Recombination Zone Modeling in Organic Light Emitting Field Effect Transistors

Molecular Materials and Nanosystems

Dimitri Charrier
Martijn Kemerink
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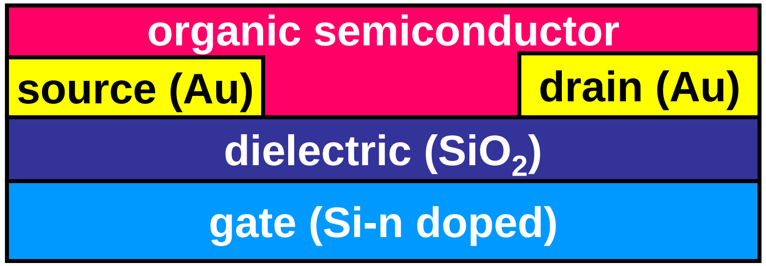
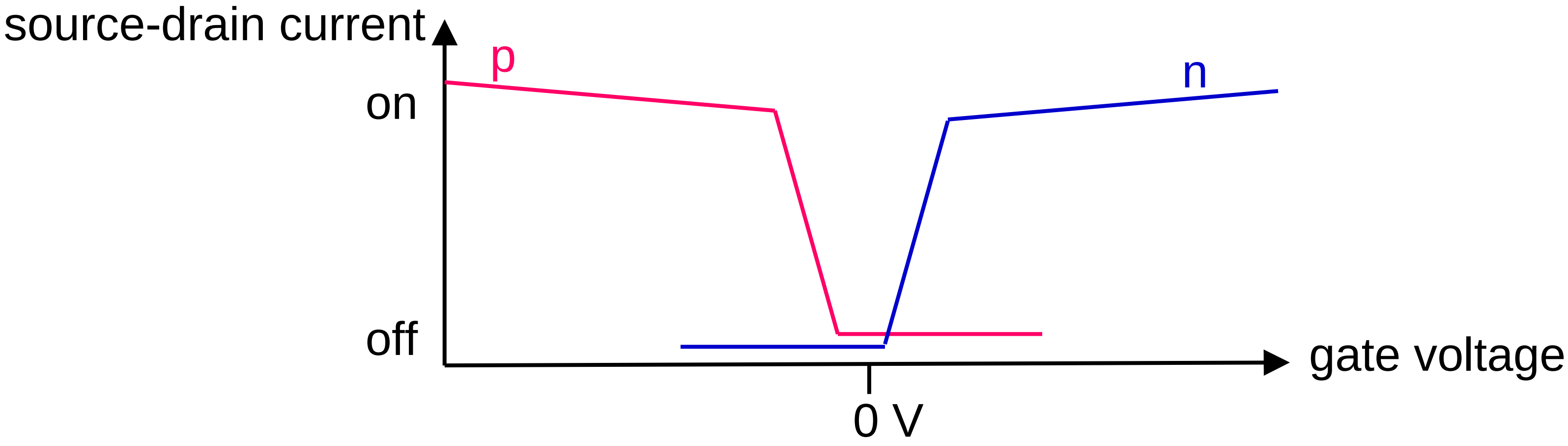
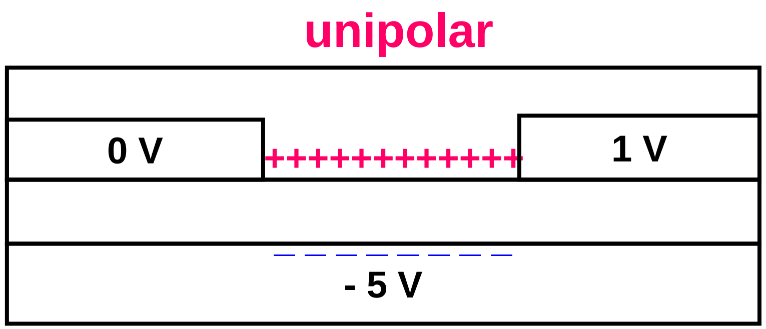
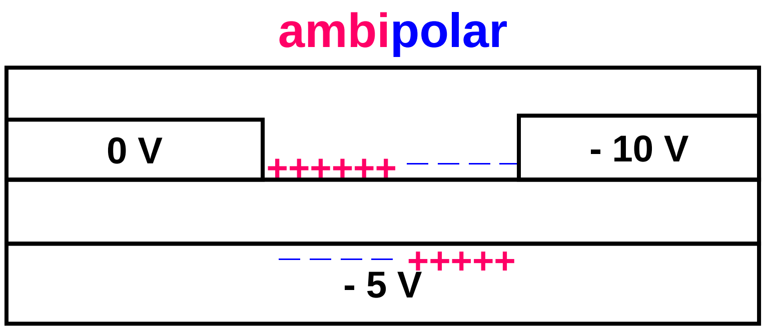
Organic Transistor

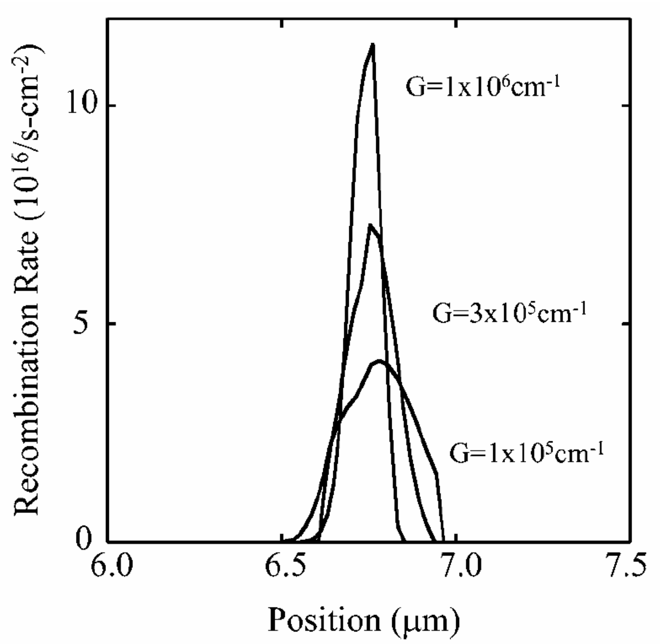




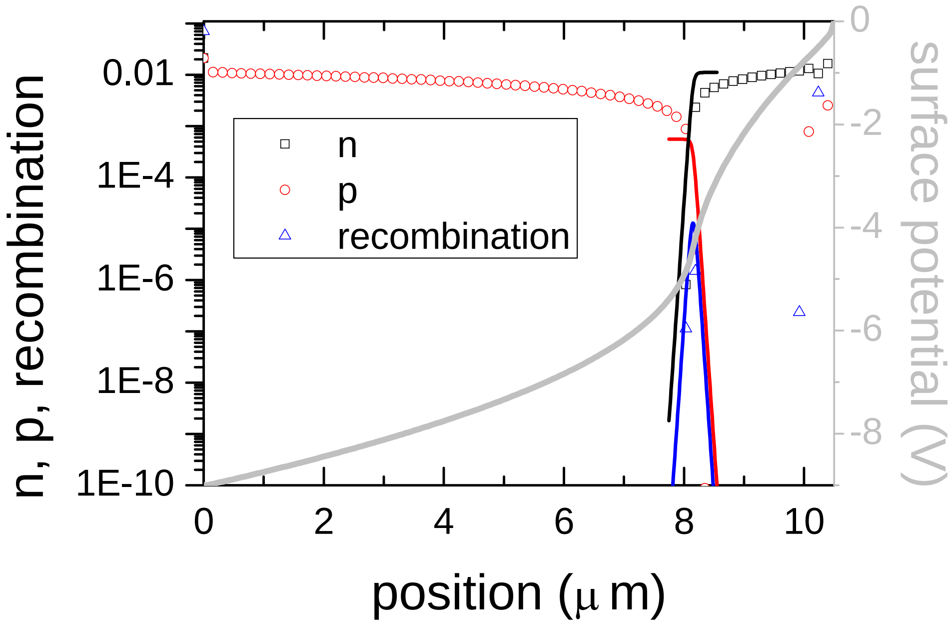




Theoretical Predictions



D.L. Smith *et al*, J. Appl. Phys. **101**, 084503 (2007)



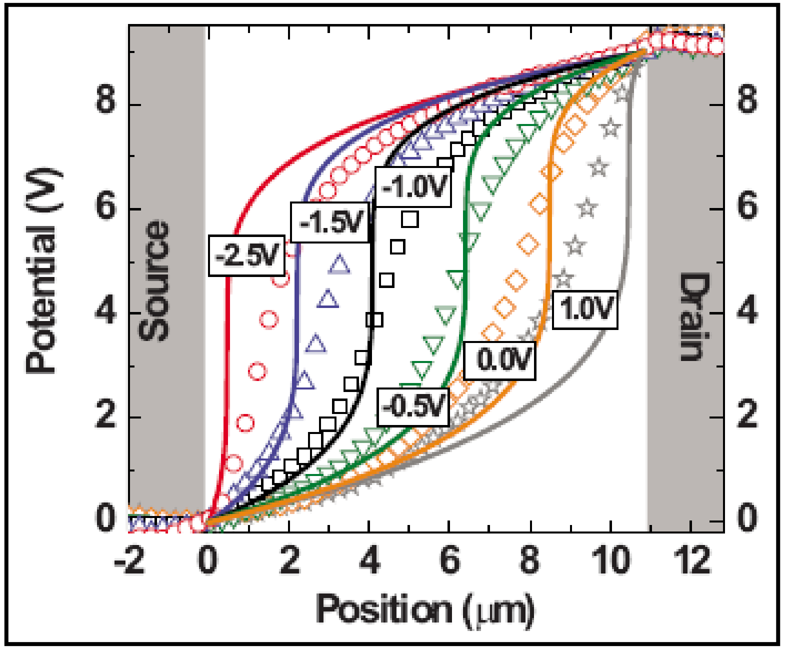
Numerical drift/diffusion model
vs. Analytical drift-only model
(recombination according to Langevin)

Martijn Kemerink

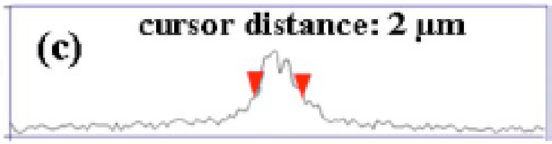
Full Width at Half Maximum $\boxed{\text{FWHM} \sim 20 - 200 \text{ nm}}$

Experimental Results

Scanning Kelvin Probe Microscope
NiDT



Confocal microscope / High fields
PPV



J.S. Swensen *et al*, J. Appl. Phys. **102**, 013103 (2007)

E.C.P. Smits *et al*, Phys. Rev. B **76**, 125202 (2007)

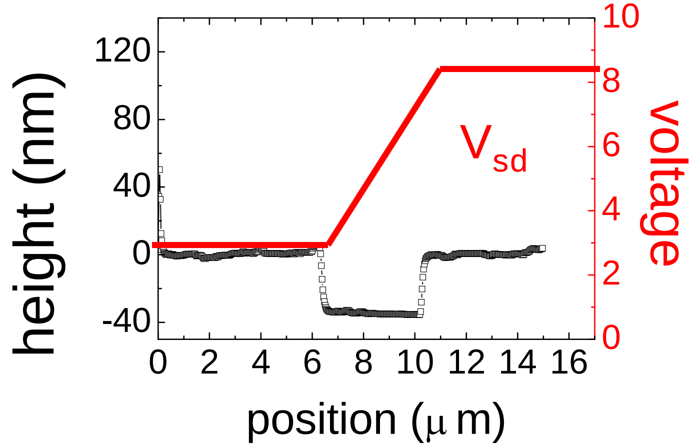
FWHM ~ 2 µm

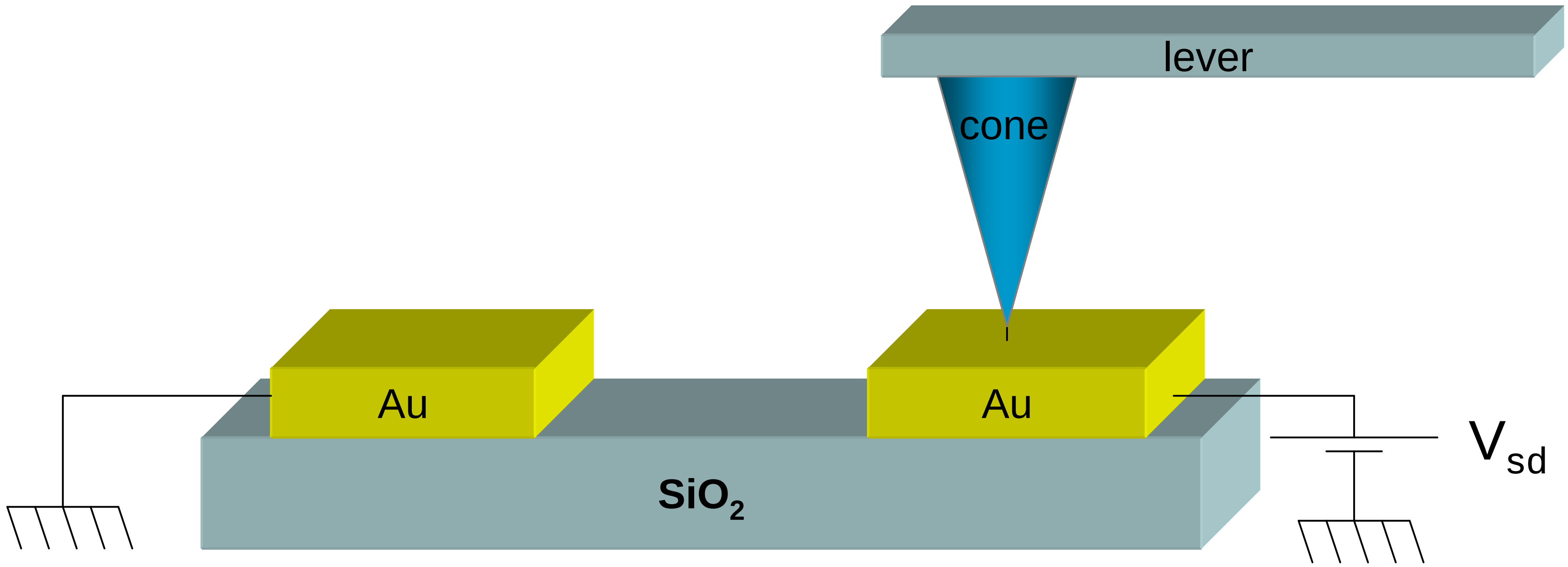
Scanning Kelvin Probe Microscope = SKPM

Interleave mode

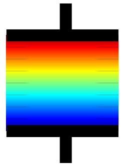
-Atomic Force Microscope in tapping mode

-Surface potential at Lift Height Z_L





Principle: First Harmonic Force Microscope



$$F = -\frac{V^2}{2}\frac{dC}{dz}$$

F = force between tip and sample
V = tip-sample voltage difference
C = capacity between tip and sample

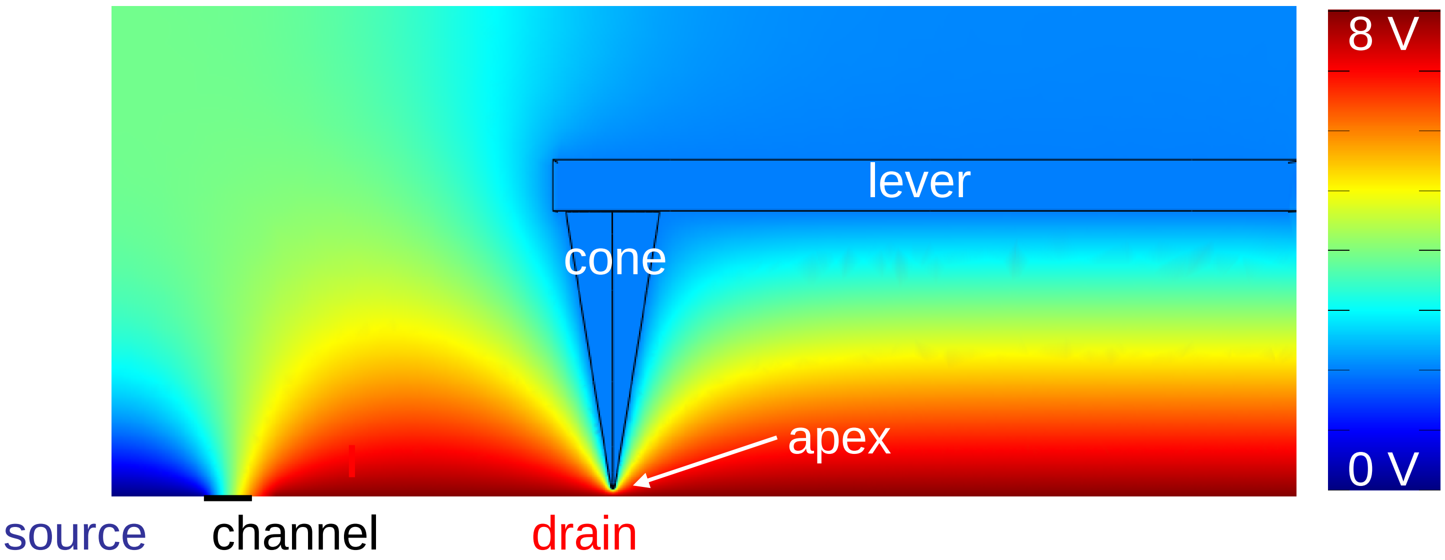
$$V = V_{dc} + V_{ac}\sin(\omega t) - V_{cpd}$$

$$F = F_{dc} + F_{\omega}\sin\omega t + F_{2\omega}\cos 2\omega t$$

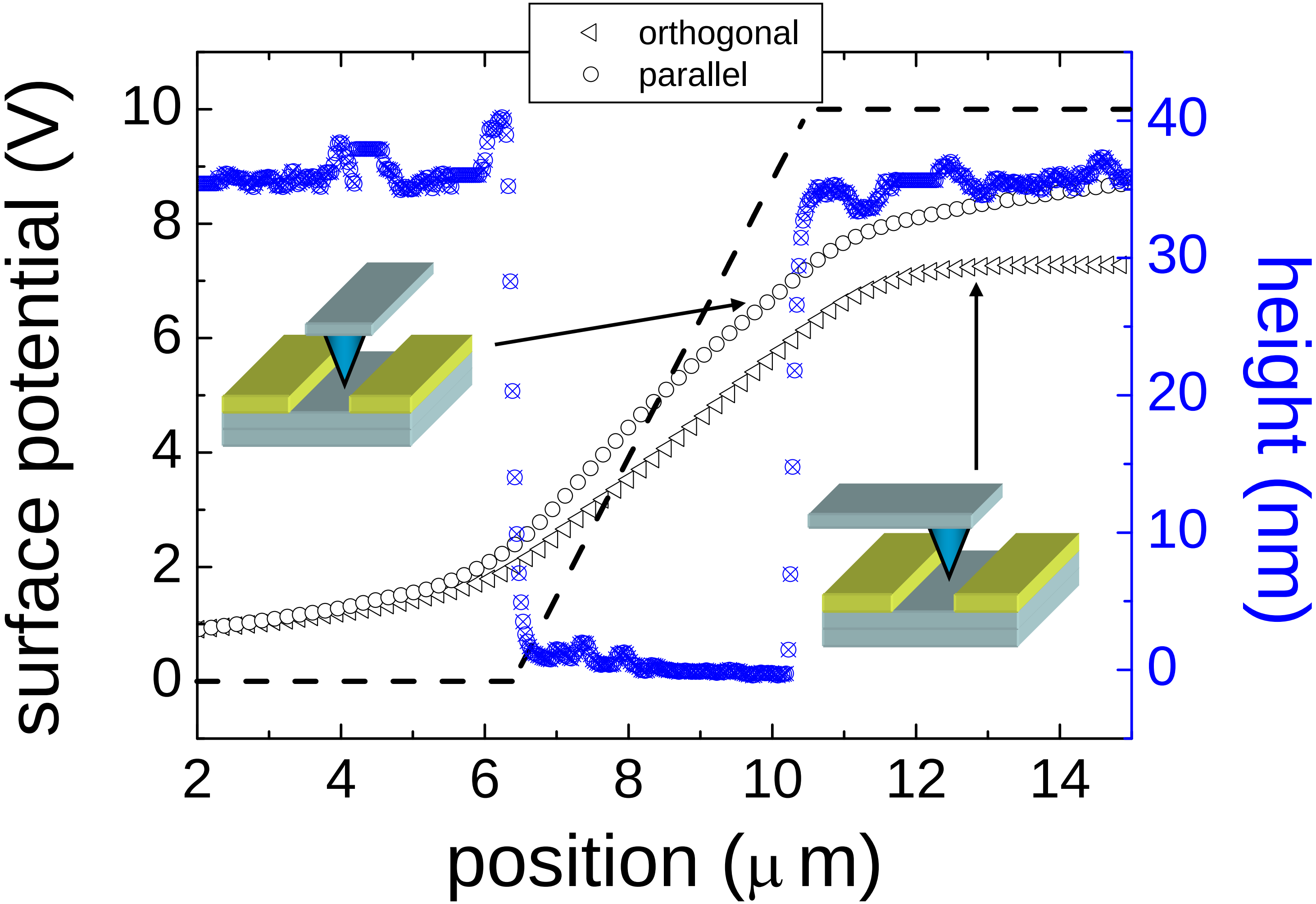
V_{dc} = *tip voltage*
V_{ac} = *amplitude voltage*
V_{cpd} = *contact potential difference*

$$F_{\omega} = \frac{dC}{dz}V_{ac}(V_{cpd} - V_{dc})$$

Then $V_{cpd} = V_{dc}$
For F_{ω}=0



Instrumental Problem: SKPM Response

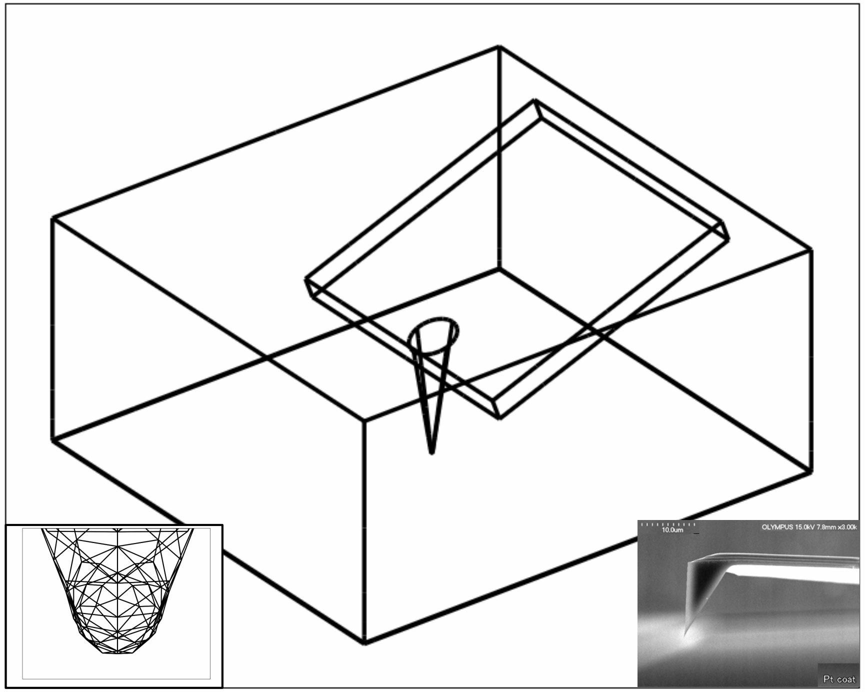


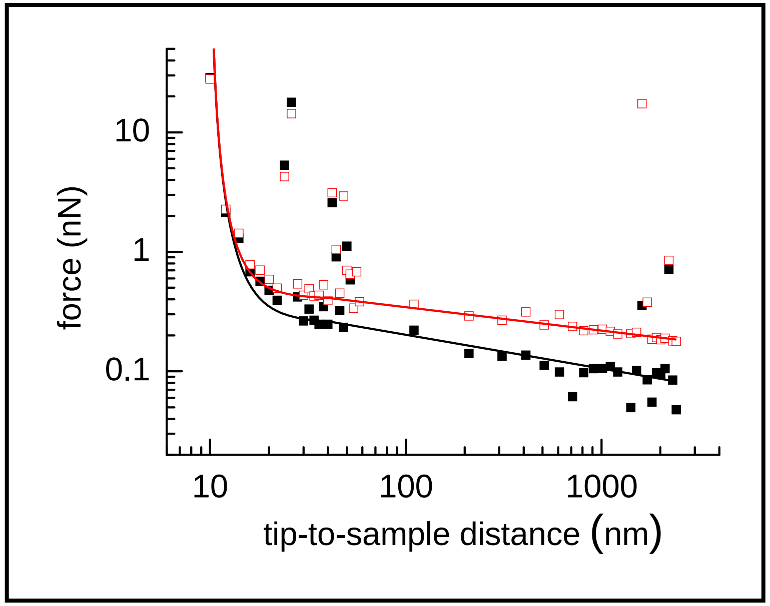
Problems:

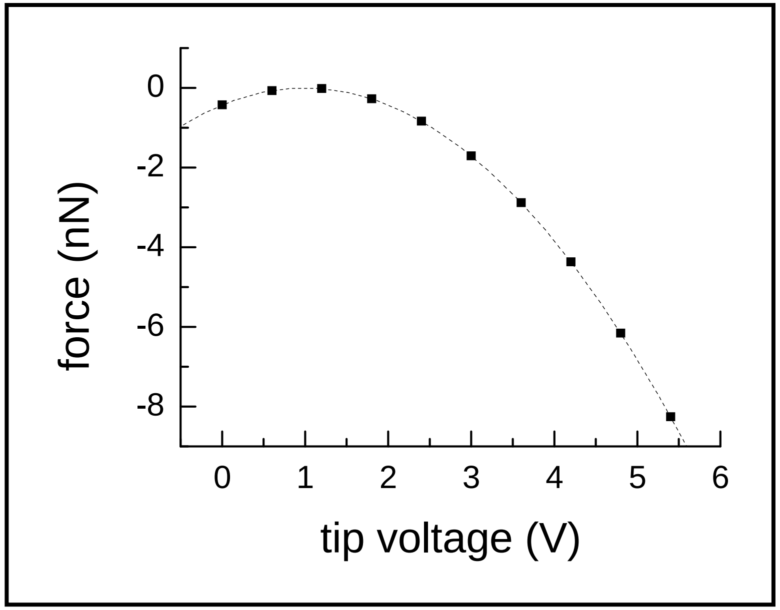
- Asymmetry
- Rounding
- Magnitude

SKPM Response 3D Model

Simulated
with Finite Element Program
(COMSOL)

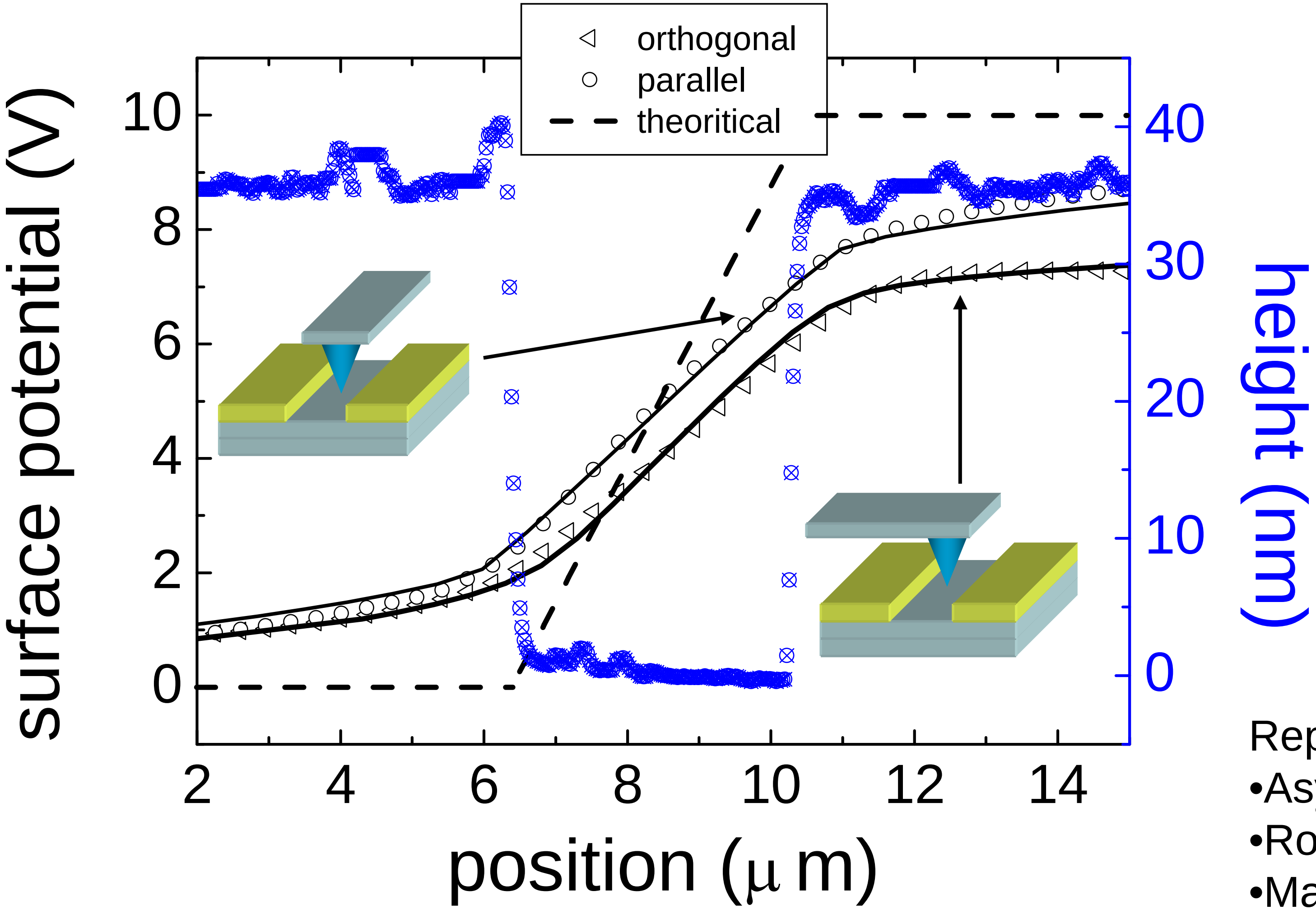






Scattering = meshing limitation

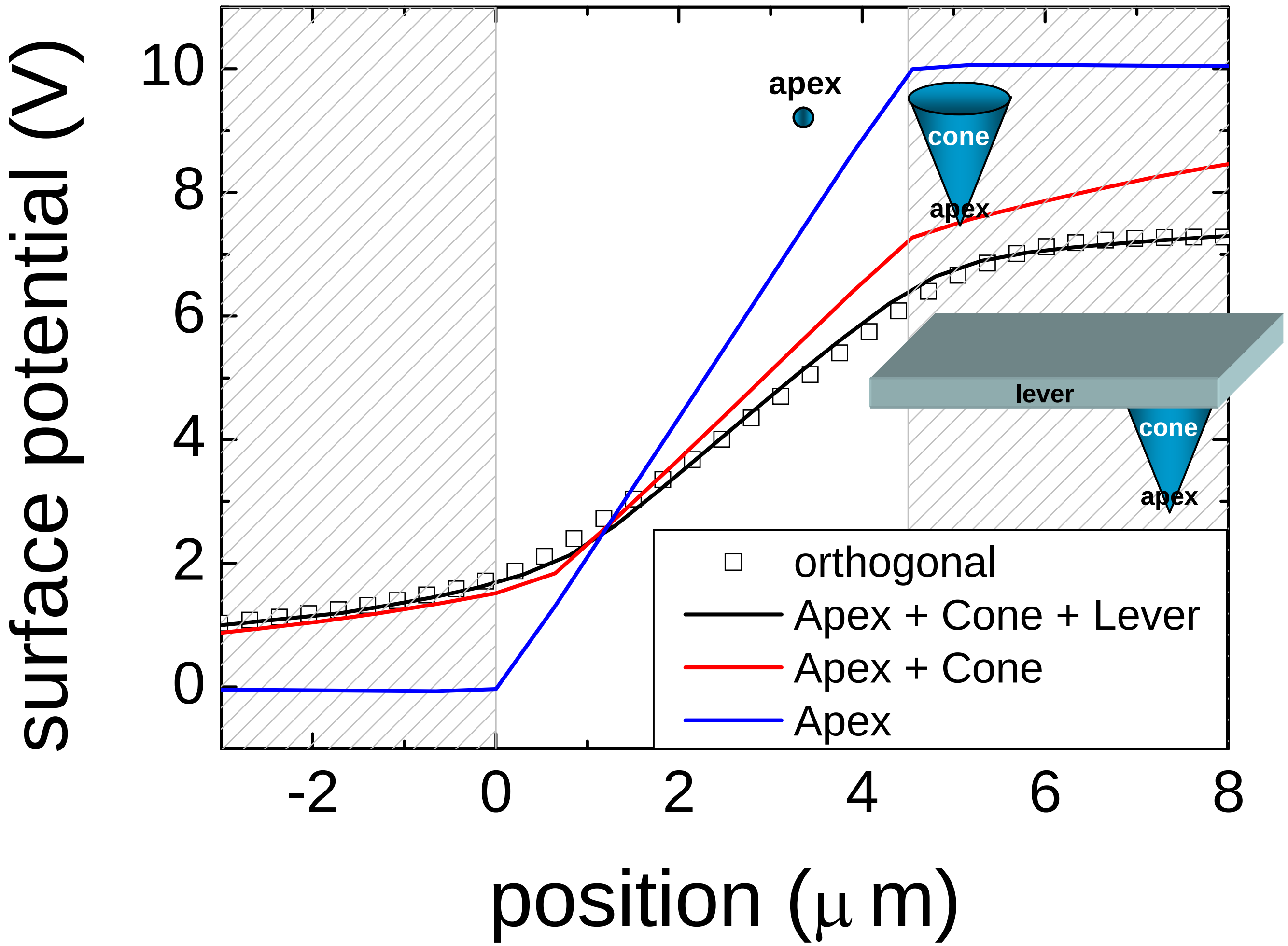
Calculated SKPM Response



Reproduced features:
- Asymmetry
- Rounding
- Magnitude

D. Charrier *et al*, ACS Nano **2**, 622-626 (2008)

Tip = Apex + Cone +Lever

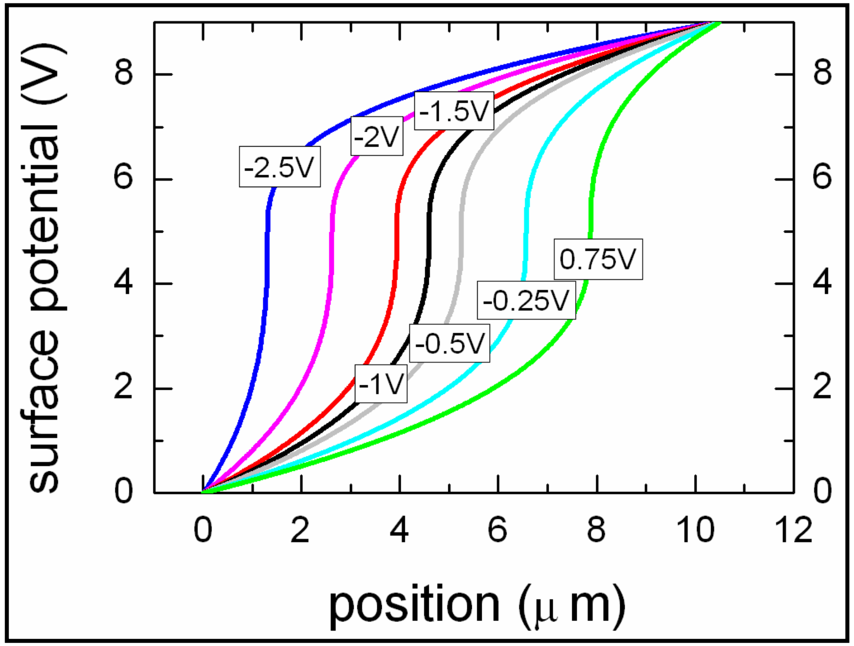


- Apex = perfect probe
- Cone = magnitude + rounding
- Lever = asymmetry

D. Charrier *et al*, ACS Nano **2**, 622-626 (2008)

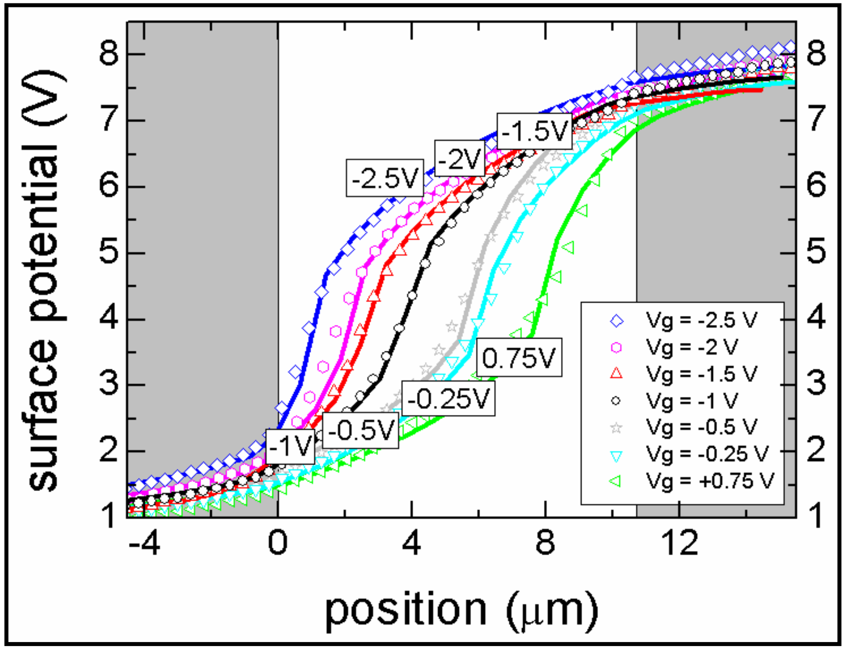
SKPM Response for FET

Theoretical predictions (drift) from Smits
= input of SKPM modeling



Assumption:
FWHM = “0” nm

SKPM
experiments + modeling

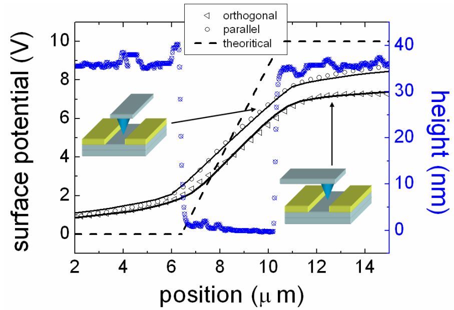


‘real’ FWHM < 0.5 micron

Note: We checked that the SKPM probe influence only few % the source drain current.

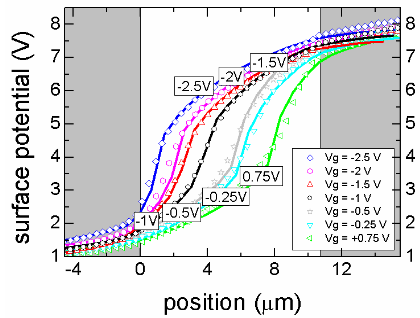
M. Kemerink, D. Charrier *et al*, submitted

Conclusions



•Identified the full problem of SKPM response:

Developed a numerical model to predict the SKPM response from any theoretical potential.



•FWHM recombination:
- •theoretical (Langevin) ~ 200 nm
- •experimental SKPM response
  - •raw ~ 2.1 µm
  - •difference with model < 0.5 µm

•SKPM is not optimal for investigating the recombination width.

Thanks to

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