



GRAND

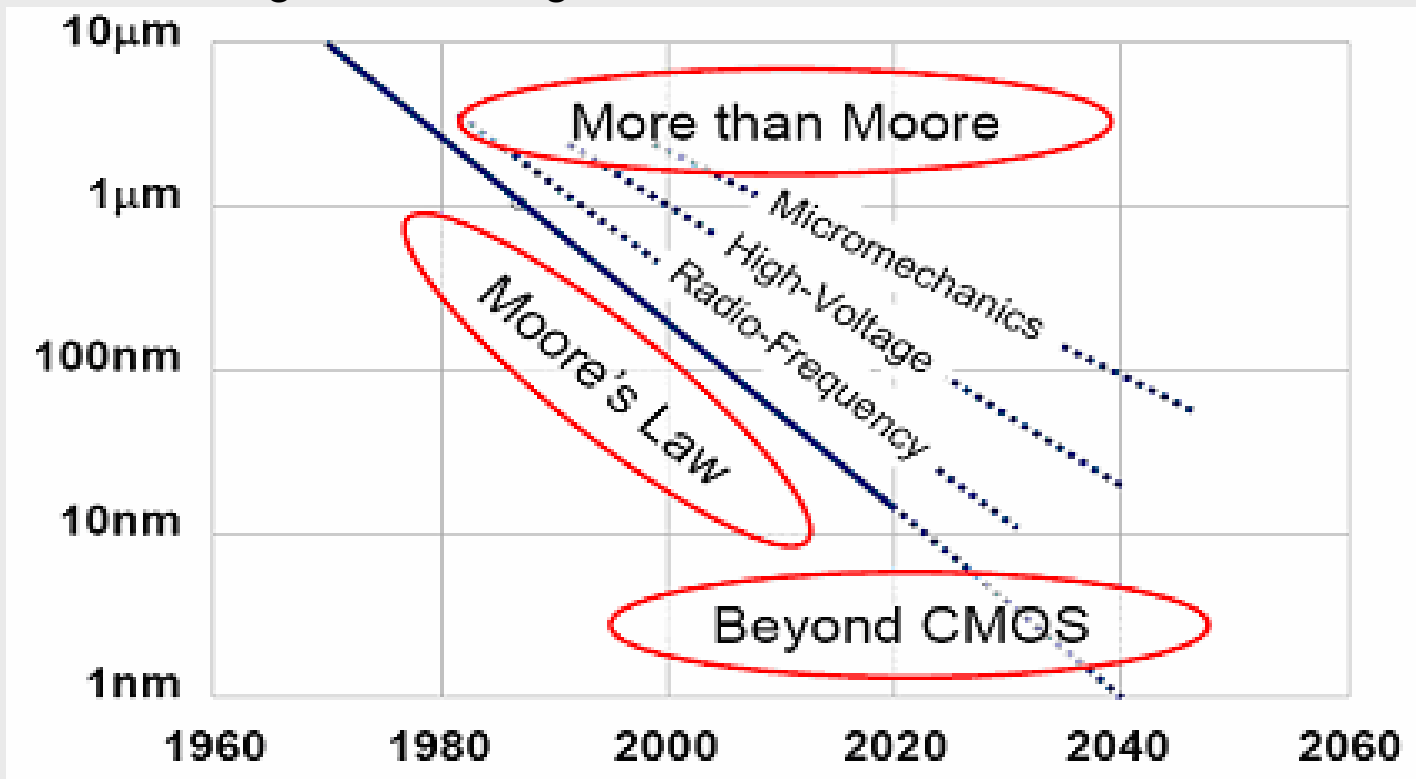
Graphene-based Nanoelectronic Devices

Small or medium-scale focused research project

01.01.2008 - 31.12.2010

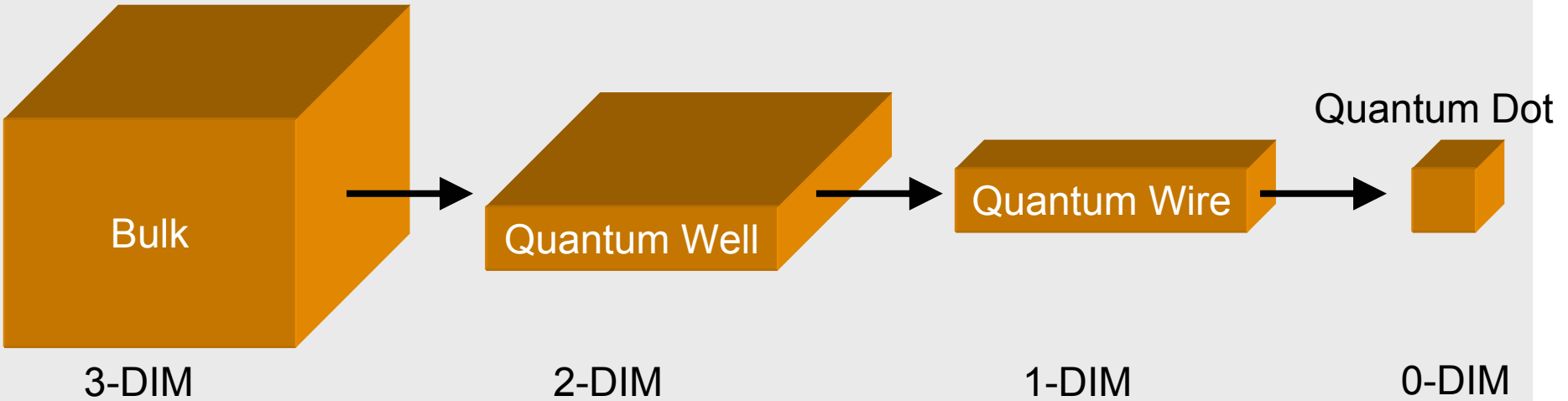
European Nanoelectronics Initiative Advisory Council (ENIAC)

1. "More (of) Moore"
2. "More than Moore"
3. **"Beyond CMOS"**
4. "Heterogeneous Integration"

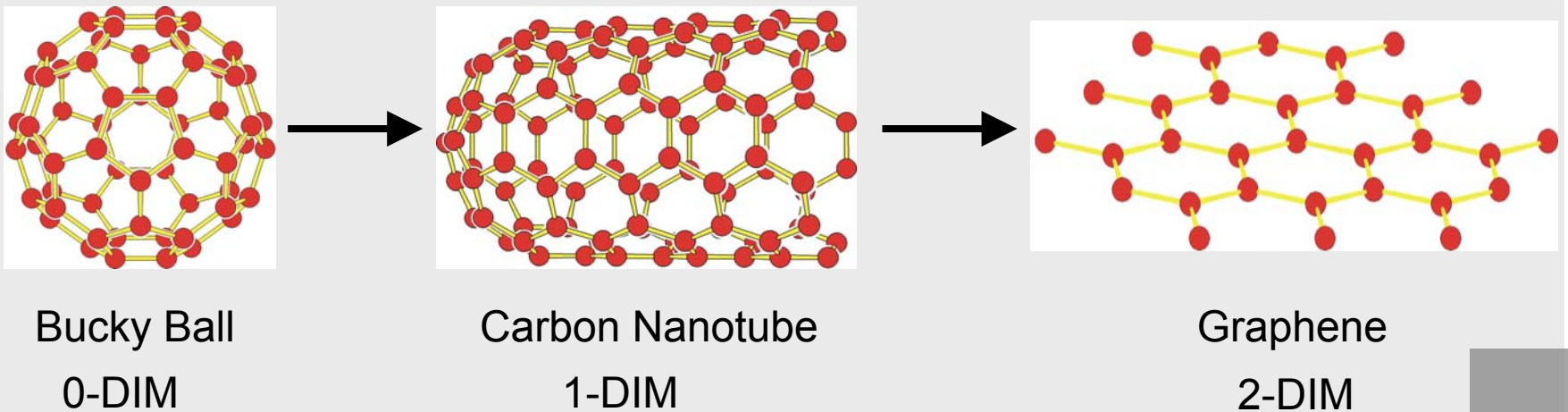


ENIAC, Strategic Research Agenda, First Update, November 2006.

Schrödinger World

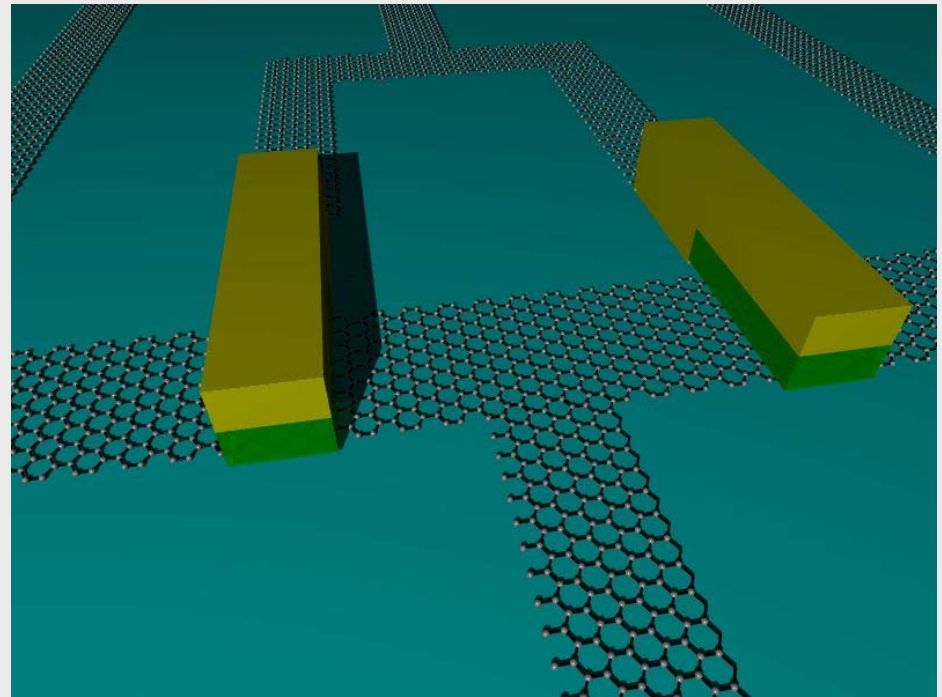


Dirac World



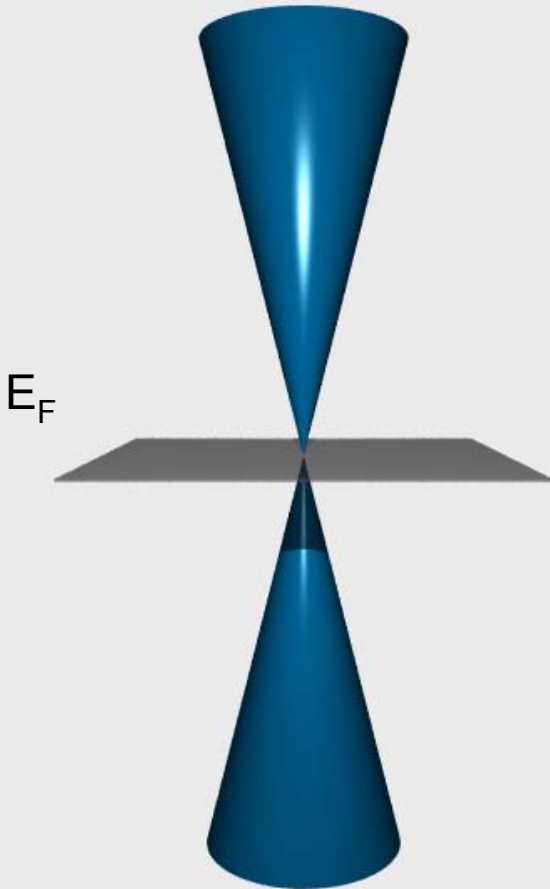
“Nano-scale ICT devices and systems”:

1. Demonstration of new concepts for **switches or memories**
2. Demonstration of new concepts, technologies and architectures for local and chip-level **interconnects**
3. Demonstration of **radically new functionalities**



Electronic properties of graphene

E-k diagram of graphene
near K-point



- Zero-gap semimetal
- Linear dispersion relation described by Dirac instead of Schrödinger equation
- Massless dirac fermions, $v \sim c/300$
- $\mu > 25.000 \text{ cm}^2/\text{Vs}$ @ 300K
- $J > 10^8 \text{ A/cm}^2$
- $L_{\text{MFP}} \sim 400\text{nm}$ @ 300K
- Transport in π -orbitals

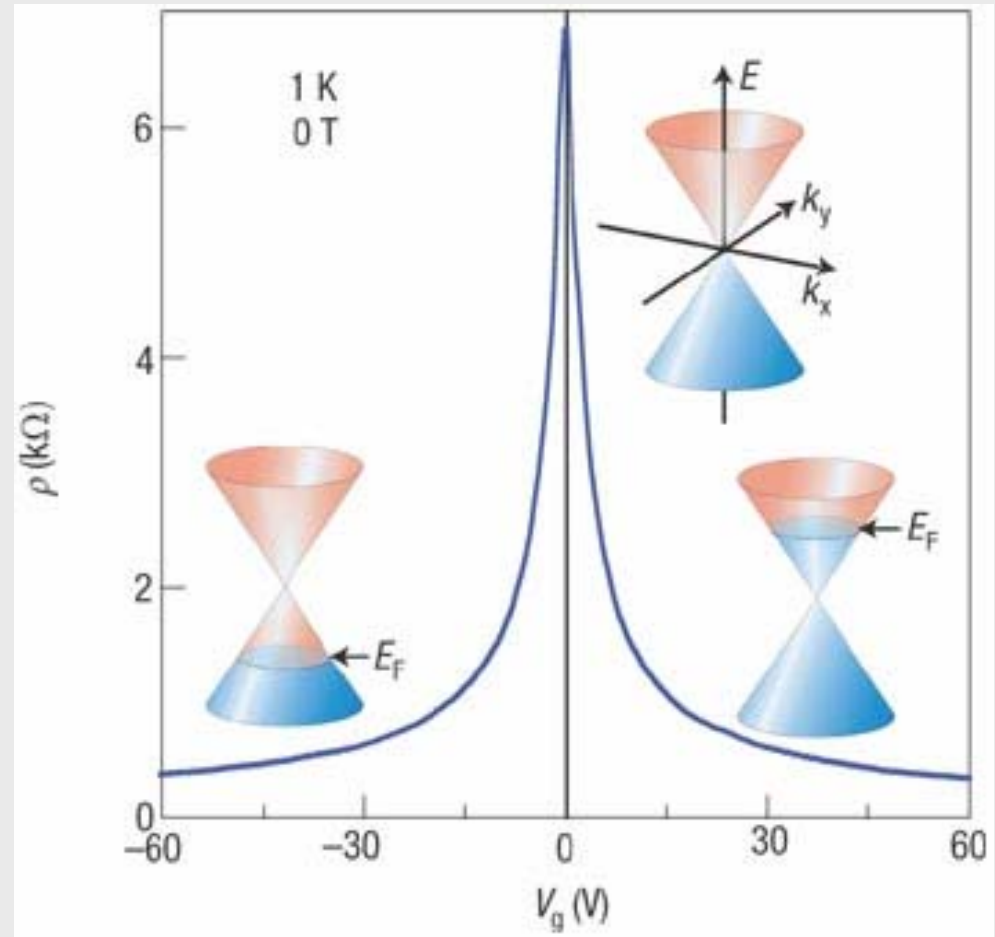
Potential for:

- High switching speeds (THz)
- Ballistic devices
- Carbon interconnects

Carriers in graphene:

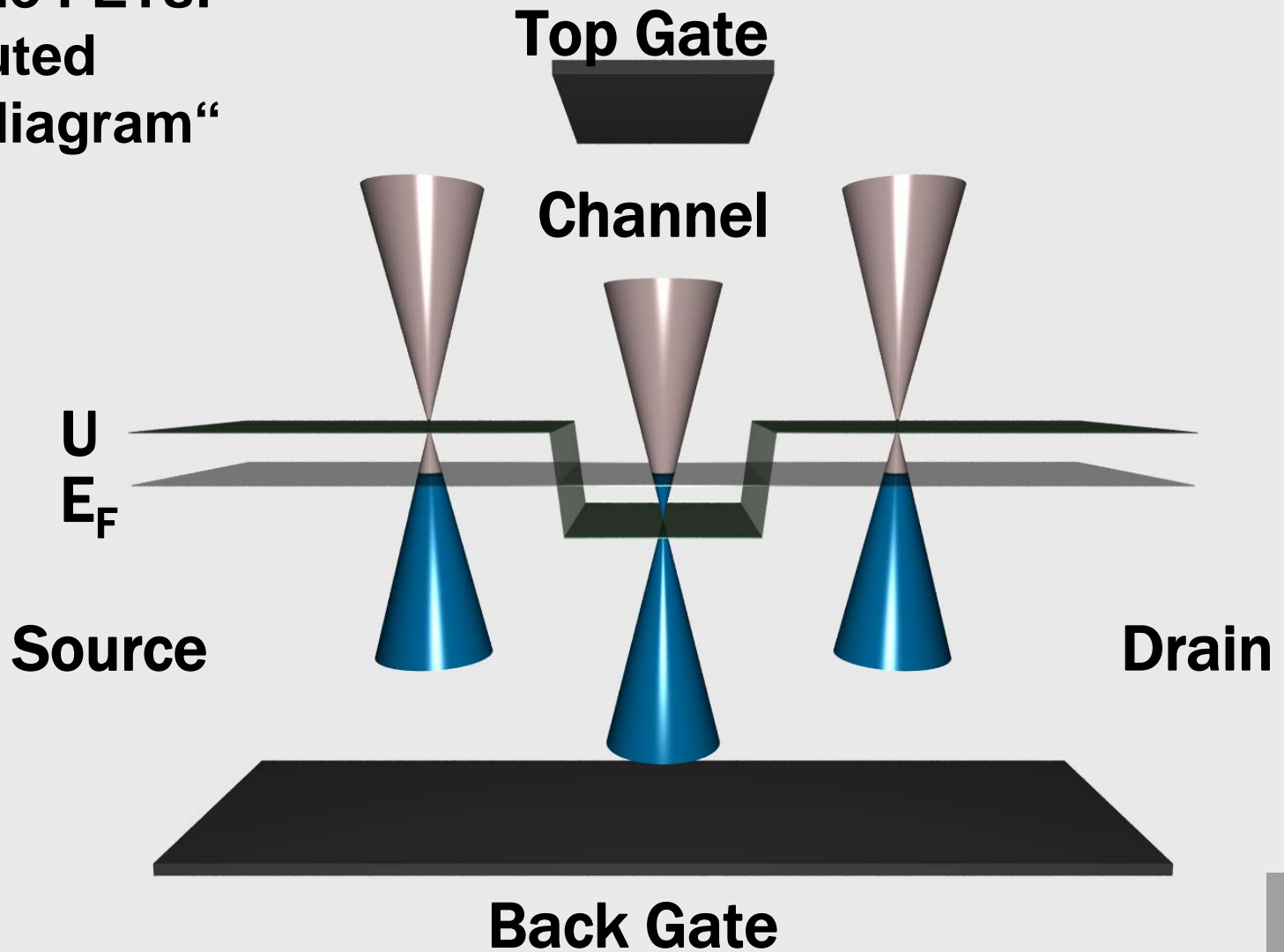
- low- E quasiparticles
- Dirac-like hamiltonian

$$\hat{H} = \hbar v_F \begin{pmatrix} 0 & k_x - ik_y \\ k_x + ik_y & 0 \end{pmatrix} = \hbar v_F \boldsymbol{\sigma} \cdot \mathbf{k},$$

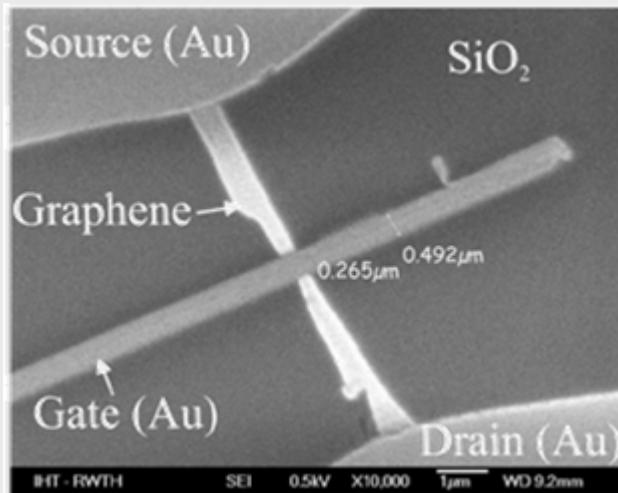


A.K. Geim, Nature Materials 6, 183 - 191 (2007)

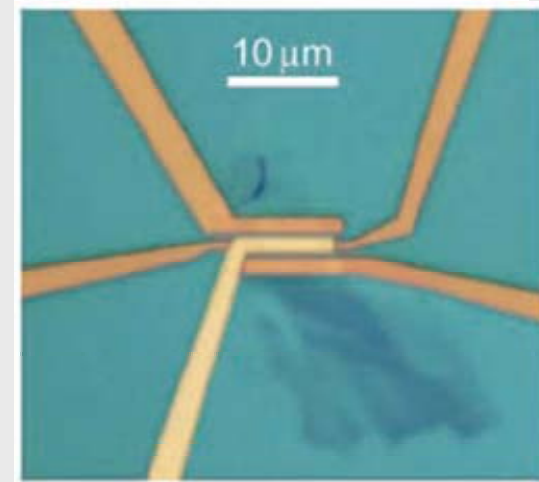
**Graphene FETs:
„distributed
E-k diagram“**



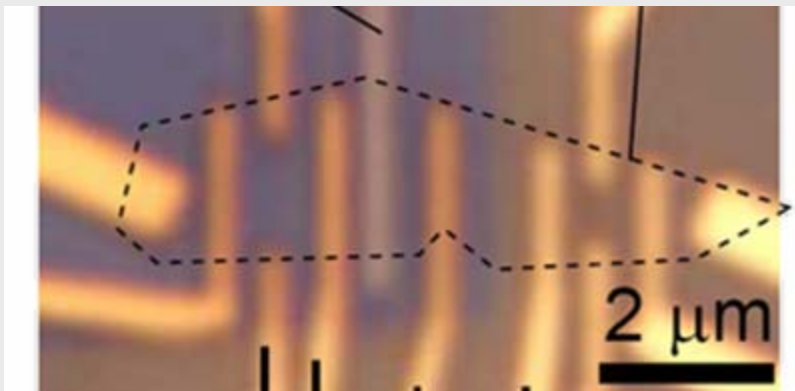
Graphene FEDs: State-of-the-Art



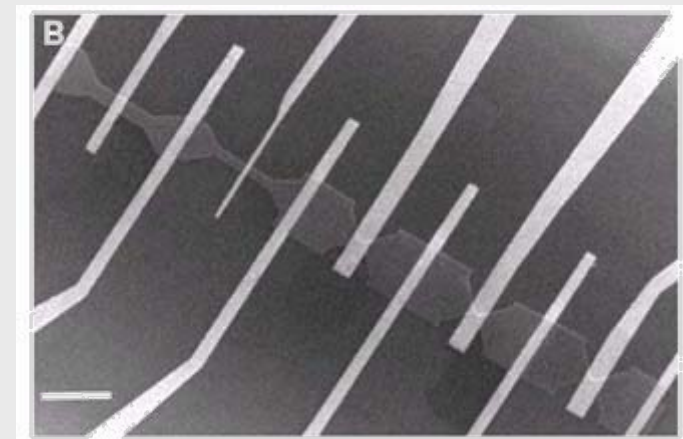
AMO: Lemme et al., IEEE EDL, April 2007



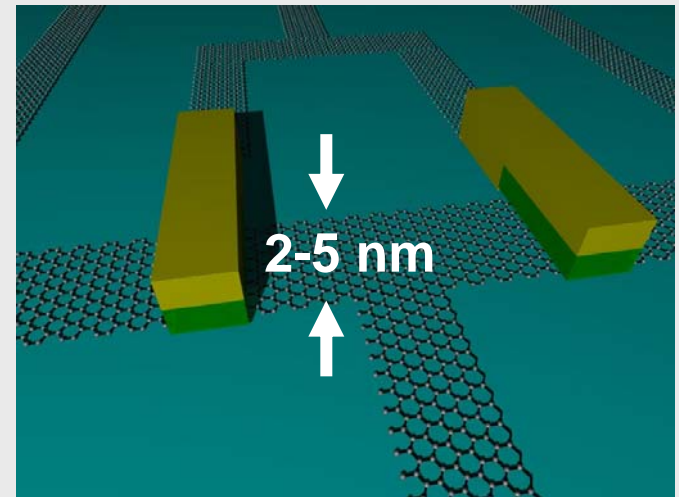
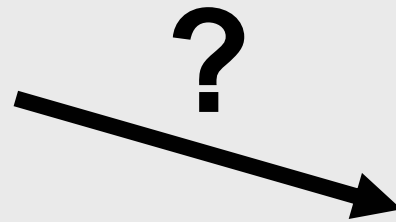
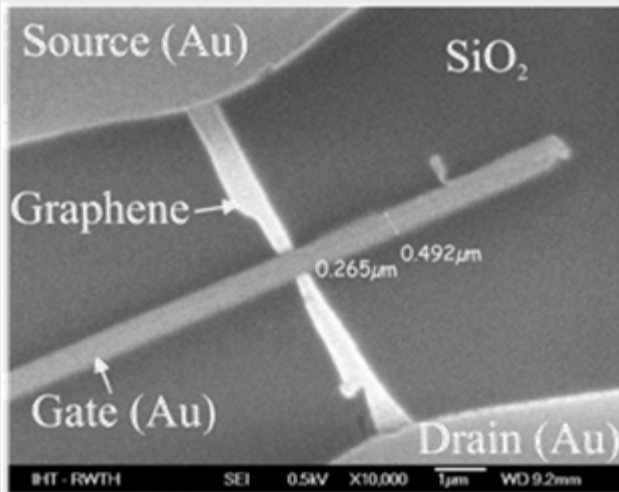
Harvard: Williams et al., Science, July 2007



Stanford: Huard et al., Phys. Rev. Lett. June 2007



Columbia: Özyilmaz et al., tbp 2007



AMO: Lemme et al., IEEE EDL, April 2007

- Nanotechnologie -> AMO (Germany)
- Simulation -> IUNET (Italy)
- Materials -> CEA LETI (France)
 - Nanoanalytics -> Cambridge (UK)
 - Chemistry -> Tyndall (Ireland)
 - Industrial relevance -> ST (France)

