DATA ANALYSIS B-DOPED DIAMOND FILMS

1) ATOMIC + KELVIN PROBE FORCE MICROSOPY

- ↳ ANALYSIS WITH GWYDDION SOFTWARE → PHYSICALLY SQUARE
- ↳ TOPOGRAPHIC IMAGES vs PHASE IMAGES vs POTENTIAL IMAGES
  - ↳ NEED TO BE FLATTENED
    - ↳ STARTING POINT: { MASK OUTLIERS + REMOVE PARABOLIC BACKGROUND
  - ↳ FROM TOPO IMAGES → TERRACES/GROOVES STATISTICS
    - ↳ SURFACE ROUGHNESS
    - ↳ FRACTAL DIMENSION

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↳ ANALYSIS WITH GWYDDION SOFTWARE → PHYSICALLY SQUARE

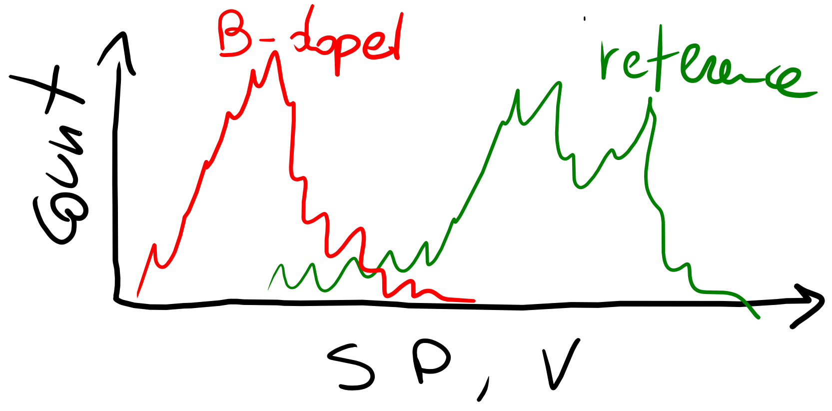
↳ TOPOGRAPHIC IMAGES VS PHASE IMAGES VS POTENTIAL IMAGES

↳ FROM POTENTIAL IMAGES OF BOTH B-DOPED AND REFERENCE FILMS

↳ BEWARE CONTAMINATIONS! → ANALYZE ONLY CLEAN AREAS

↳ PHASE IMAGE MAY HELP

↳ BUILD HISTOGRAMS



↳ DIFFERENCE IN AVERAGE VALUES GIVES ΔE_F → $\boxed{\text{FERMI LEVEL SHIFT DUE TO DOPANTS}}$

DATA ANALYSIS B-DOPED DIAMOND FILMS

2) SHEET RESISTANCE AND HALL EFFECT

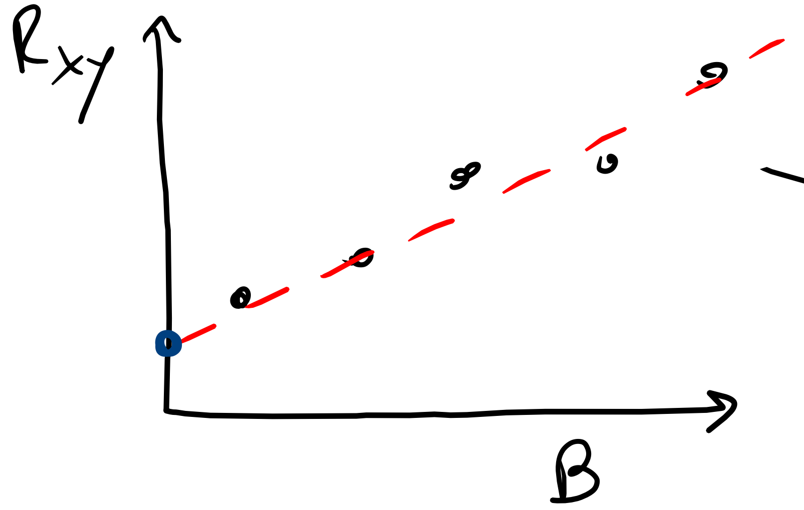
↳ $R = \rho \frac{1}{t}\frac{l}{w} \Rightarrow R_s = \frac{\rho}{t} = R\frac{w}{l}$

→ INDEPENDENT ON ASPECT RATIO

→ DEPENDENT ON THICKNESS

↳ OBTAINED BY SOLVING THE VAN DER PAUW EQ.

↳ R_H: $R_{xy}(B) = R_r + R_H \cdot B \rightarrow R_{xy}$ OBTAINED BY AVERAGING THE R_{vs} B CURVES IN THE TWO TRANSVERSE CONFIGURATIONS



→ LINEAR FIT

↓

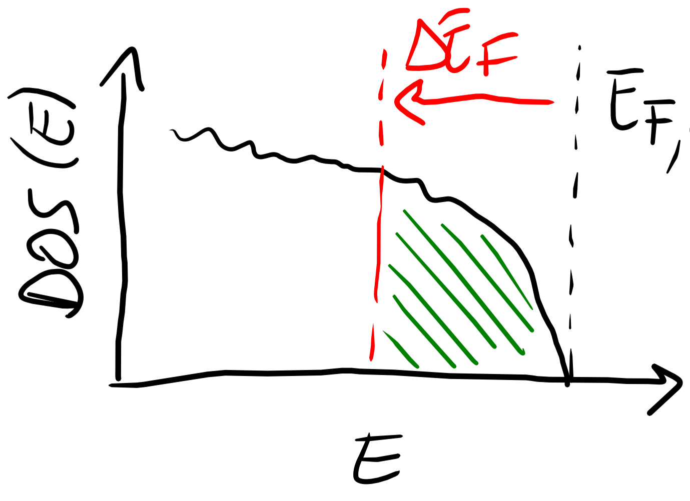
SLOPE → $R_H = \frac{1}{e n_H}$ → (HALL) CARRIER DENSITY PER UNIT SURFACE

DATA ANALYSIS B-DOPED DIAMOND FILMS

2) SHEET RESISTANCE AND HALL EFFECT

↳ n_H → SIGN? → ELECTRON OR HOLE-LIKE QUASIPARTICLES (DONORS VS ACCEPTORS)

↳ + DFT



$E_{F,0}$ → FERMI LEVEL SET BY ABINIT

KPFM → ΔE_F

→ $n_{3D} = \int_{E_{F,0}}^{E_{F,0}+\Delta E_F} DOS(E)\, dE$ PER UNIT VOLUME

↳ ESTIMATE FILM THICKNESS : $t \approx n_H / n_{3D}$ (CAREFUL ABOUT UNITS...)

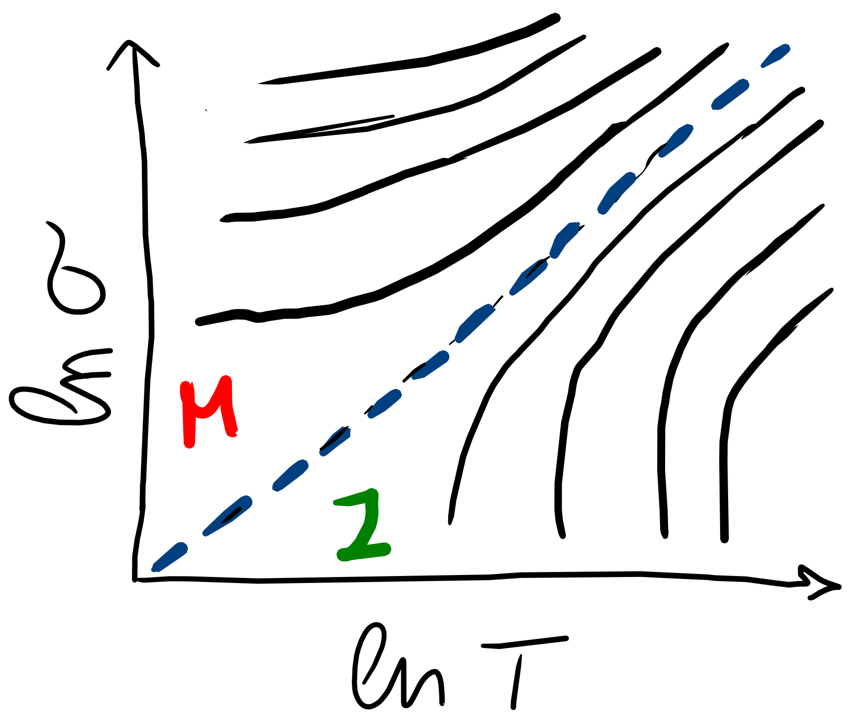
↳ COMBINE: $R_S^{-1} = e\, n_H\, \mu_H$ → HALL MOBILITY → COMPARE WITH LITERATURE

+ BOLTZMANN → $\mu = \dfrac{e\tau}{m^*}$ → IOFFE REGEL PARAMETER $x = \dfrac{\Delta E_F\, \tau}{\hbar}$ ASSESS IMT

DFT → m^*

DATA ANALYSIS B-DOPED DIAMOND FILMS

3) RESISTIVITY VS TEMPERATURE

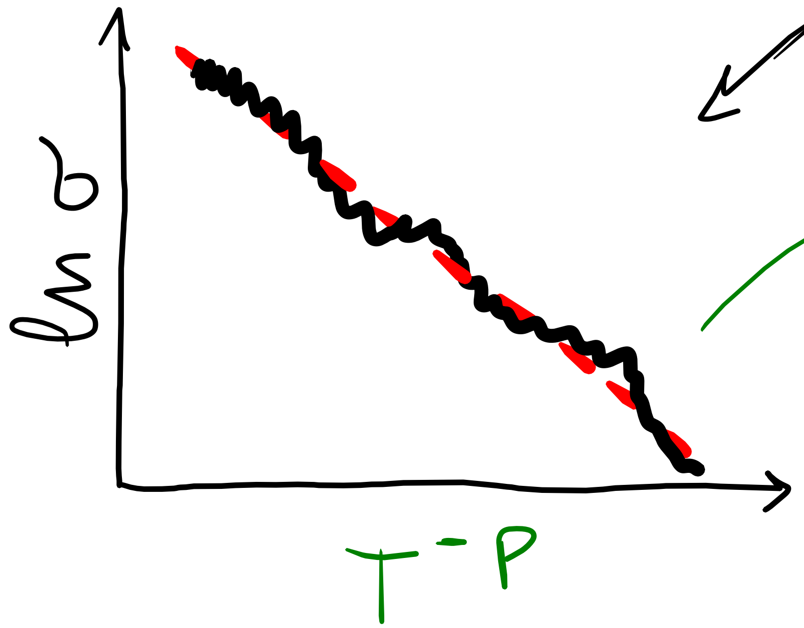


→ ASSESS INSULATOR-TO-METAL TRANSITION

$\sigma \propto T^{\beta}$
- $\beta < 1/3$ → HEAVILY DISORDERED METAL
- $\beta = 1/3$ → I-M TRANSITION
- $\beta > 1/3$ → INSULATOR

QUANTUM CRITICAL REGIME

$$\sigma \propto \exp\left[-\left(T_0/T\right)^{p}\right]$$ → STANDARD INSULATOR



FIND p THAT BEST REALIZES LINEAR BEHAVIOR(s)

- $p = 1$ → NEAREST-NEIGHBOR HOPPING
- $p = 1/2$ → EFROS-SHKLOVSKII VARIABLE RANGE HOPPING
- $p = 1/3, 1/4$ → 2D, 3D MOTT VARIABLE RANGE HOPPING

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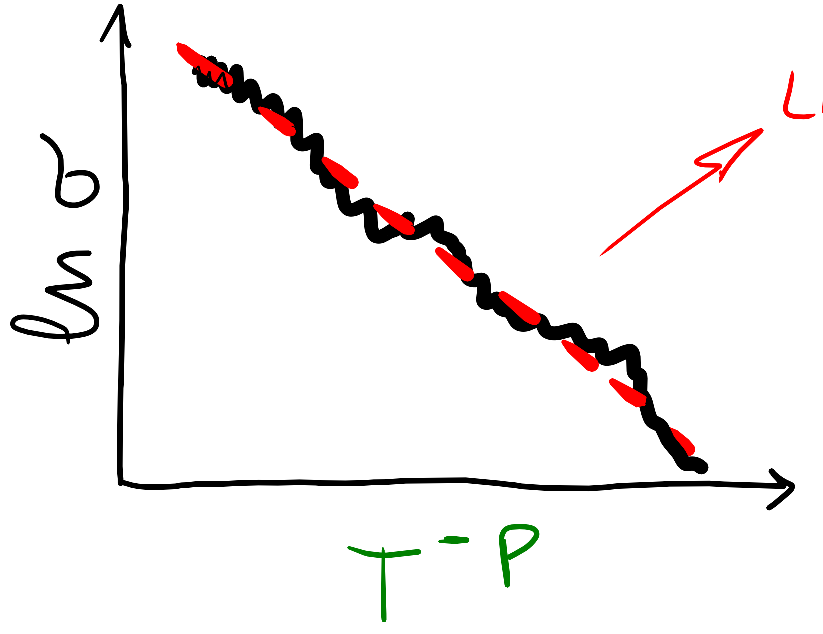


LINEAR FIT → FIND $T_0 = f(p, DOS(E_F), \xi_{loc})$

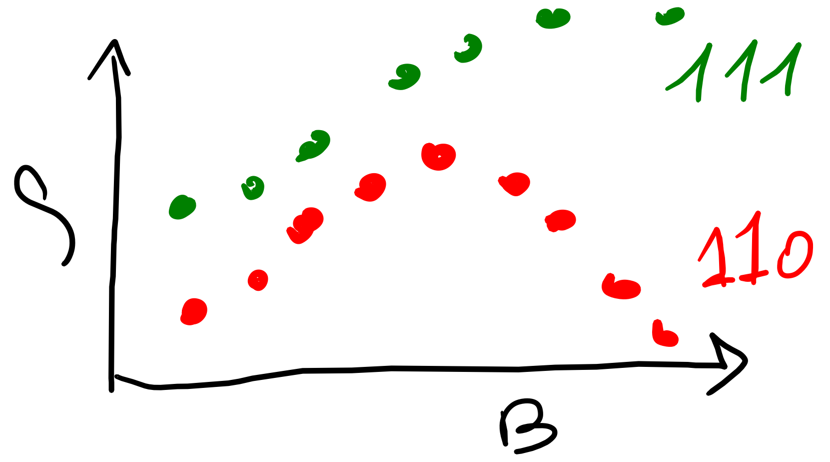
DFT + KPFM

LOCALIZATION LENGTH

→ FIND $R_{HOP} = f(p, \xi_{loc}, T)$ HOPPING LENGTH

→ COMPARE WITH LITERATURE, CELL SIZE, FILM THICKNESS, SURFACE ROUGHNESS...

4) RESISTIVITY VS MAGNETIC FIELD



→ POSITIVE MR AT LOW B + "NEGATIVE" MR AT HIGH B IS <u>SOMEWHAT UNUSUAL</u>

→ SEARCH THE LITERATURE FOR AN EXPLANATION AND IDEALLY A FITTING MODEL $f(\xi_{loc})$...