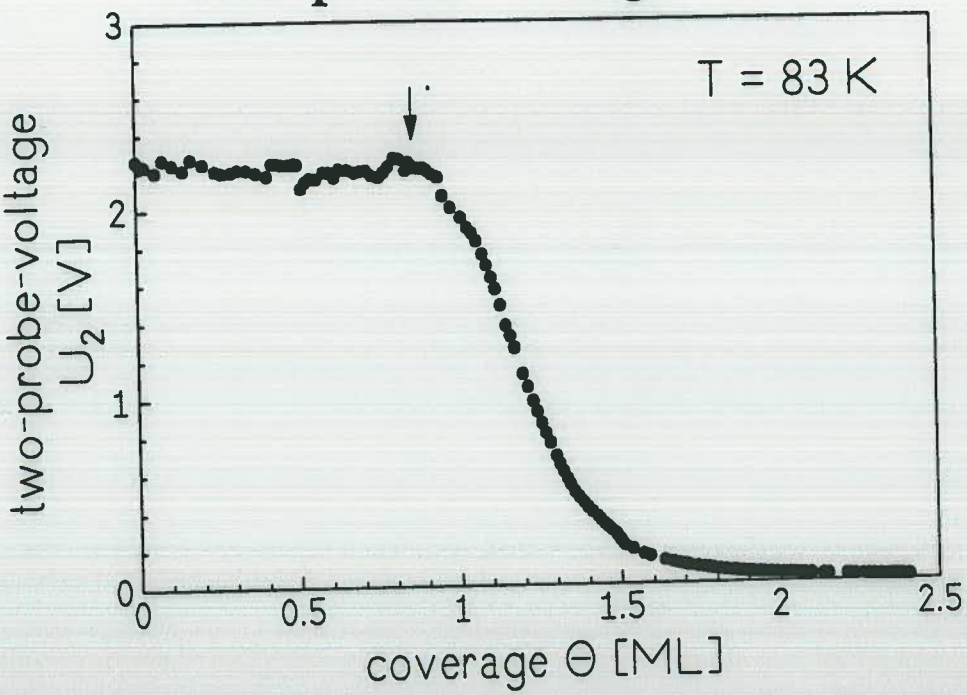
Measurement

dc conductivity measurements

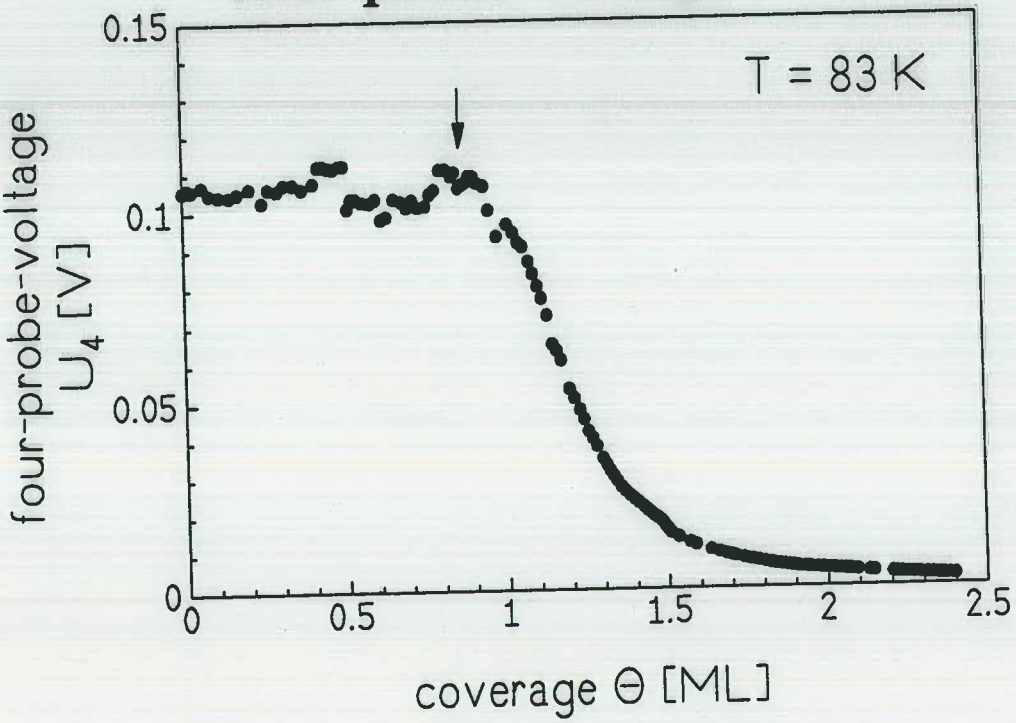
- during growth of epitaxial thin films
- rate: 20 min. per monolayer (ML)
- in a thickness range from 0-100 ML
- at 50K to 200K
- in situ in UHV
- according to van der Pauw



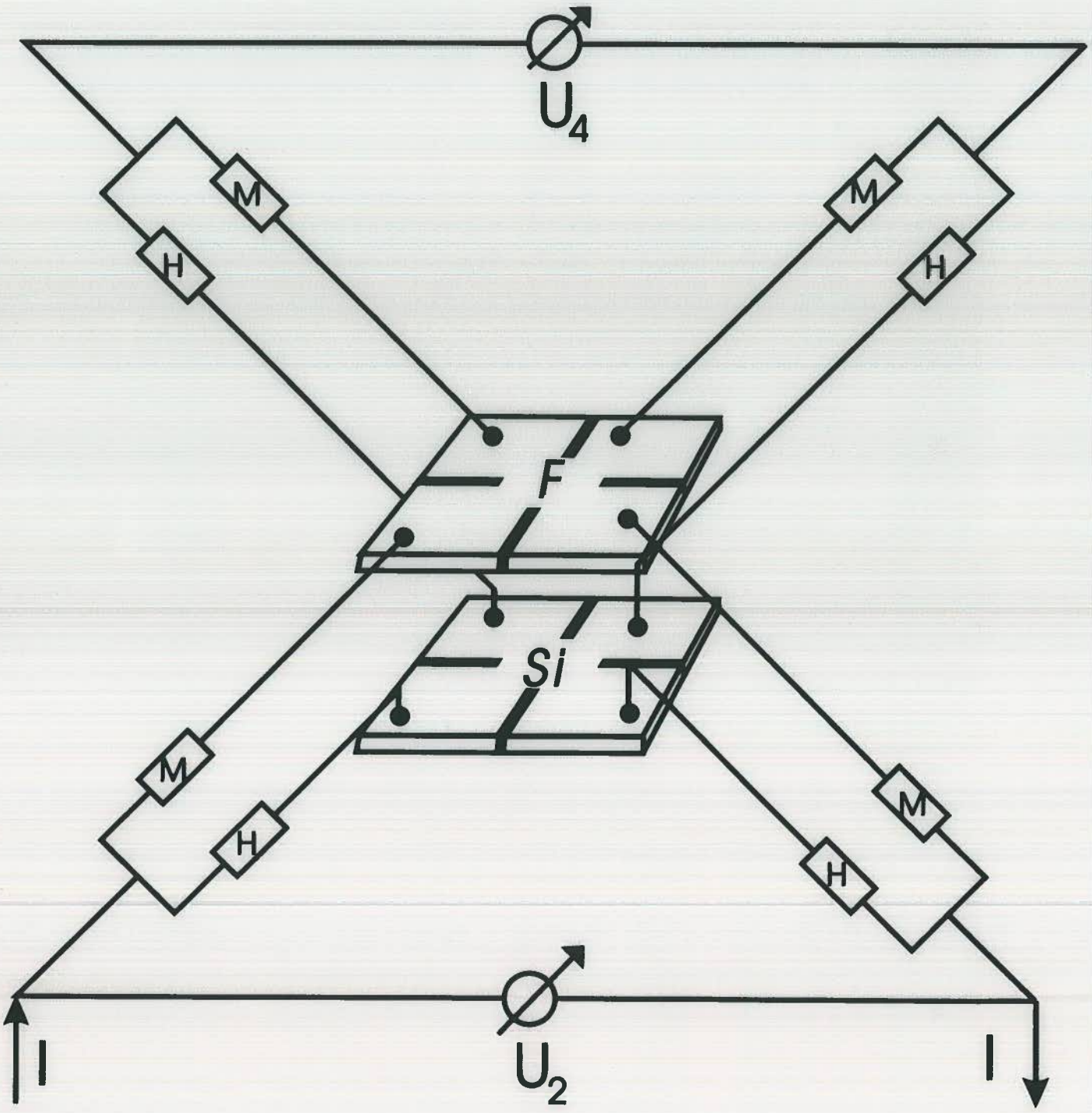
two-probe voltage



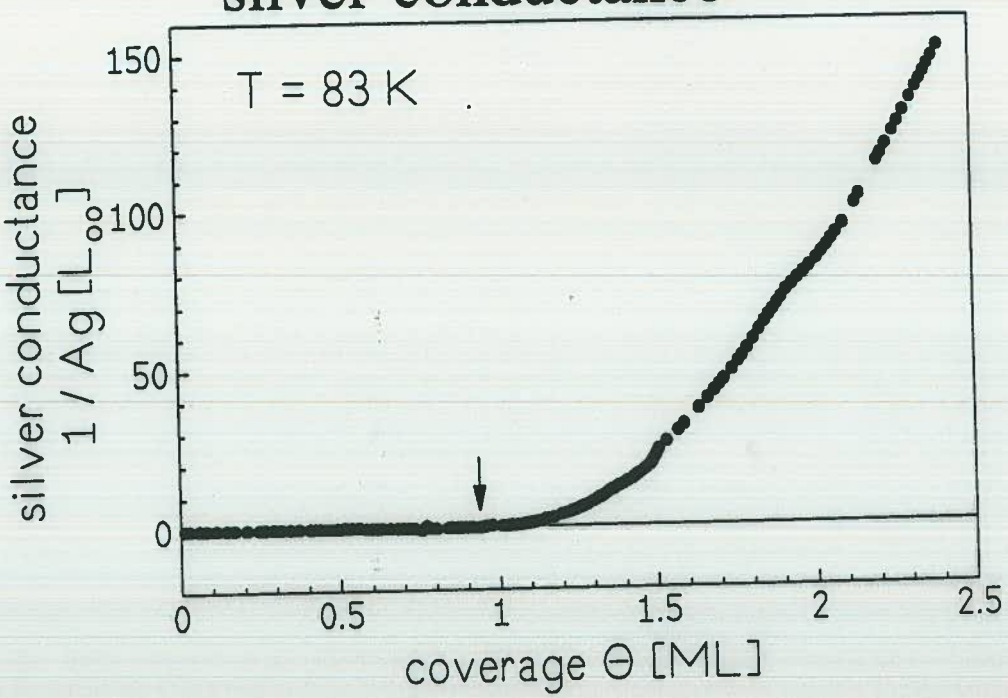
four-probe voltage



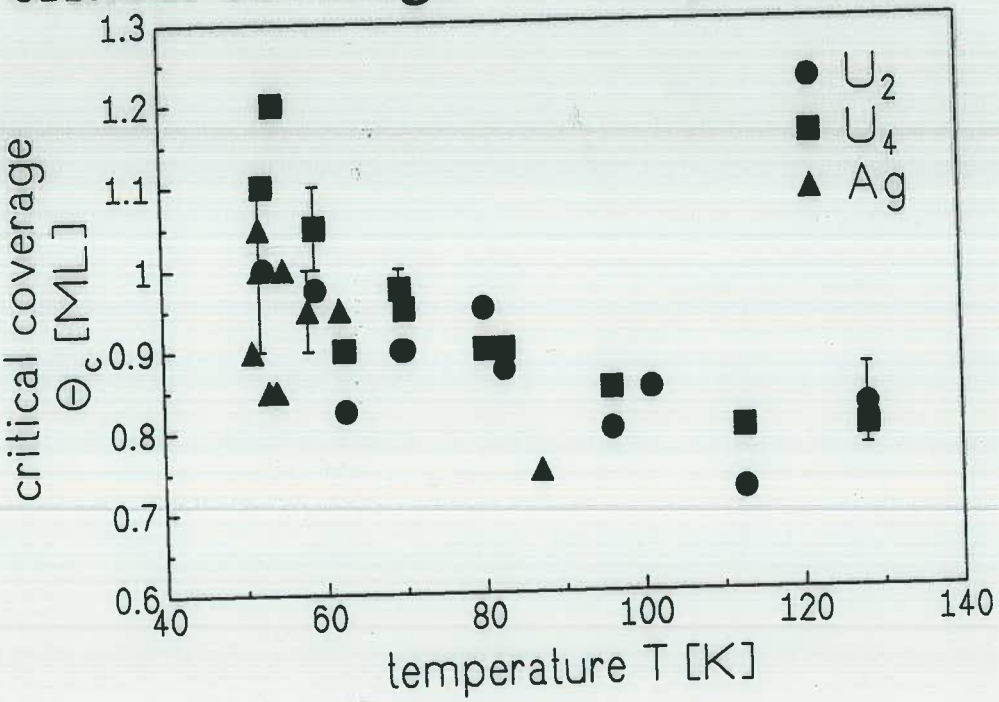
The model

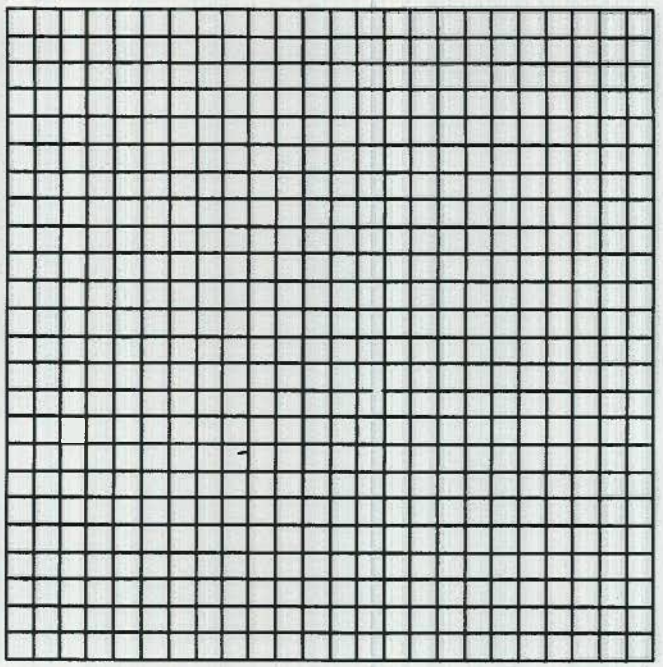


silver conductance

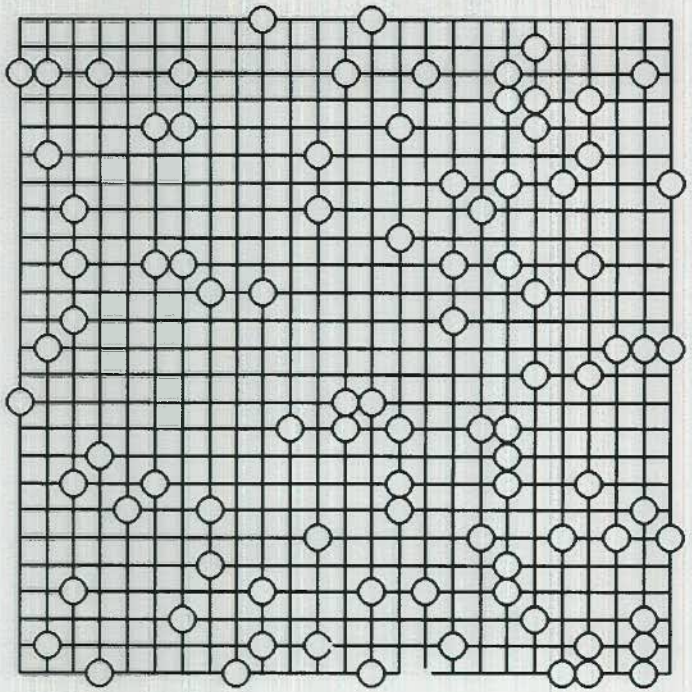


critical coverage vs. temperature

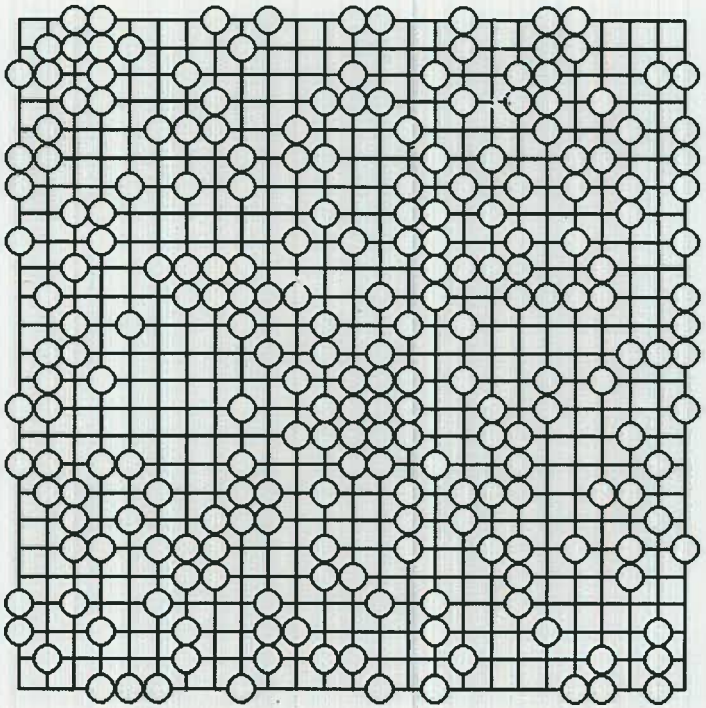




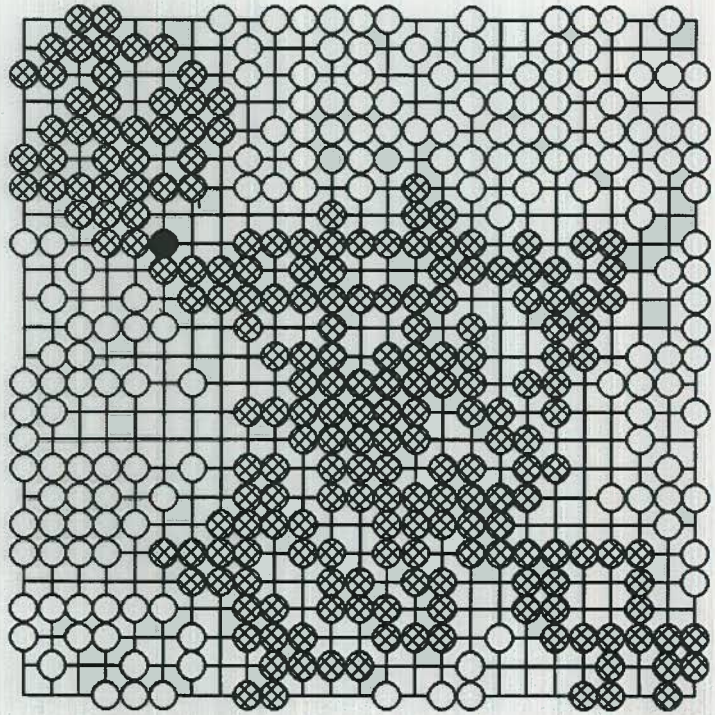
θ=0



θ=0.15



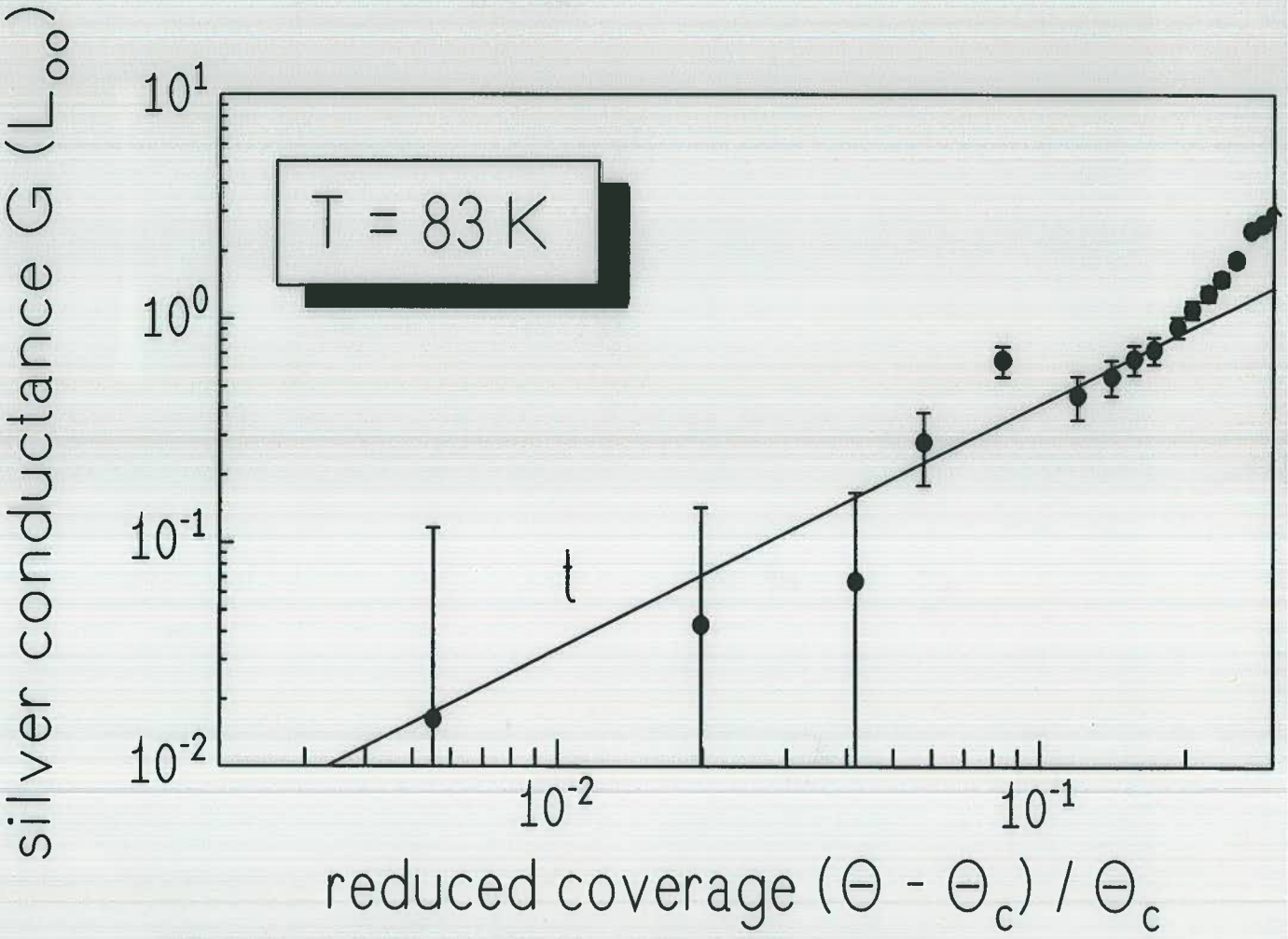
θ=0.36



θ=0.59

Percolation

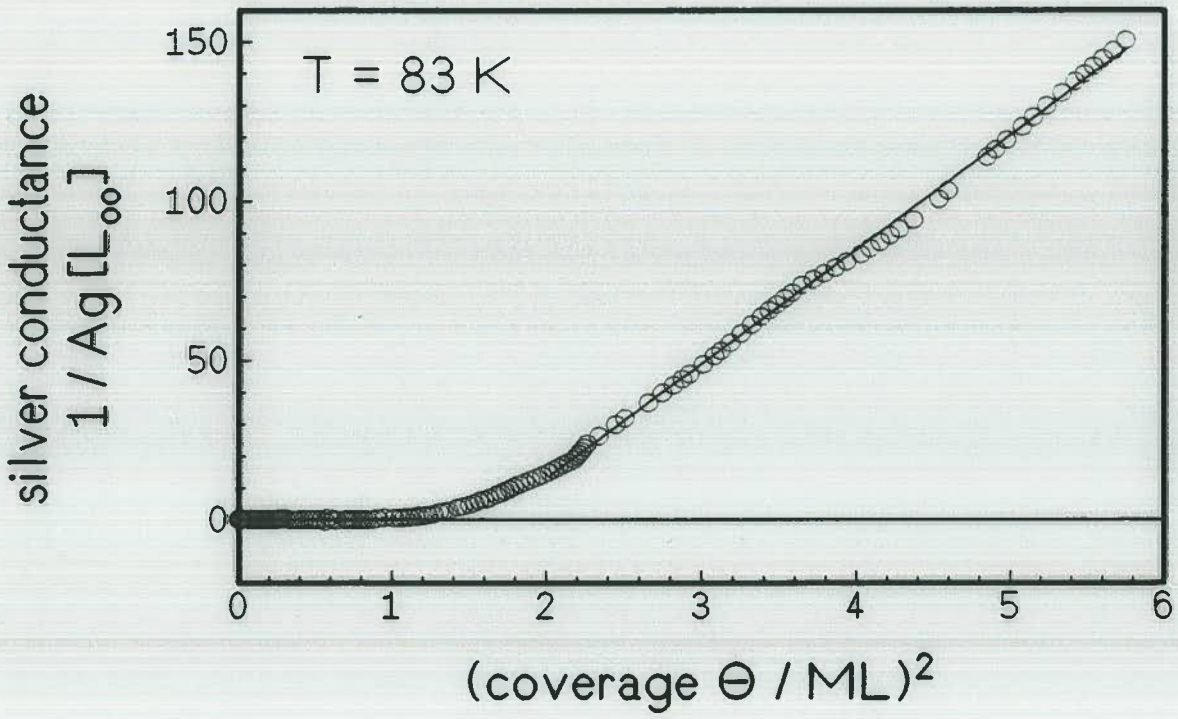
$$G \propto (\theta - \theta_c)^t$$



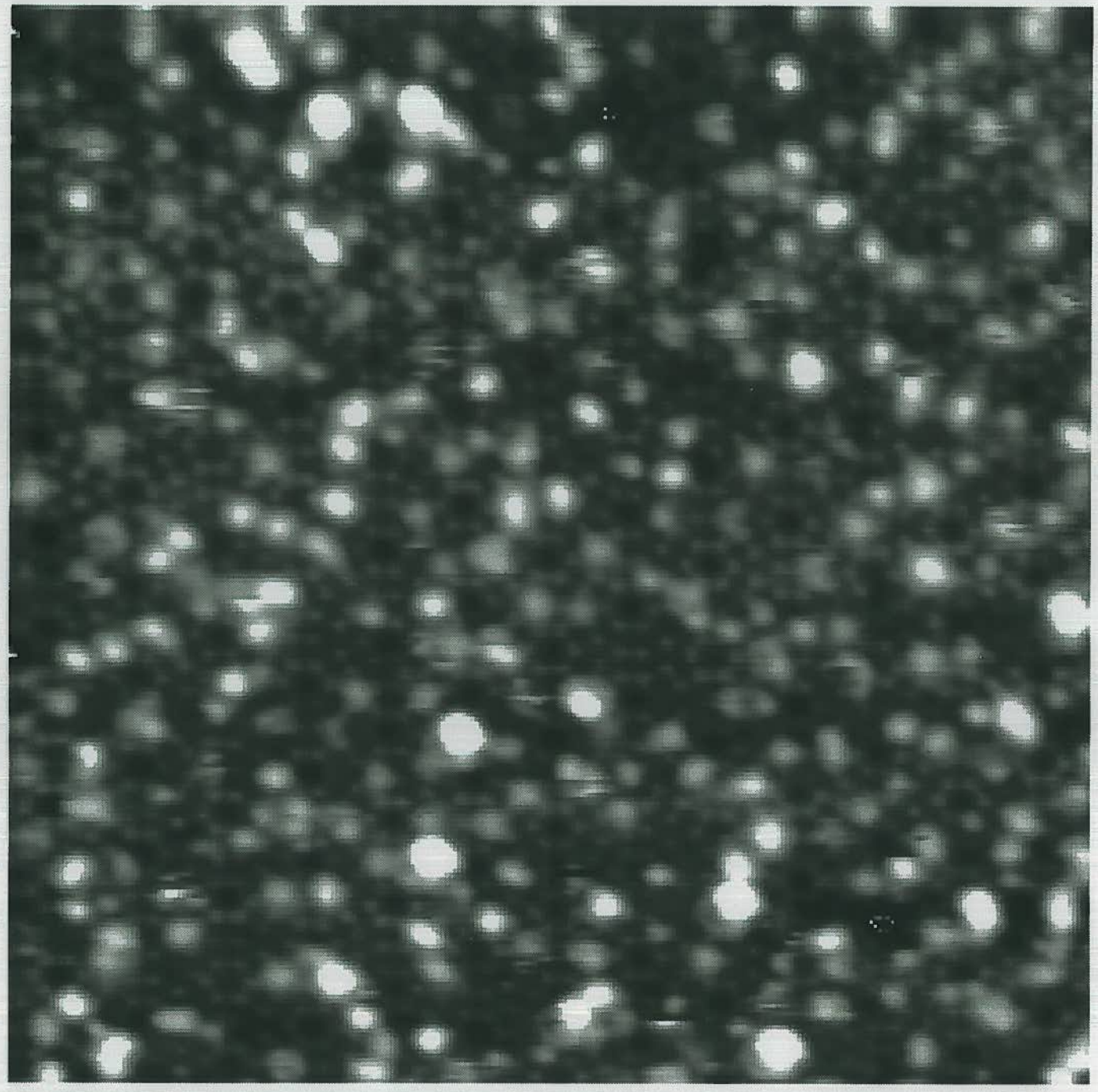
$$t = 1.36 \pm 0.25$$

Effektiv – Medium – Theorie:

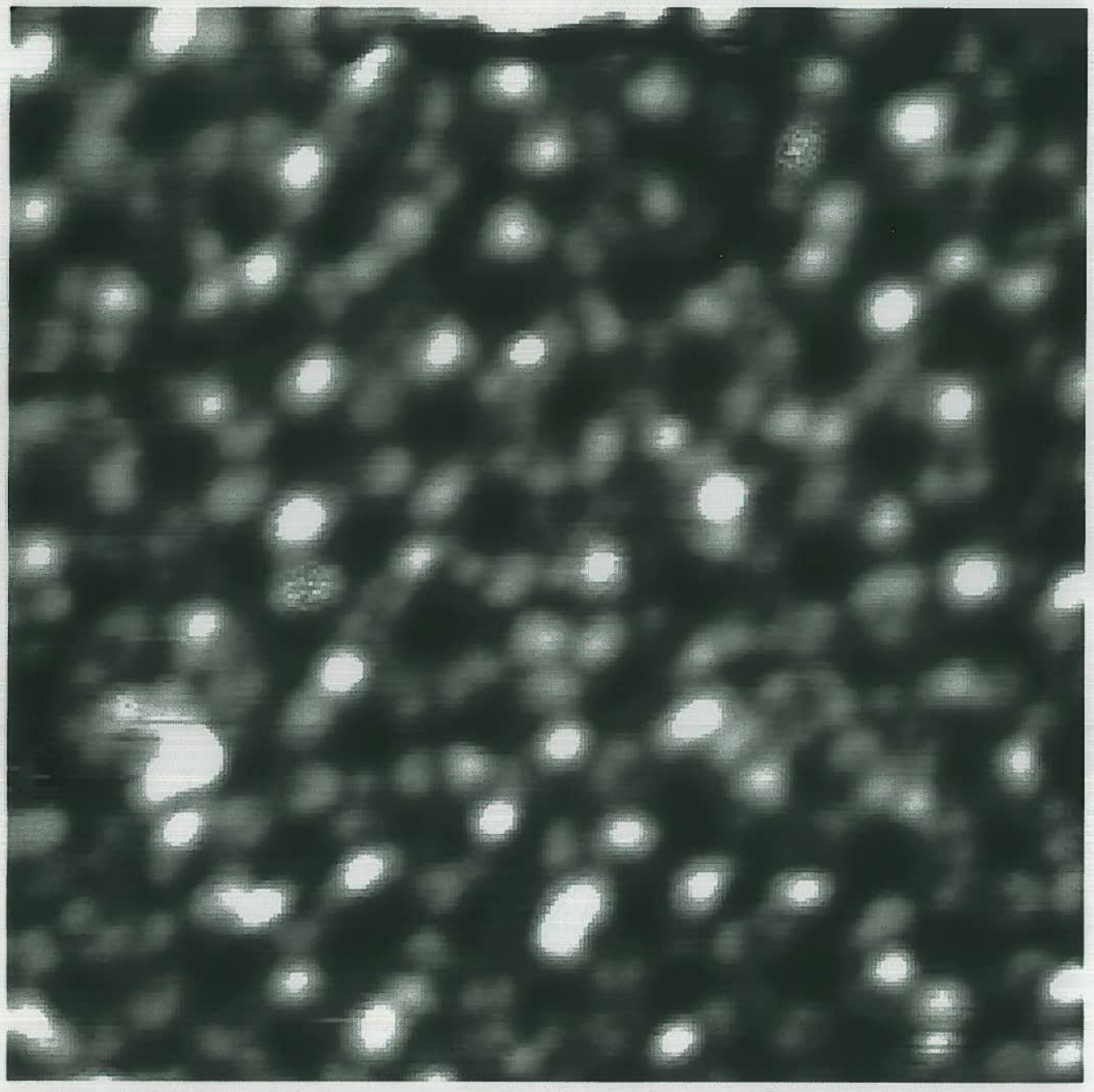
$$1/A_g \propto \theta^2 - \theta_c^2$$



0.25 ML Ag / Si(111)-7x7 at 80K



0.5 ML Ag / Si(111)-7x7 at 80K



Vergleich mit Theorie:

triangular site percolation: . $\vartheta_c = 0.5$

Perkolation in 2D: $t \approx 1.3$

Monte-Carlo-Simulation (Li & Strieder 1982):

Für $(\vartheta - \vartheta_c) / \vartheta_c \leq 0.2$ gilt Potenzgesetz der Perkolationstheorie

Für größere ϑ gilt effective medium theory

Warum ist ϑ_c so groß?

Wachstumsmoden

- → statistisches WT
- → funneling
- → Lage für Lage - WT

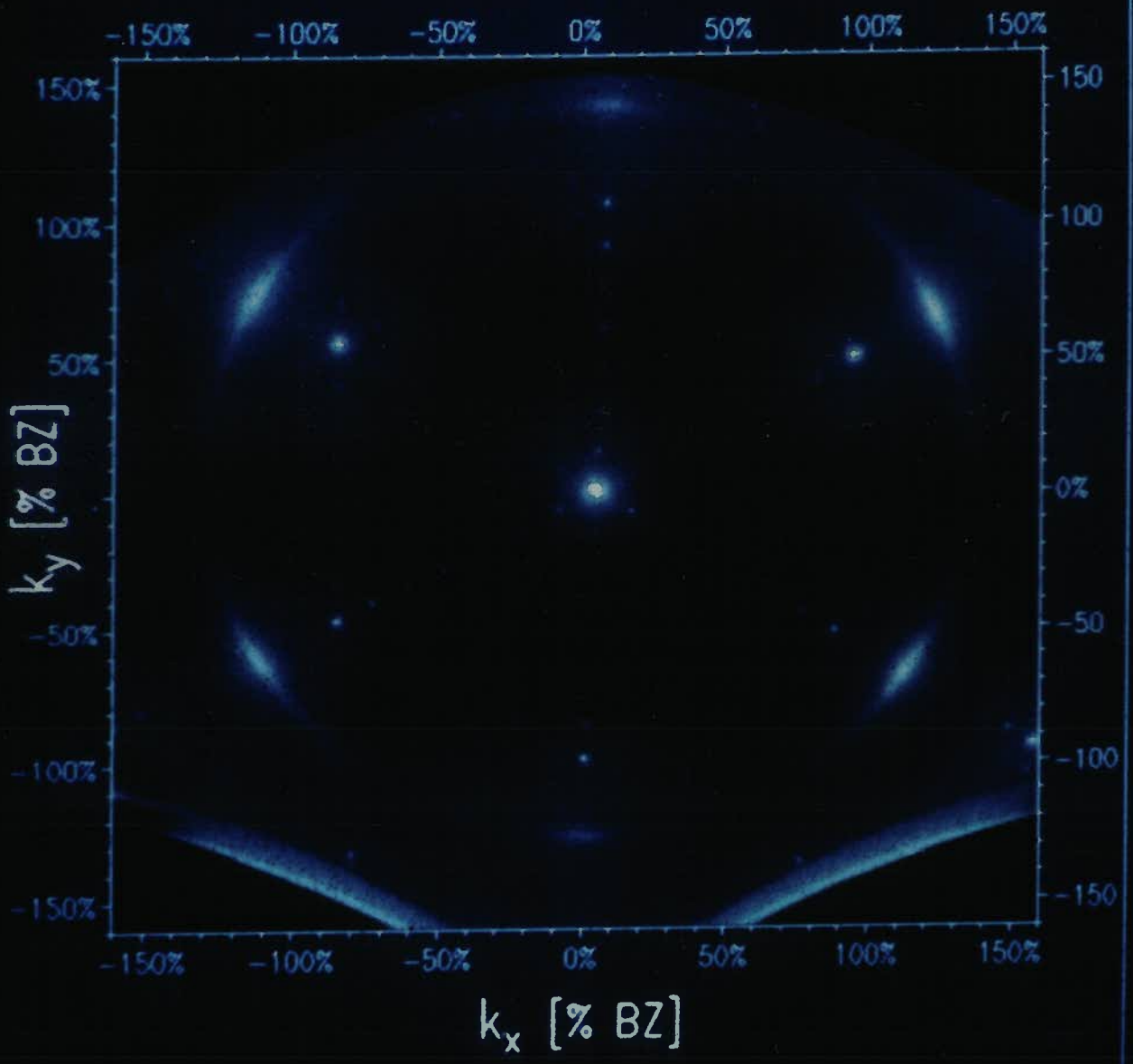
Gitterkonstanten $a_{Si} = 4/3\ a_{Ag}$

Widerstand der Silber"kugeln" umgebungsabhängig

Conductivity of thin films

Si(111) – (7x7)

Si(111) / 3ML Ag / 180 K



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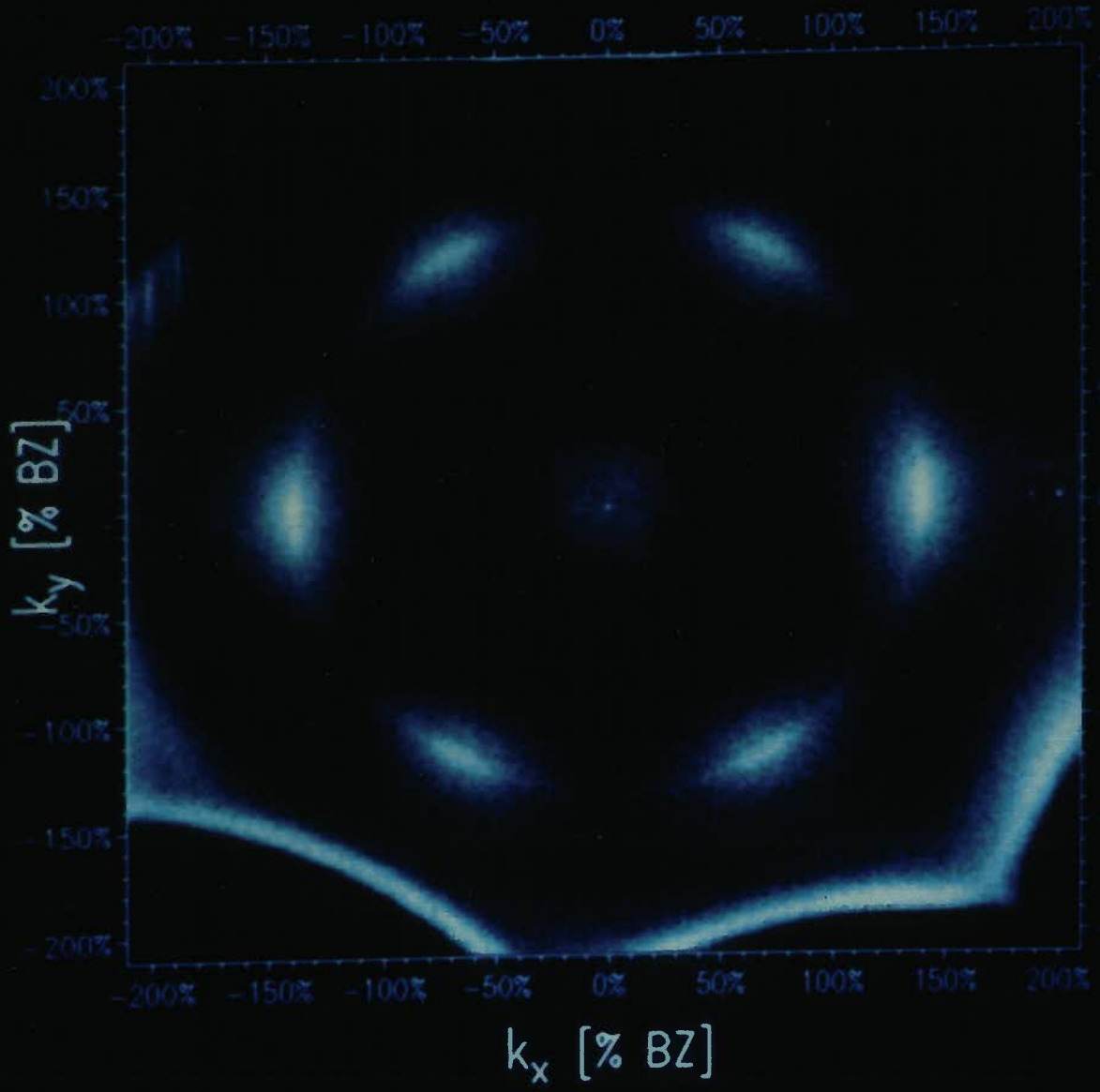
Conductivity of thin films

Si(111) - (7x7)

Si(111) / 4ML Ag / 50 K



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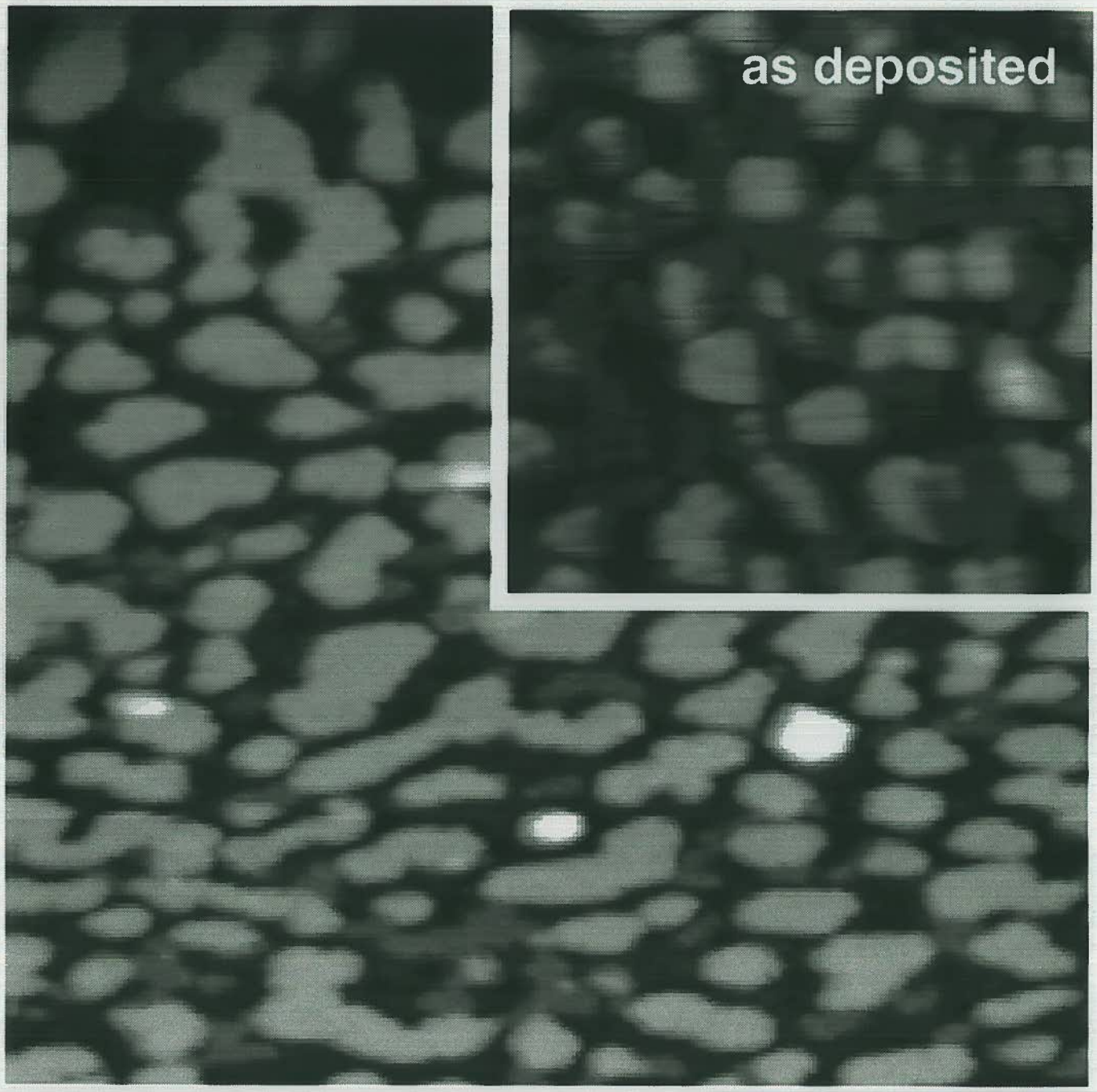
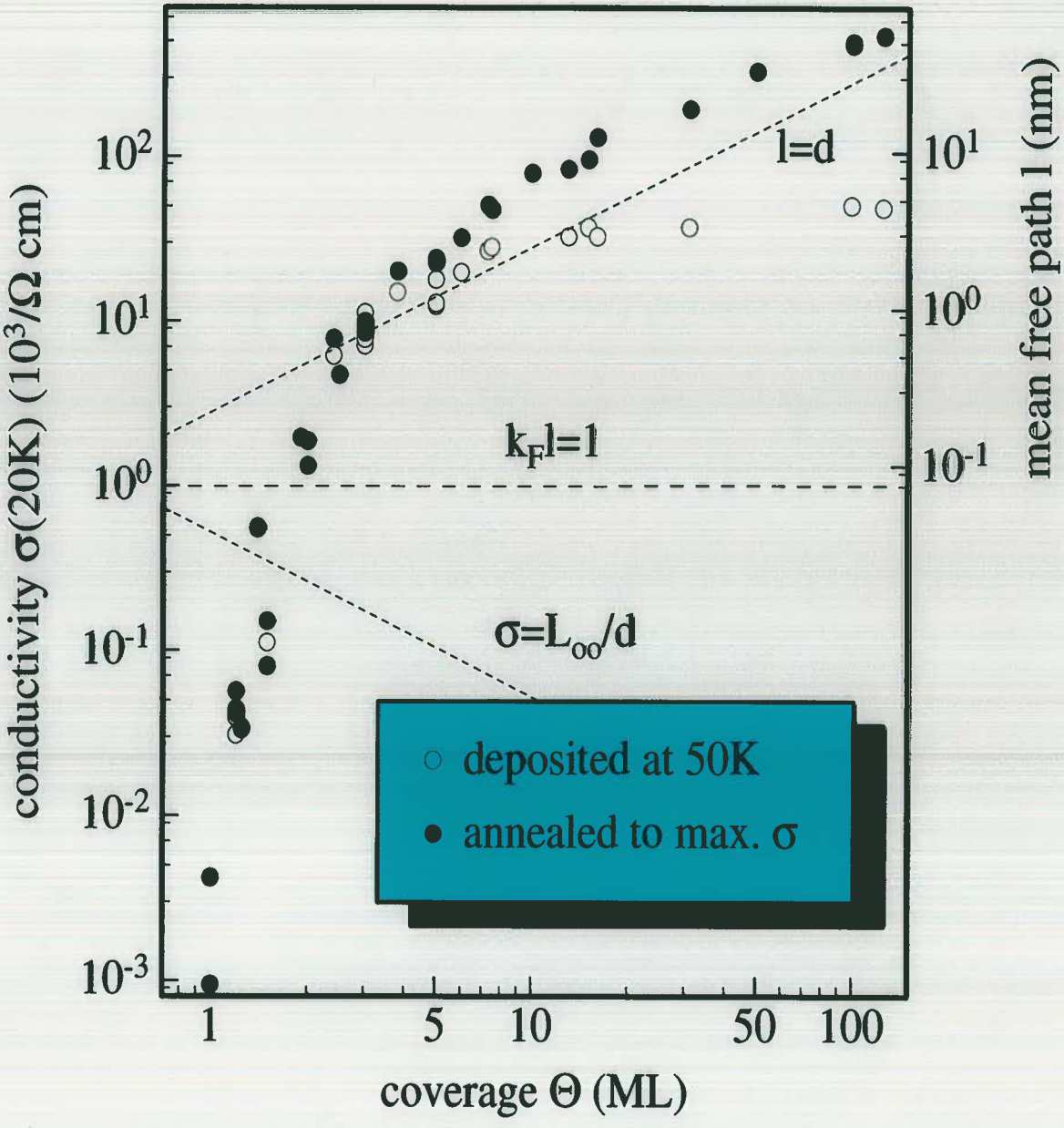
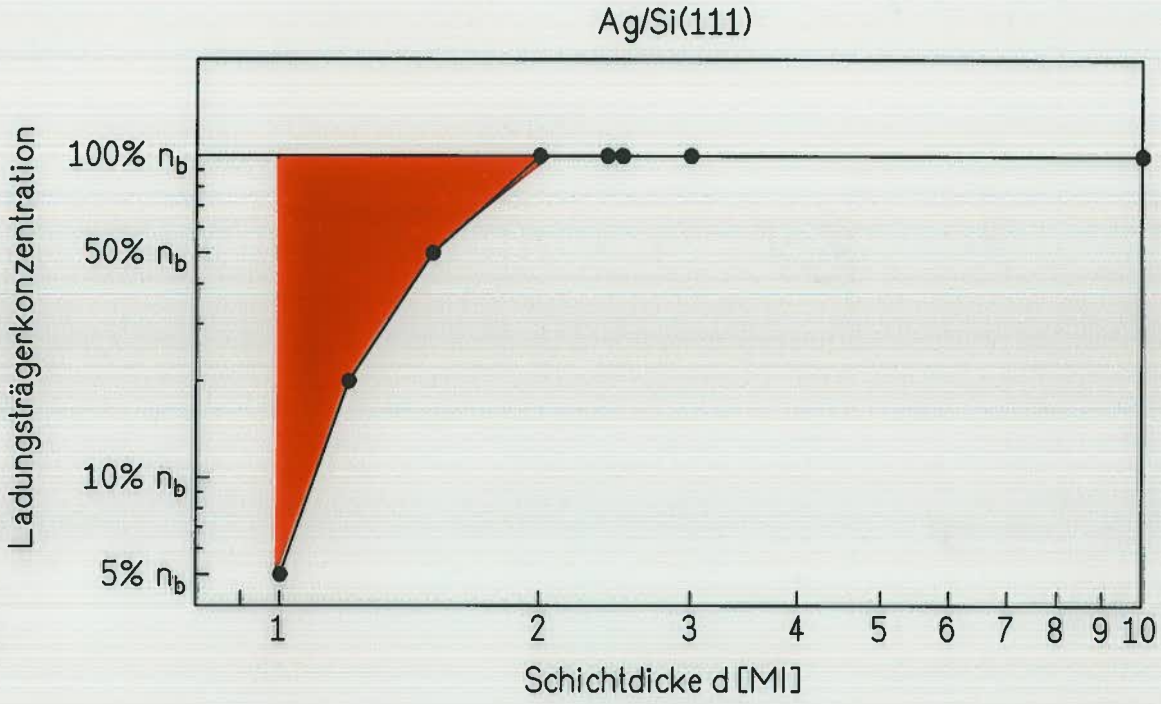
3 ML Ag / Si(111)-7x7 at 80K
460Å x 460Å



annealed to 200K


conductivity σ(20K) (10³/Ω cm)
mean free path l (nm)
coverage Θ (ML)
l=d
k_F l=1
σ=L_oo/d
deposited at 50K
annealed to max. σ
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10¹
10⁰
10⁻¹
1
5
10
50
100

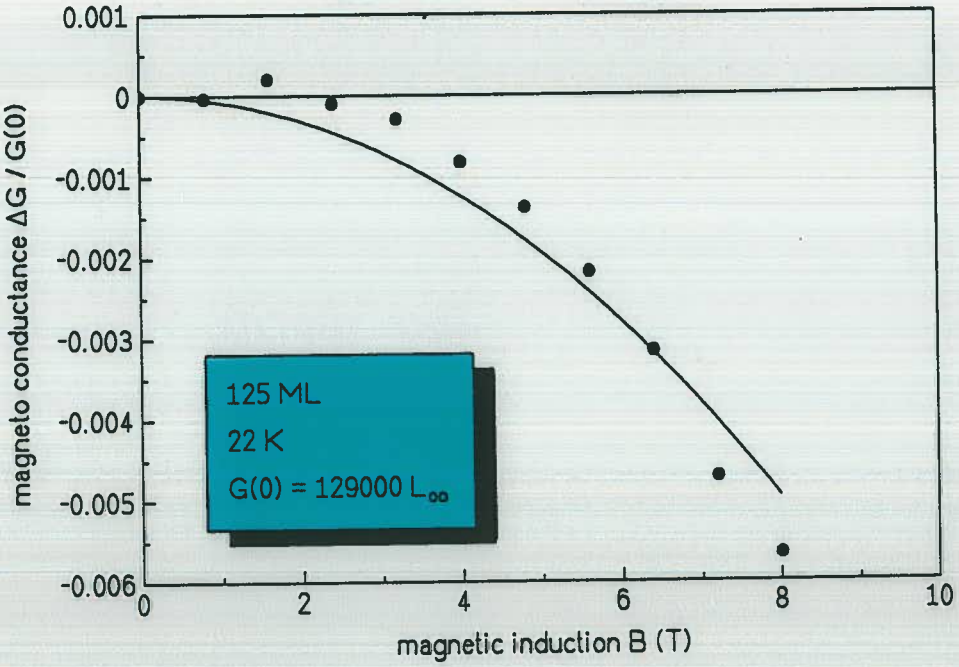
Hall-Effekt



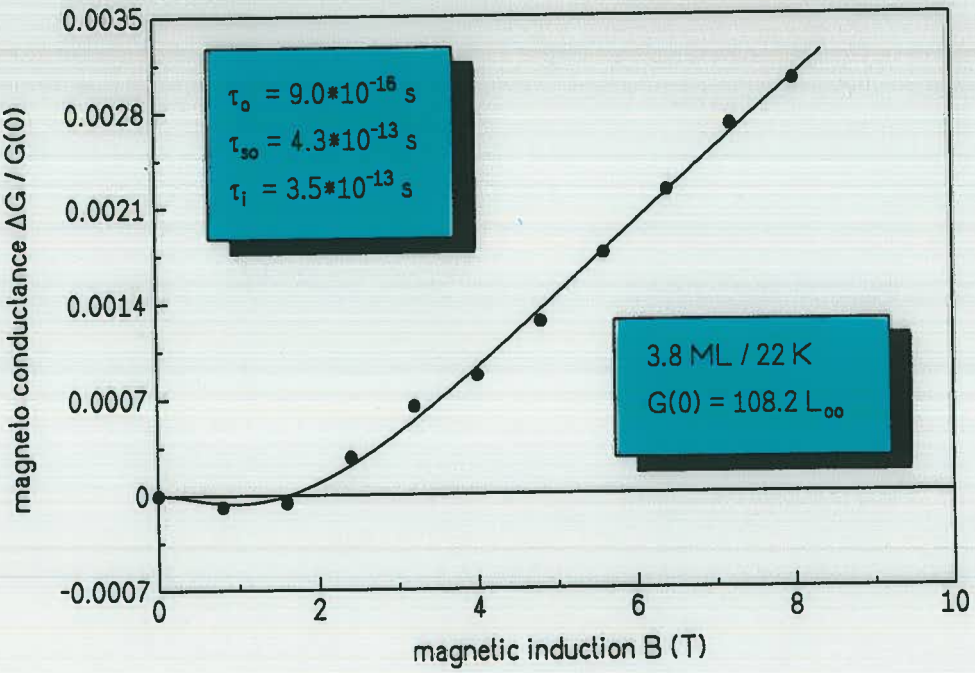
$$R_H = -\frac{1}{ne}$$

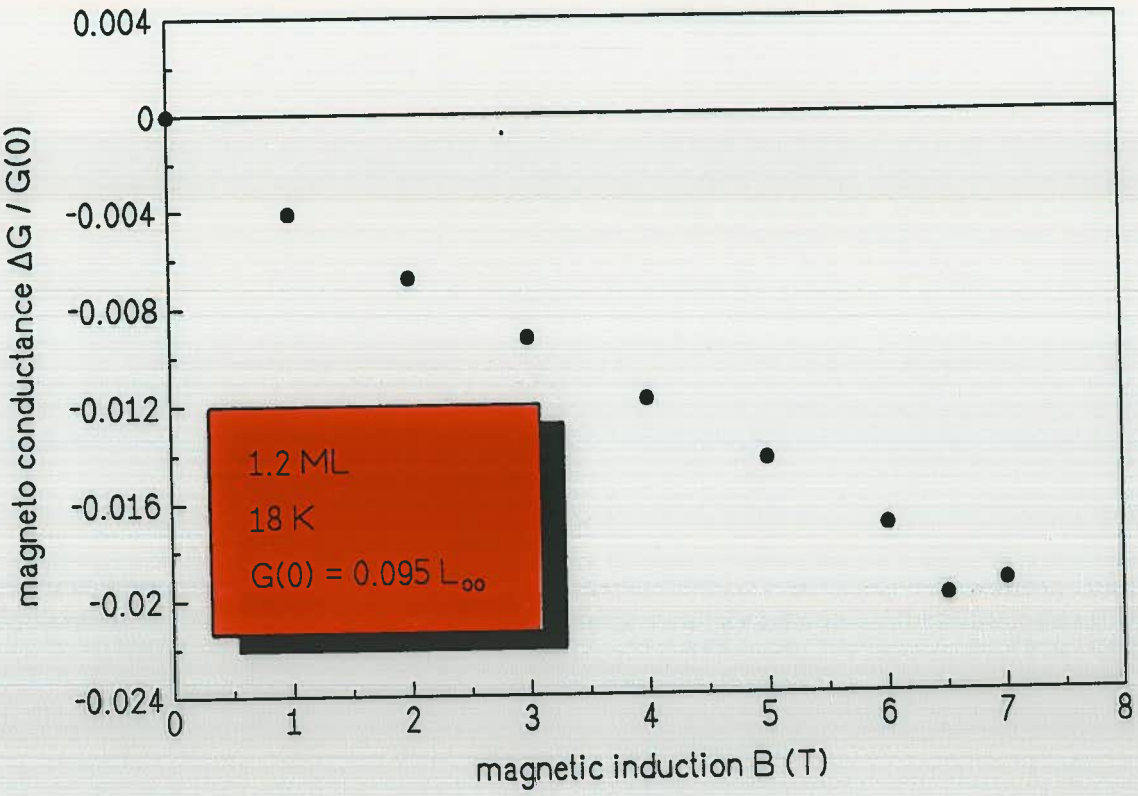
classical magneto resistance

$$\sigma = \sigma_0(1 - (\omega_c\tau_0)^2)$$

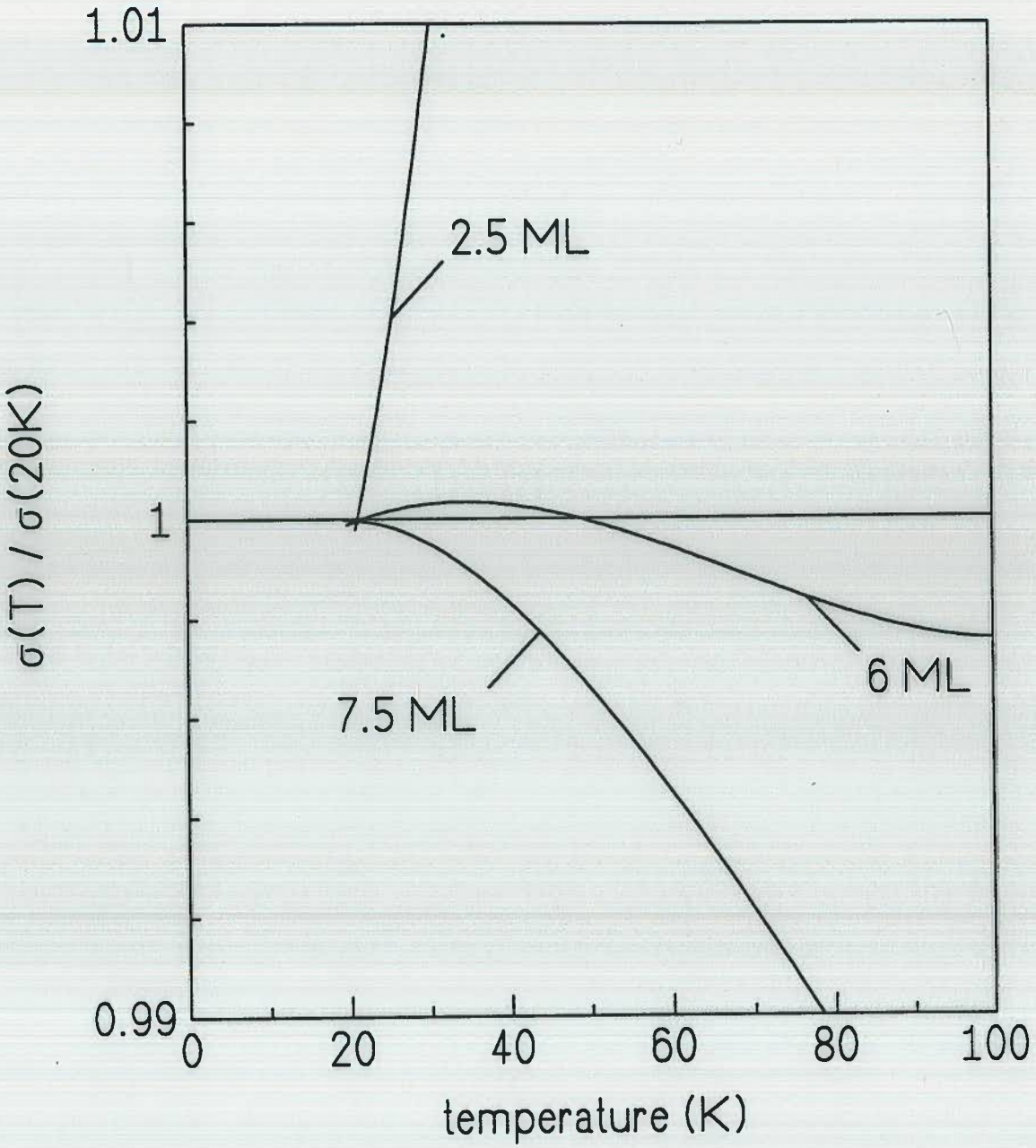


2 -20 ML: regime of weak localisation evaluation following Hikami




0.004
0
-0.004
-0.008
-0.012
-0.016
-0.02
-0.024
magneto conductance ΔG / G(0)
1.2 ML
18 K
G(0) = 0.095 L∞
0
1
2
3
4
5
6
7
8
magnetic induction B (T)

TCR

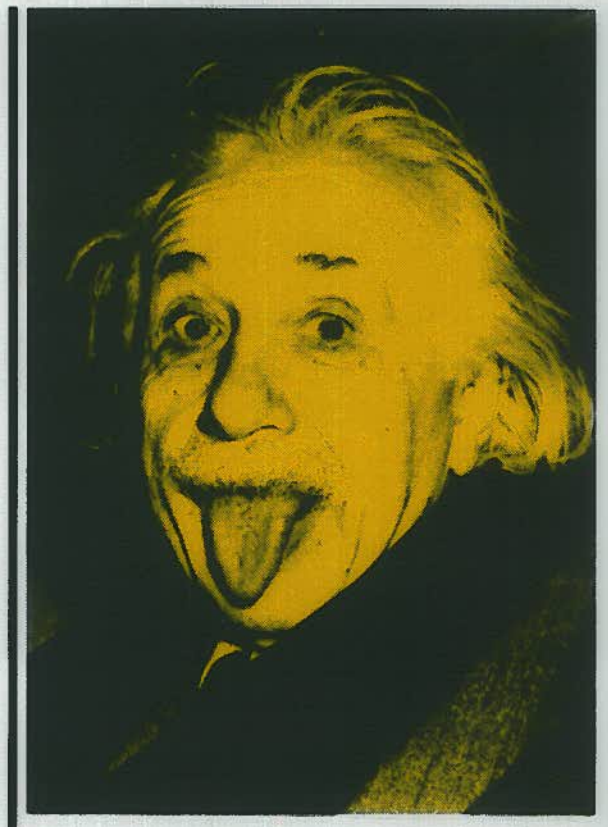


d > 7 ML: normal metallic behaviour

d = 6 ML: effects of weak localization visible

d < 6 ML: incipient localization

percolation



metal-insulator transition

-> conductivity
-> Hall-effect
-> magneto-resistance
-> TCR

0 1 2 **coverage**