Nanoelectronics in the NCN

Supriyo Datta

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NANOELECTRONICS: Broad Vision

to develop a general framework for relating atomic structure to device and circuit level performance.

- **Conceptual Understanding**
- **Practical Approaches**
- **Educational Resources**
- **Simulation Tools**
- **Professional Leadership**

NANOELECTRONICS: Concrete Projects

to develop a general framework for relating atomic structure to device and circuit level performance.

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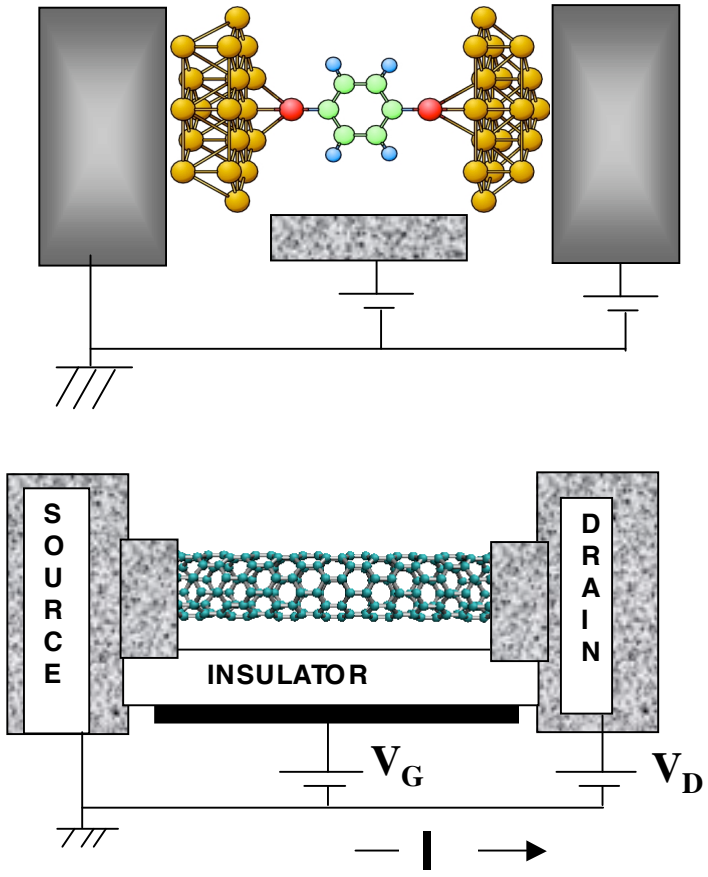
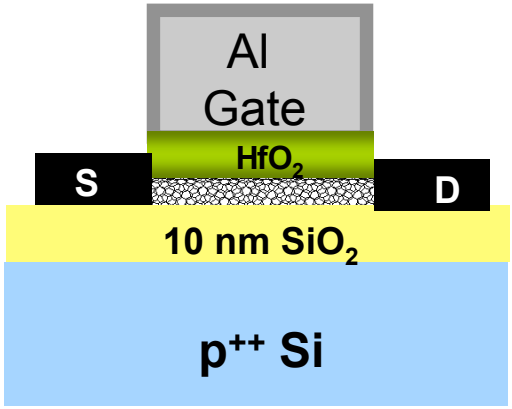
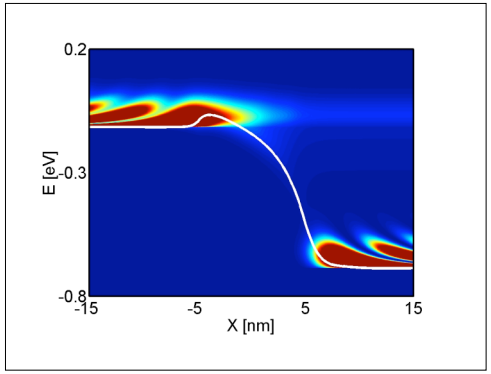


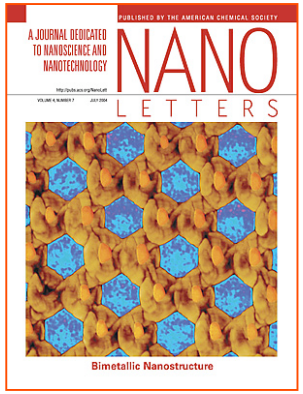
- Cho (contacts)
- Datta (basic theory)
- Lundstrom (devices)
- Leburton (phonons)
- Klimeck (software)
- Roy (circuits)
- Dai (experiments)

Carbon nanotube electronics





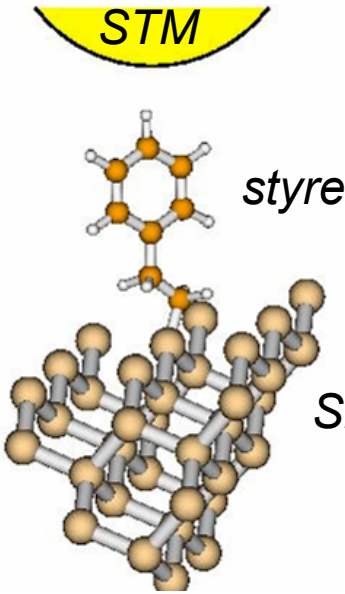
Dai / Lundstrom
Javey / Guo

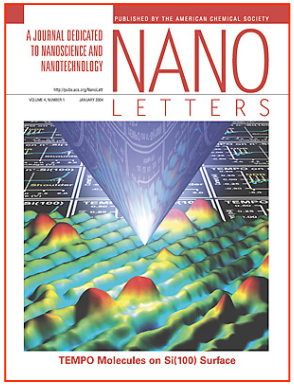


July 2004

- Ratner (chemistry)
- Datta (basic theory)
- Klimeck (software)
- Roy/Lundstrom (circuits)
- Hersam (experiments)

Molecular electronics on Si

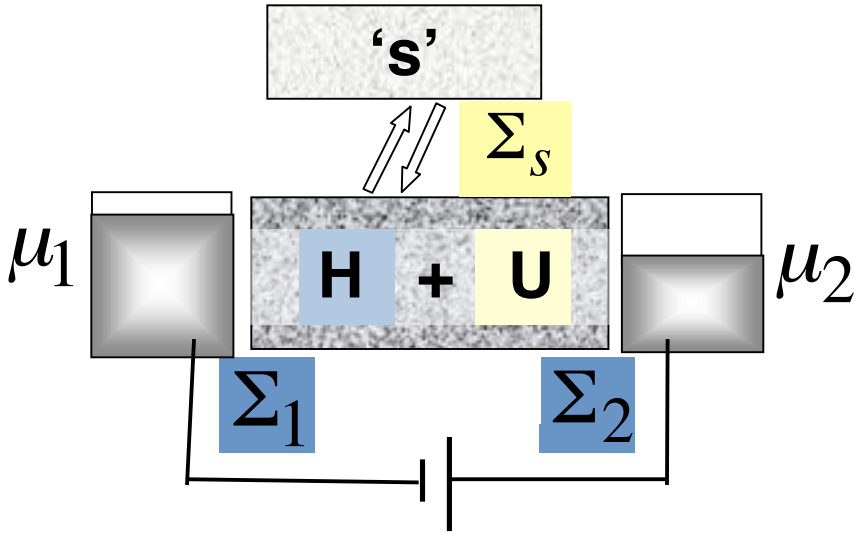




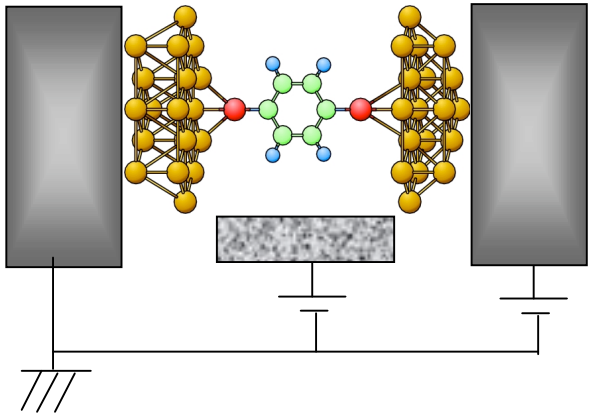
January 2004

Nanodevices: A Unified View

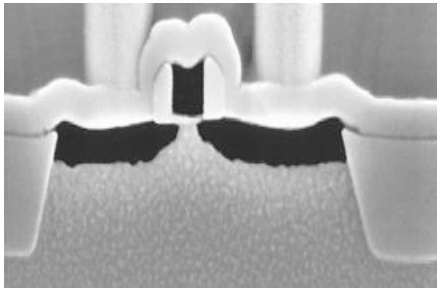
Unified Model



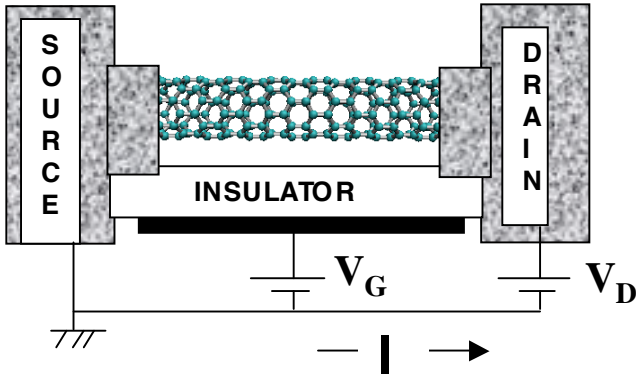
Molecular Electronics



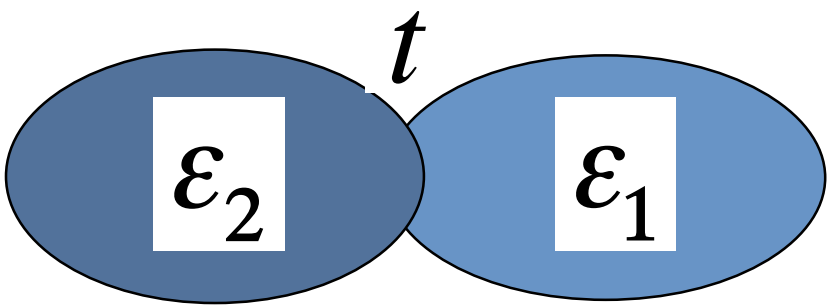
MOSFET's



CNT Electronics

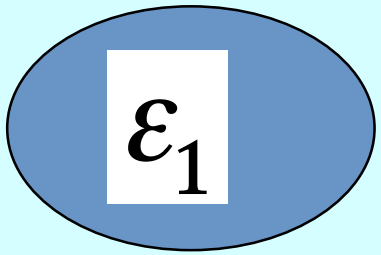


Σ : A toy example



$$\begin{bmatrix} E-\varepsilon_1 & -t \\ -t & E-\varepsilon_2 \end{bmatrix}$$

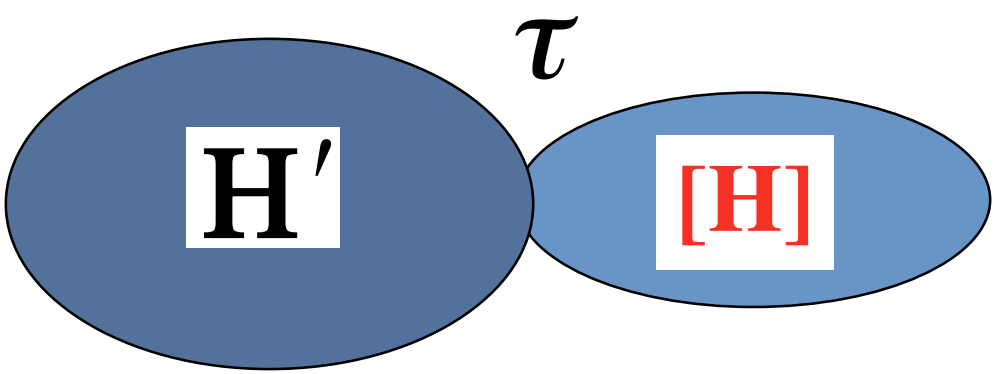
$$\frac{t^2}{E-\varepsilon_2} = \Sigma$$



$$\Sigma$$

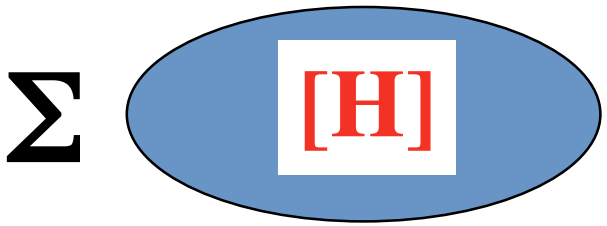
$$\left[E-\varepsilon_1-\frac{t^2}{E-\varepsilon_2}\right]$$

Σ "Self-energy"



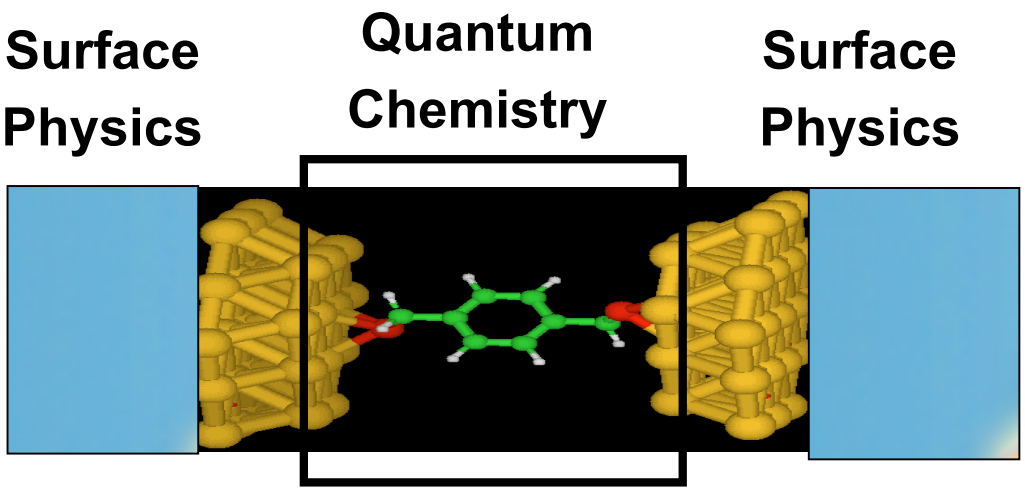
$$\begin{bmatrix} \mathrm{H} & \tau \\ \tau^{+} & H' \end{bmatrix}$$

$$\Sigma = \tau \left[\mathrm{ES} - \mathrm{H}' \right]^{-1} \tau^{+}$$



$$\left[H + \Sigma \right]$$

Bridging Disciplines

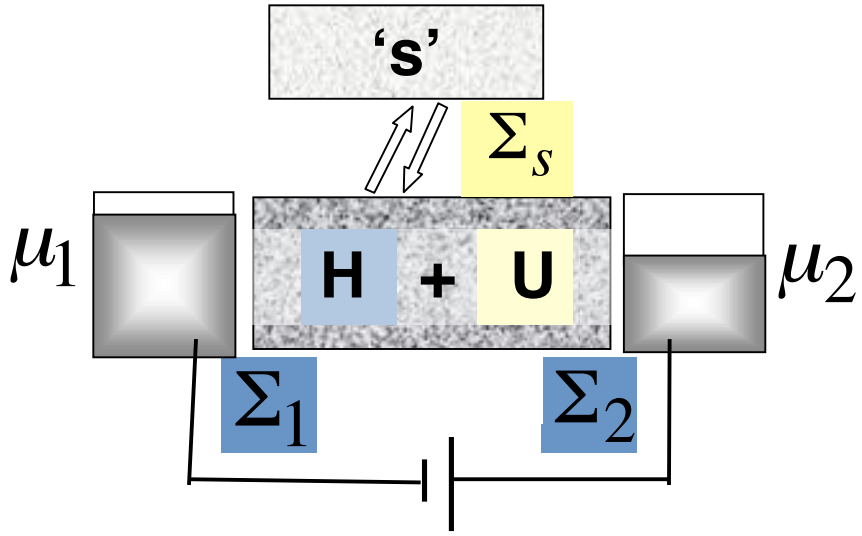


$$\Sigma(c,c) = \tau(c,p)\, g(p,p)\, \tau^{+}(p,c)$$

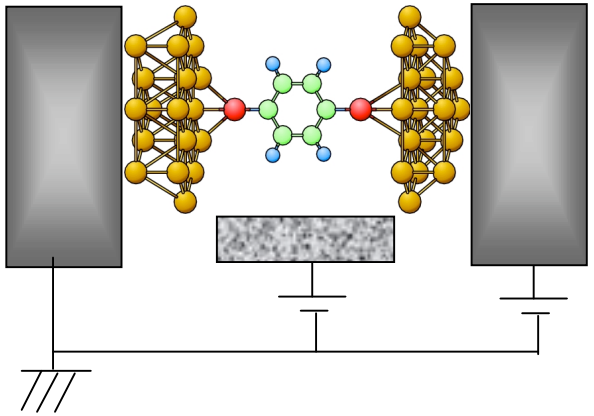
Avik Ghosh, Albert Liang, Diego Kienle, Eric Polizzi

Quantum Transport: A Unified Approach

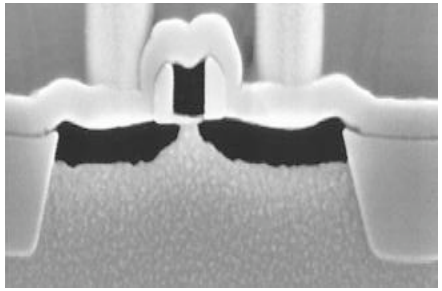
Unified Model



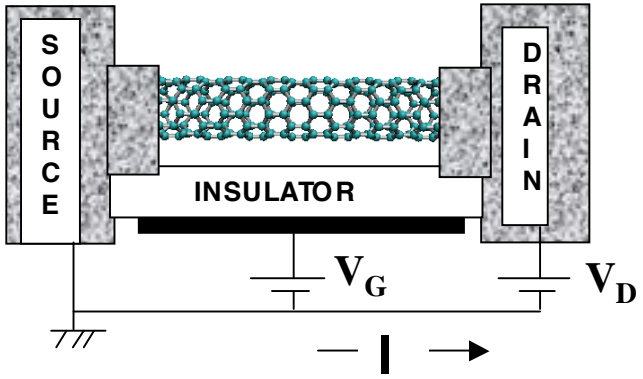
Molecular Electronics



MOSFET's



CNT Electronics



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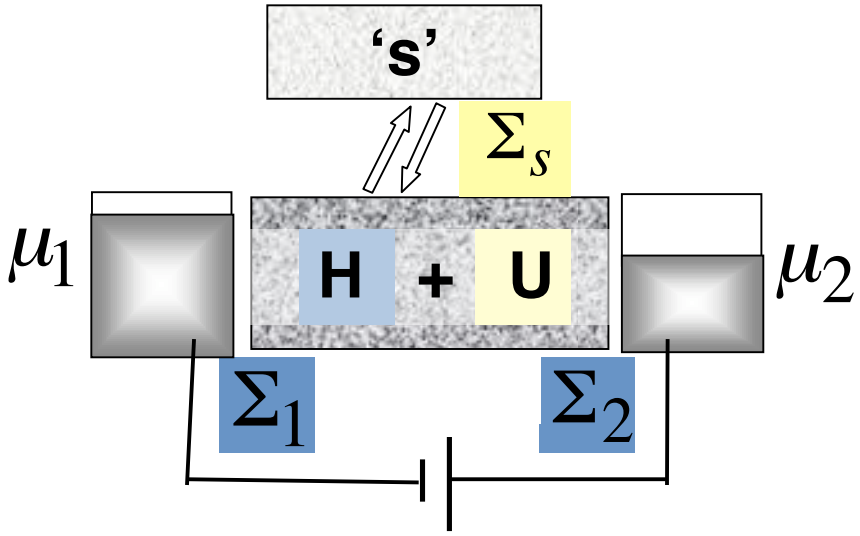

to develop a general framework for relating atomic structure to device and circuit level performance.

- Conceptual Understanding
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- Educational Resources
- Simulation Tools
- Professional Leadership

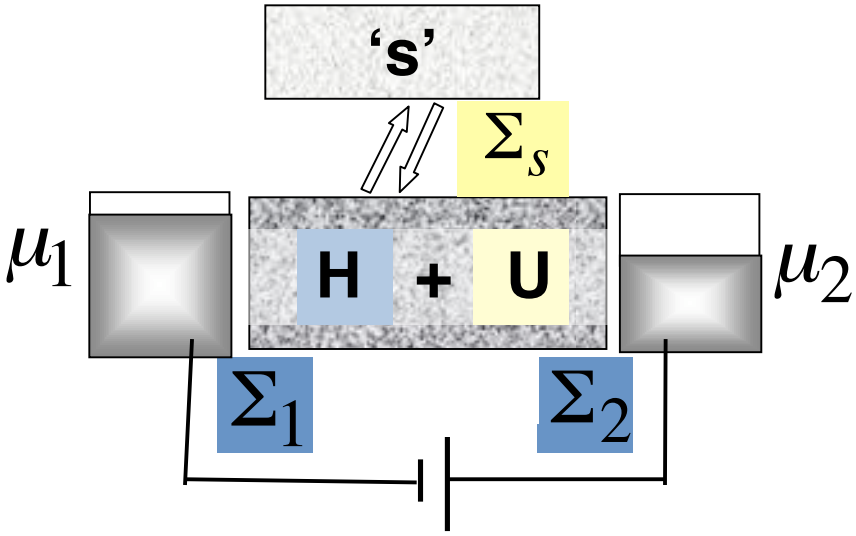
Ferdows Zahid

Tehseen Kazmi

Michael McLennan

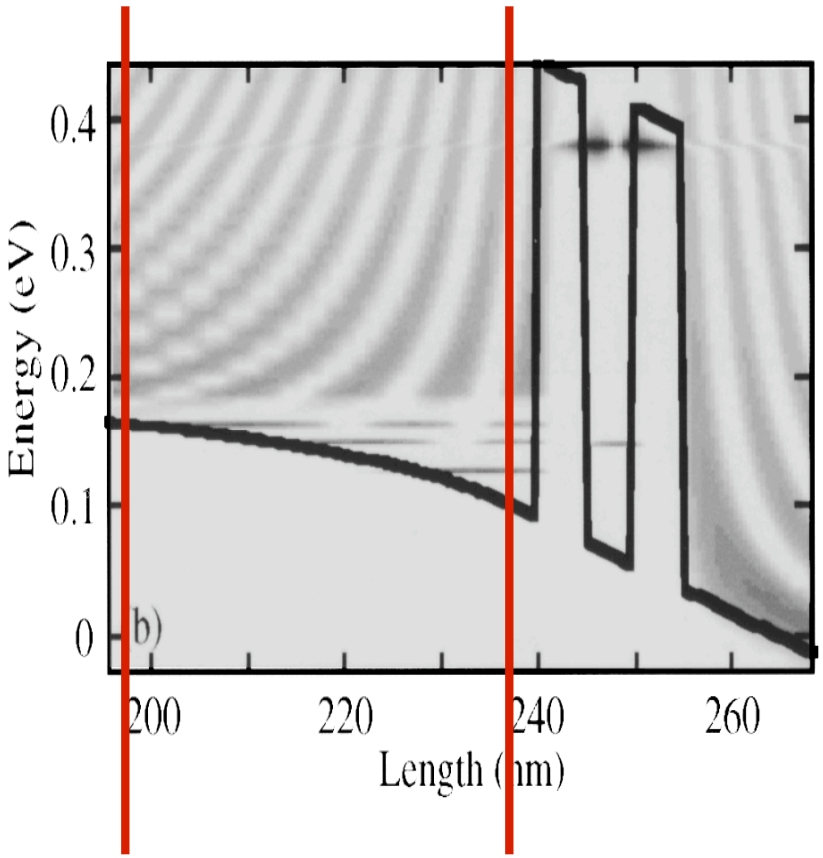
What is a contact?

Unified Model

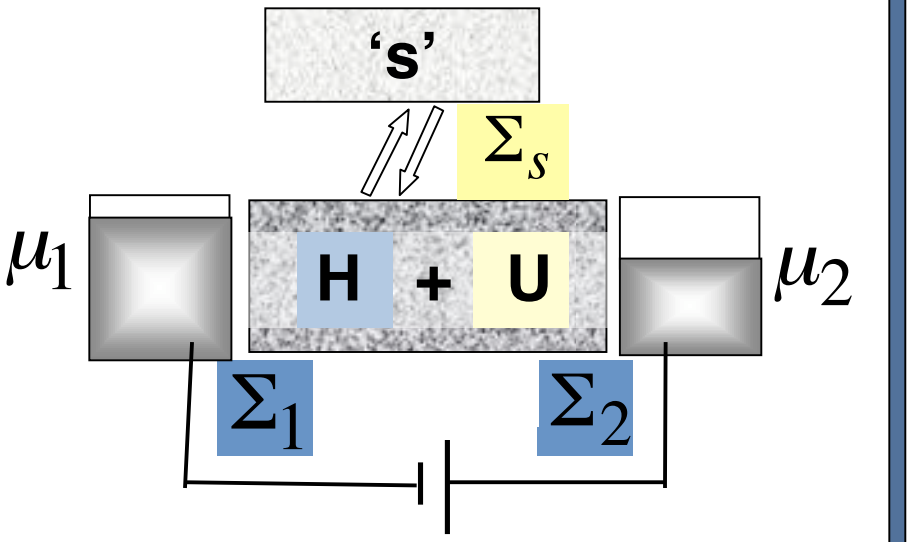


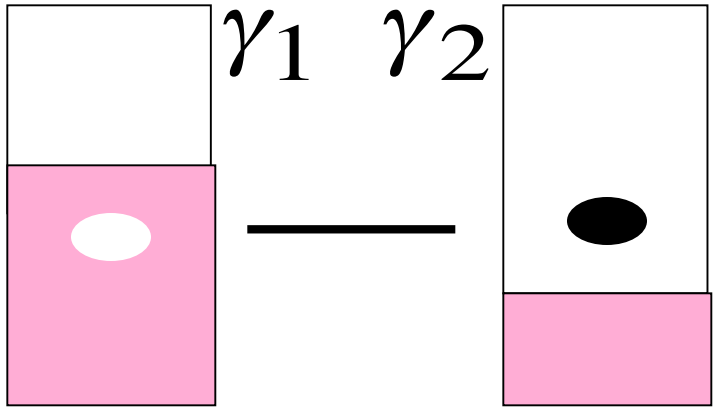
Klimeck, Lake et.al.

APL (1995)



Unified Model





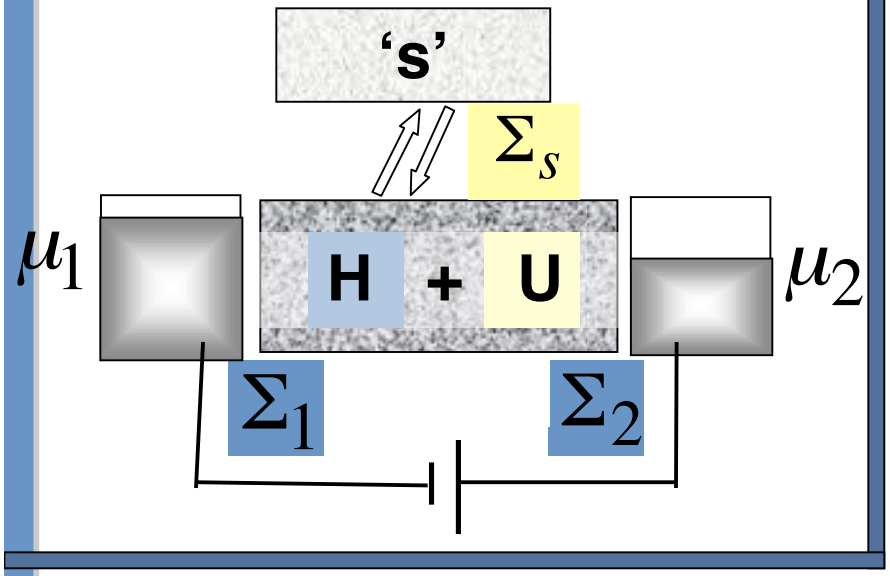
Energy has to be removed efficiently

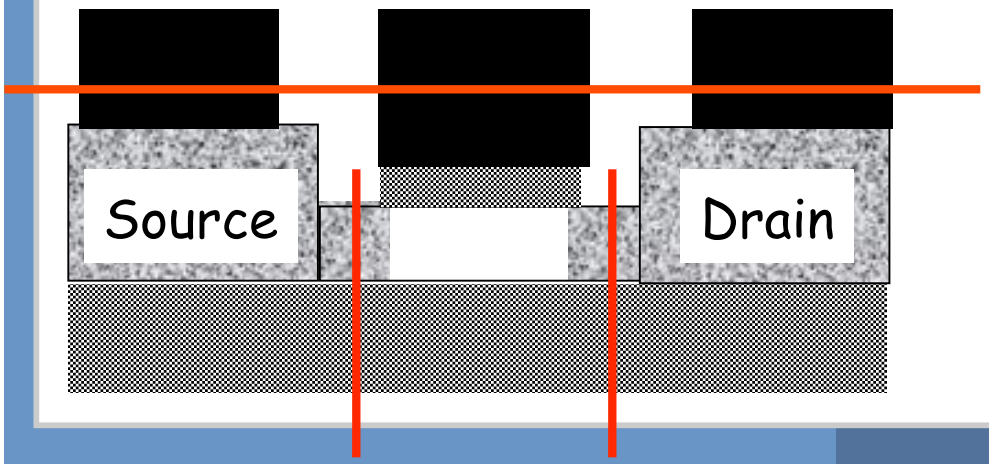
from the contacts: otherwise

--> "hot" contacts

Hot "contacts"

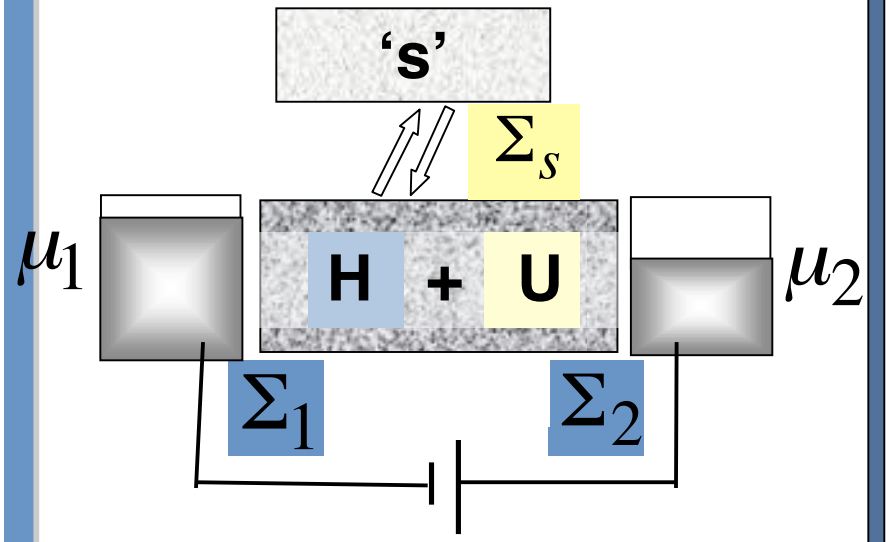
Unified Model

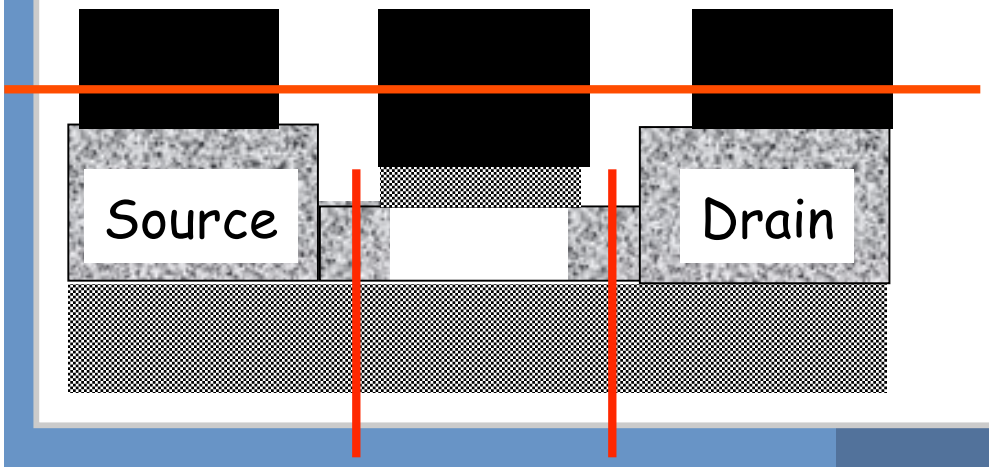




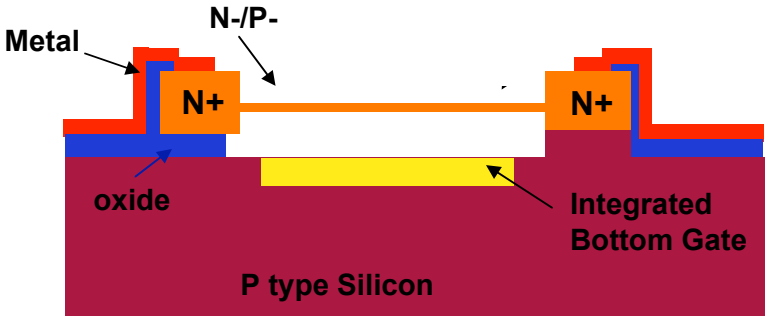
Hot "contacts"

Unified Model

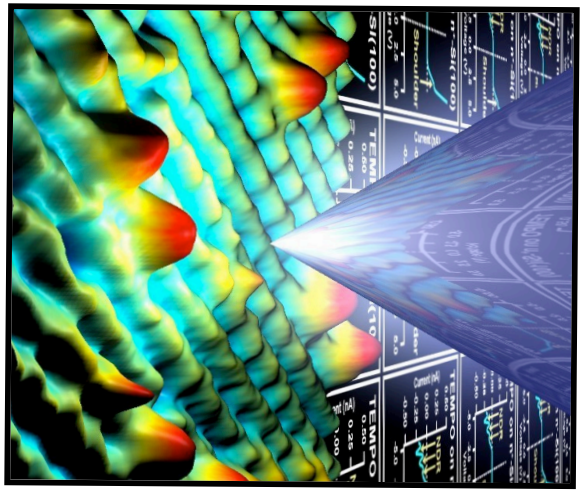




Hot phonons ?

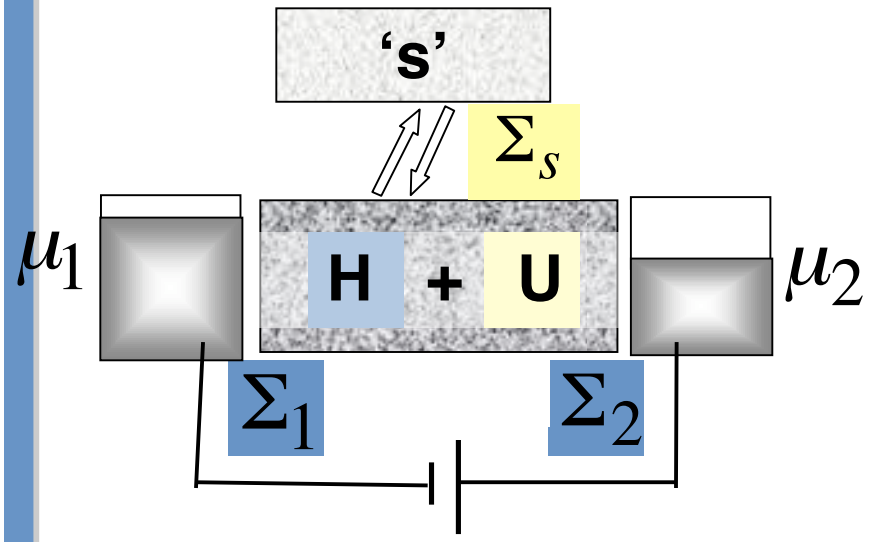


Molecular desorption ?



Modeling "hot contacts"

Unified Model



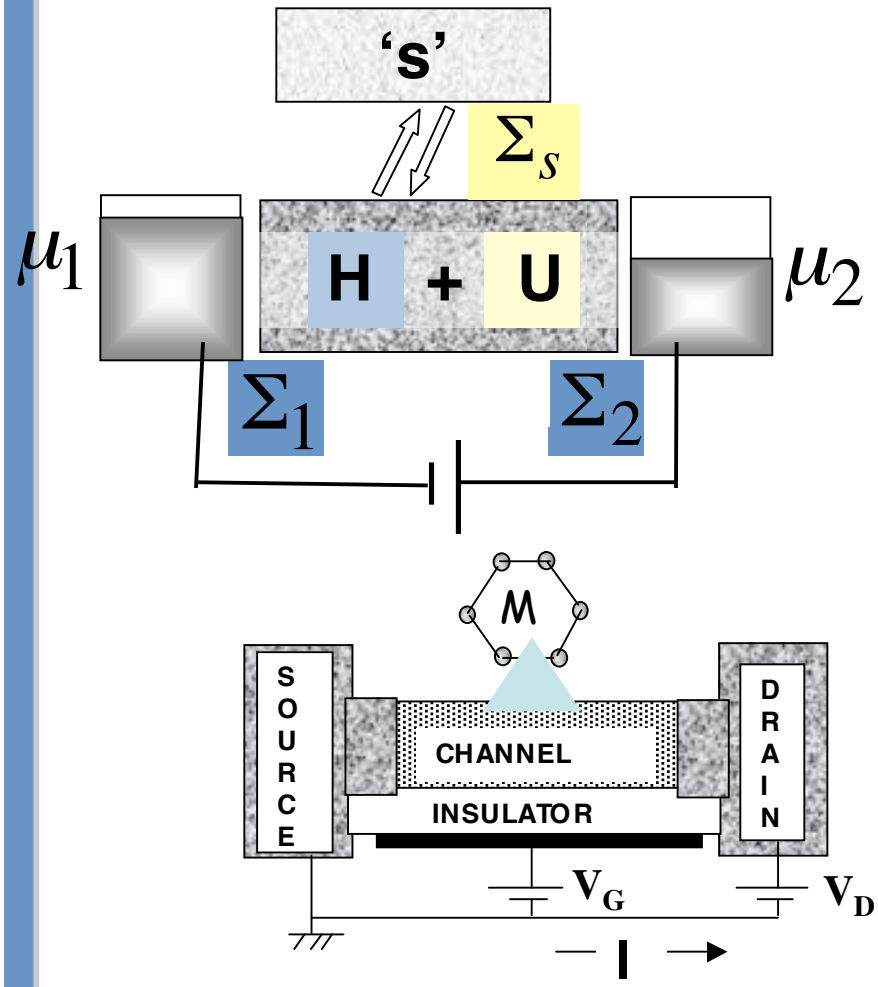
Supplement device equations with

separate equation

for "contact"

Modeling "hot contacts"

Unified Model



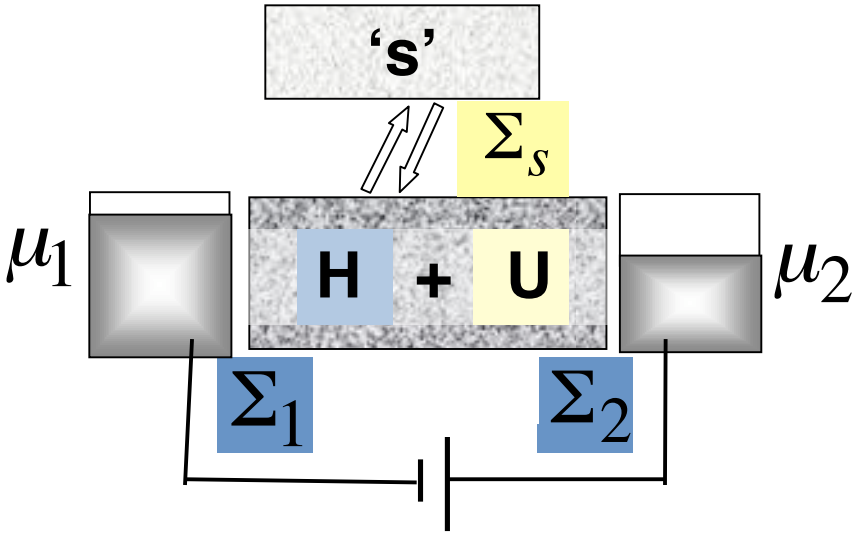
Supplement device equations with *separate equation* for "contact"

Contacts can involve different degrees of freedom:

- Mechanical
- Spin

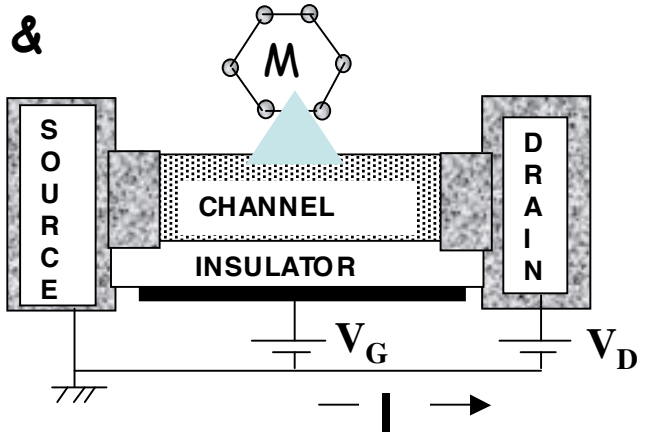
Summary

Unified Model



Electronics &

Sensing



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- Theoretical Approaches
- Educational Resources
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"Hot contacts"