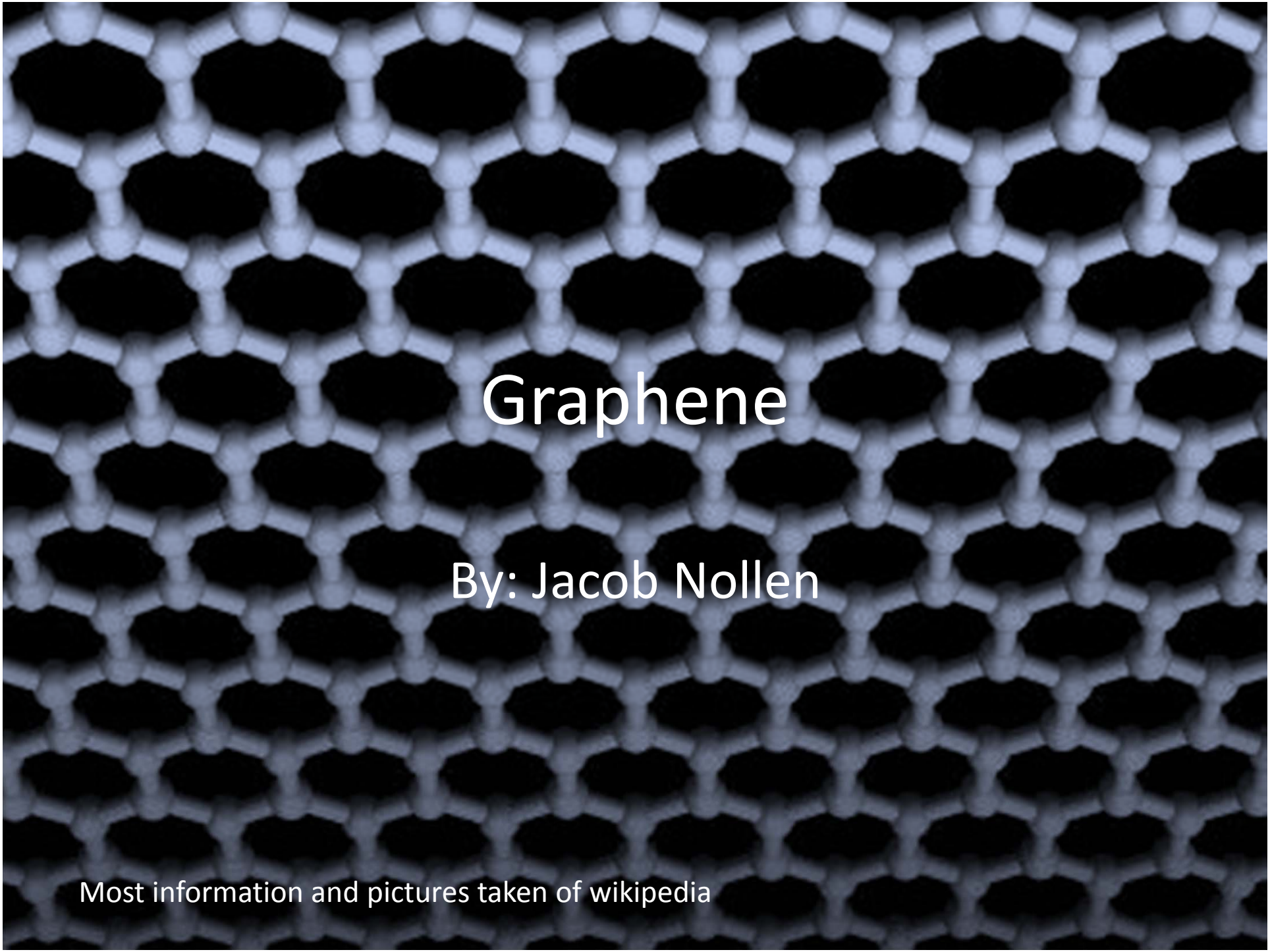


# Graphene

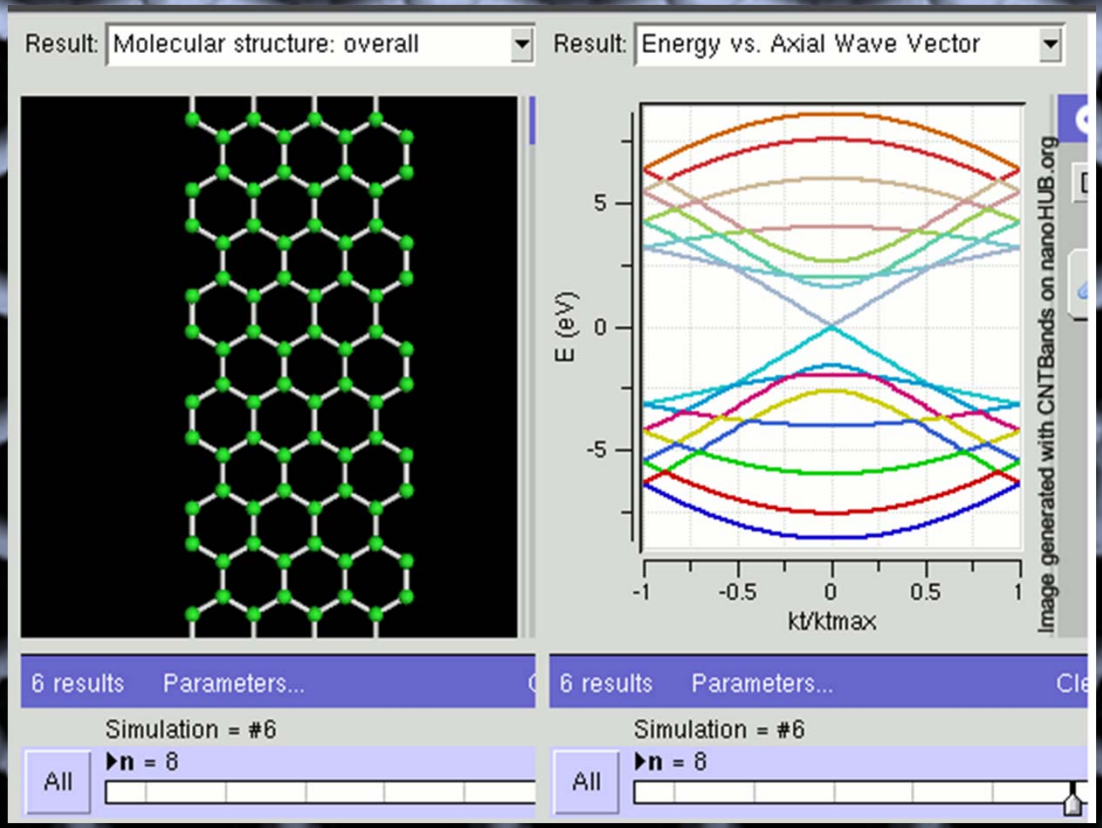
By: Jacob Nollen

Most information and pictures taken of wikipedia

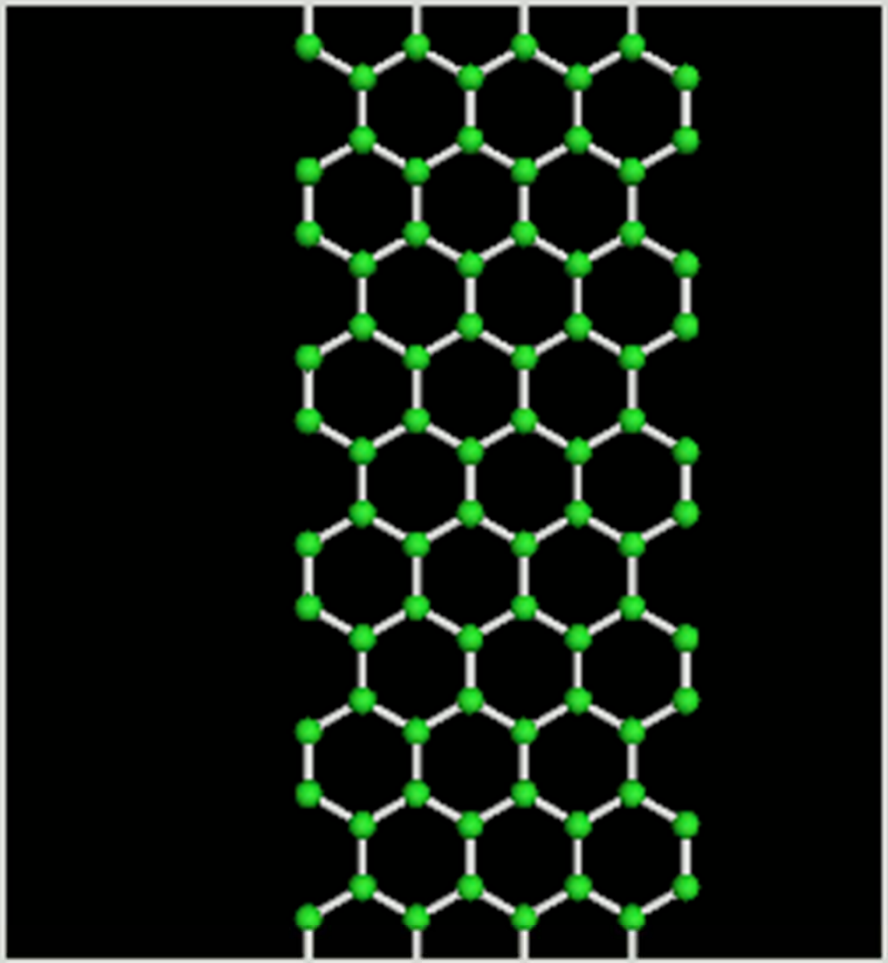

Why?

# Well lets look at Graphene's Band Structure

- This is an armchair orientation of graphene
- This is one of the orientations that has a band gap



Result: Molecular structure: overall



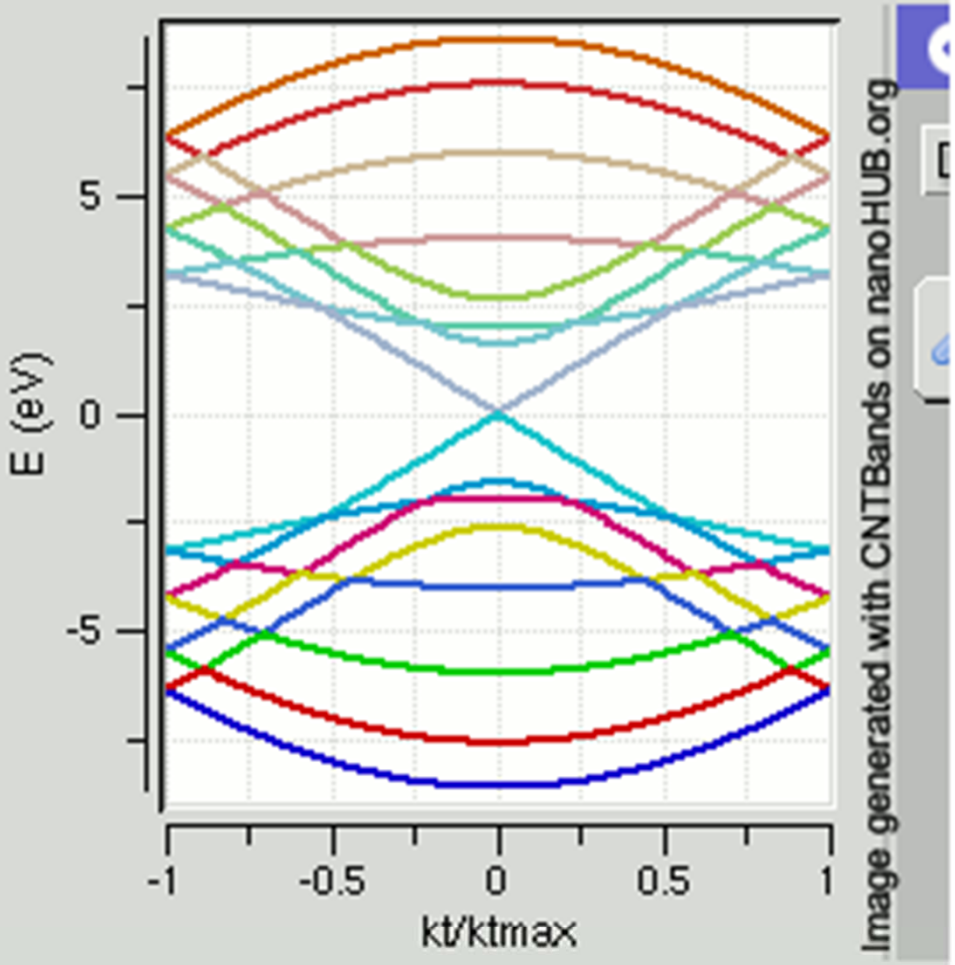
6 results Parameters...

Simulation = #6

All

n = 8

Result: Energy vs. Axial Wave Vector



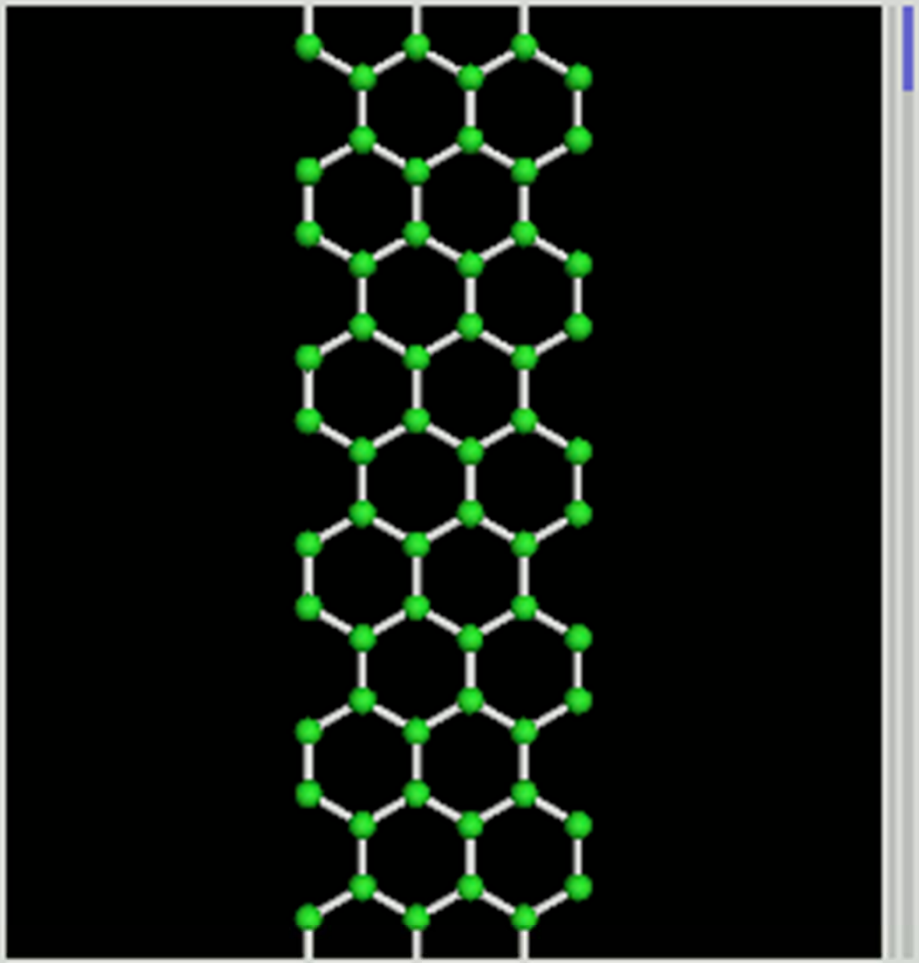

6 results Parameters... Cle

Simulation = #6

All

n = 8

Result: Molecular structure: overall



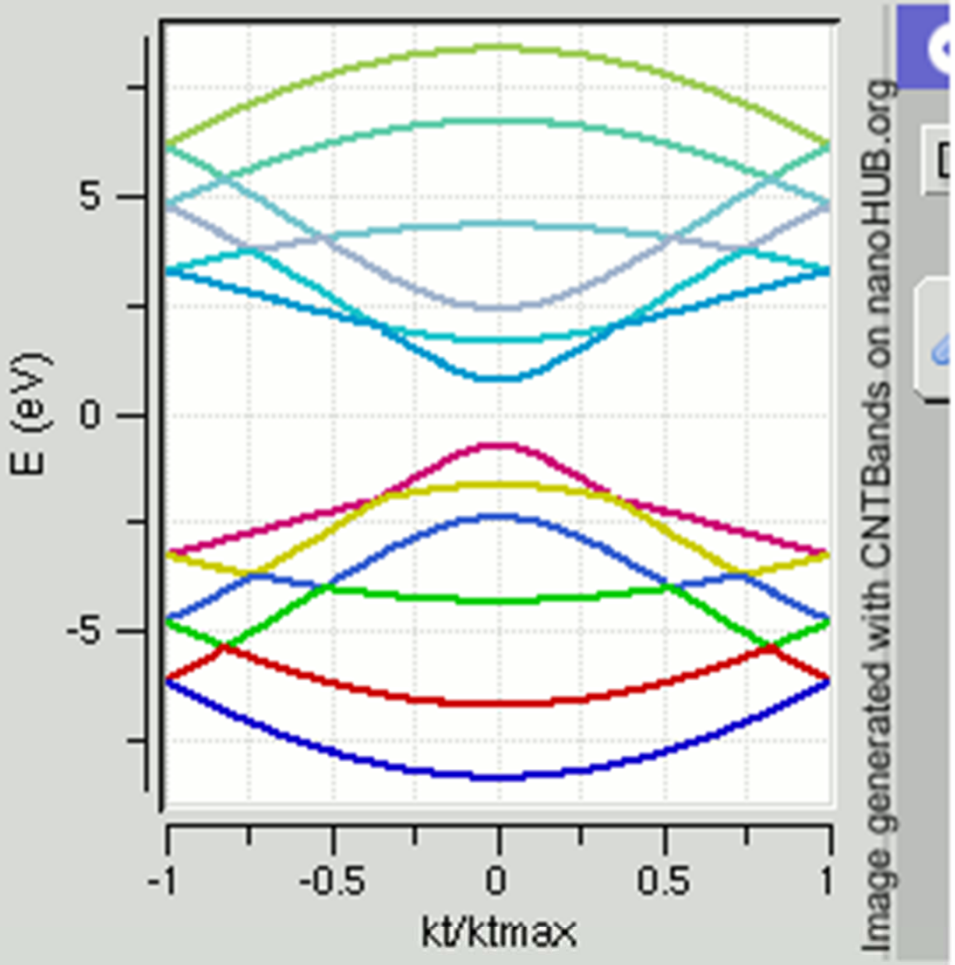
6 results Parameters...

Simulation = #4

All

n = 6

Result: Energy vs. Axial Wave Vector




6 results Parameters... Cle

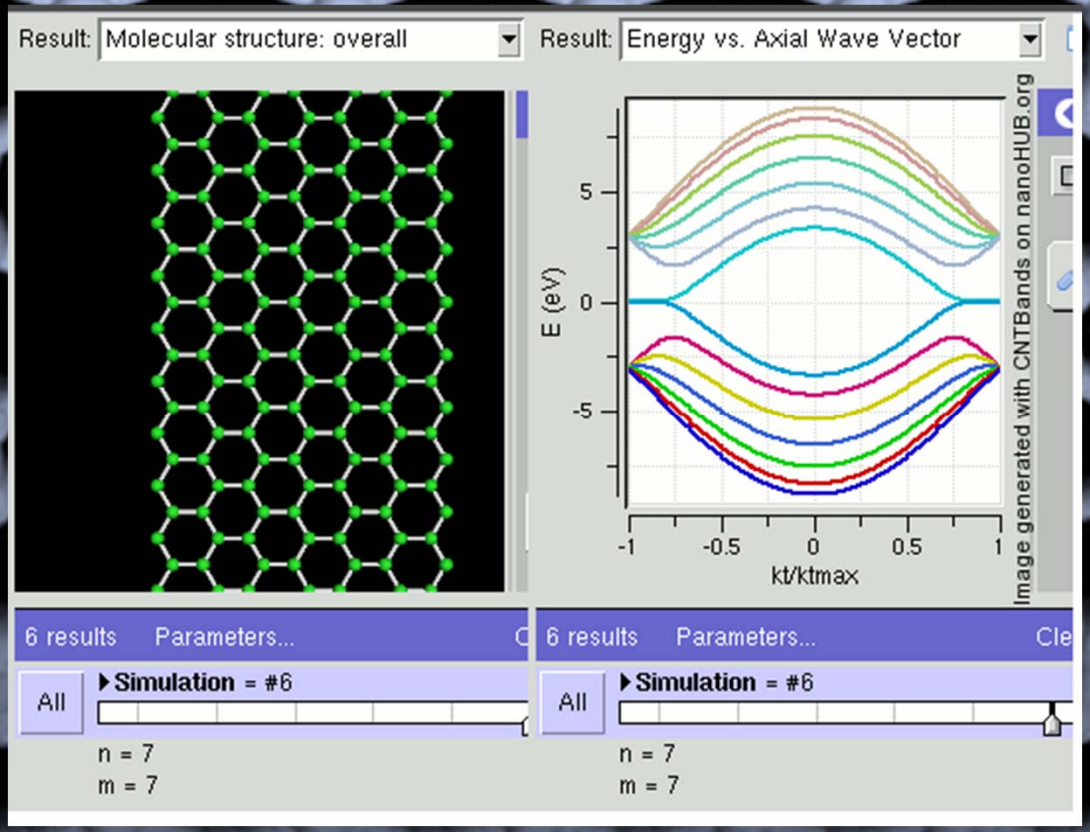
Simulation = #4

All

n = 6

# Zigzag Orientation of Graphene

- This layout has proven to always be metallic no matter how thin the ribbon is.
- It is the only orientation that shows the characteristic of being purely metallic.



# Graphene and a Band Structure

- The 6 corners hexagonal Brillouin zone have a linear band structure
  - Meaning that electrons and holes have effective mass of 0
  - This leads the particles to act like a relativistic particles according to the Dirac equation
- When graphene is cut or grown into nanoribbons a band gap opens up

# What else makes it good

- High electron mobility at room temperature
- High opacity with a mono layer
- Low electron scattering
- Low resistance in a graphene sheet
- Near absence of nuclear magnetic moments
- Temperature independence of mobility

# Mobility of Graphene's Eletrons

- The estimated limit of electron mobility is around 200,000 cm^2/V-s
- Graphene on $SiO_2$ substrate is only 40,000 cm^2/V-s
  - The substrates phonon scattering is much greater than that of Graphene

# Problems with Graphene

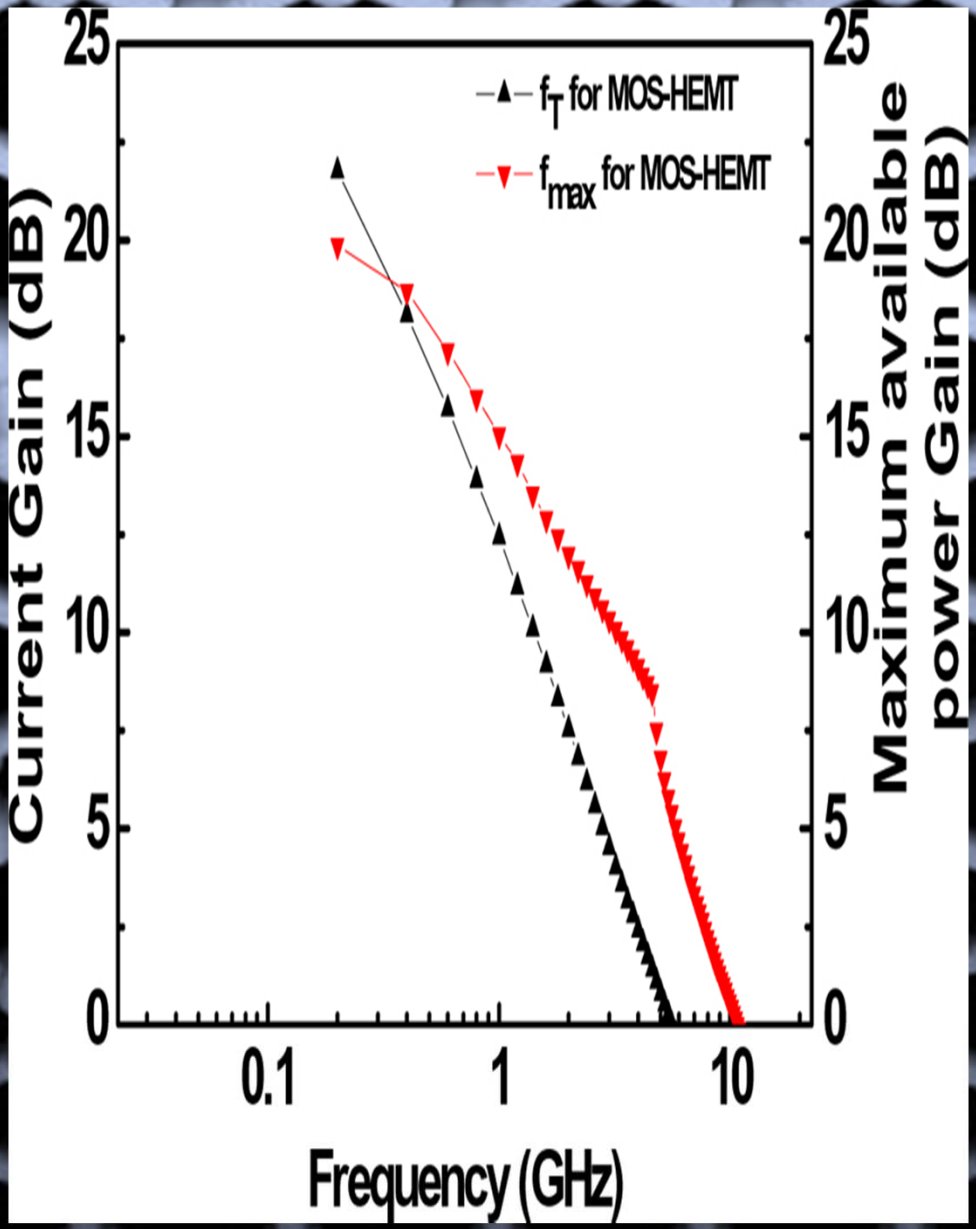
- Zero carrier density at the Dirac points
- Low conductivity
- Difficulty in creating graphene nanostrips
- Bad on off ratio
  - IBM has used a dual gate graphene FET
    - Achieved on off ratios around 100 at room temperature
    - 2000 when the device was cooled
- At max frequencies no current gain

# Ways to Grow it

- Drawing method
- Epitaxial Growth on Silicon Carbide
- Epitaxial Growth on metals
- Cutting nanotubes

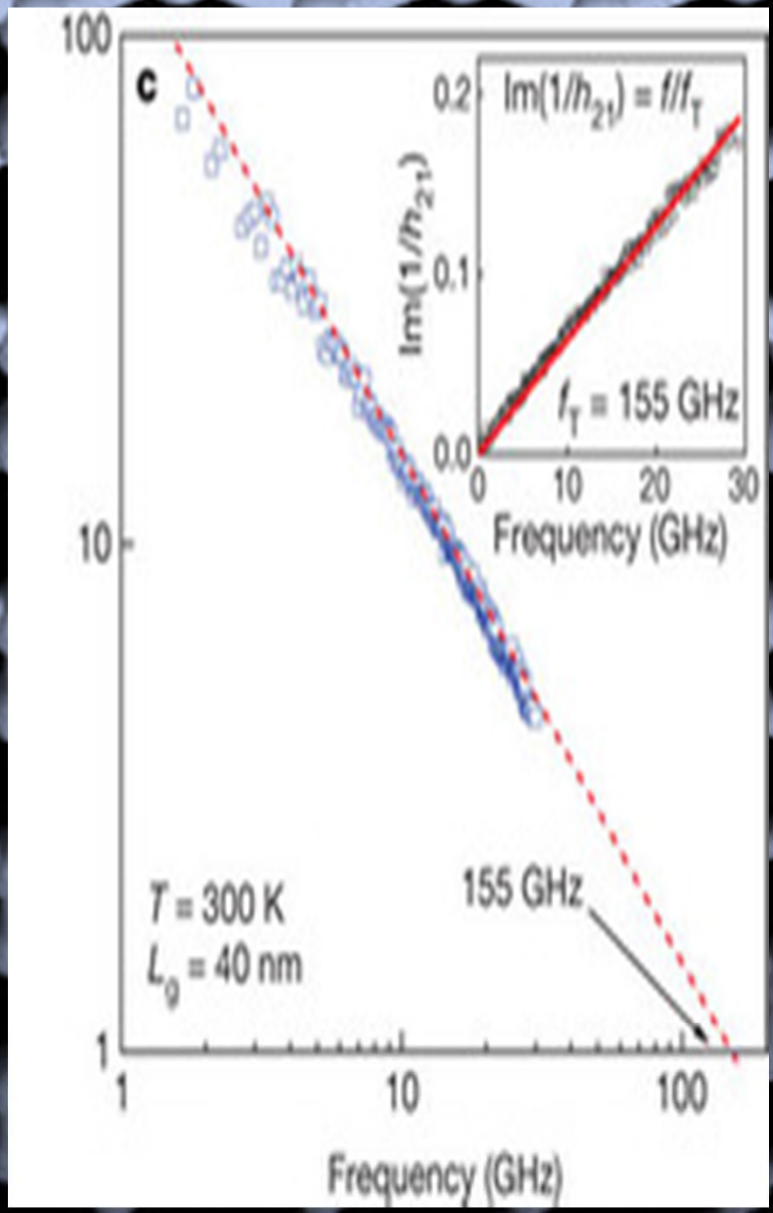
# IBM's 155 GHz HFT of graphene

- A 40 nm gate on the FET
- The estimated max  frequency with short circuit gain equal to 1
- Also unique to the graphene transistor is its disconnection from temperature
  - Operates at same speed from 4.3 K to room temperature
- The technology to make this device is already out there since it uses normal silicone manufacturing techniques




AlGaN MOSFET

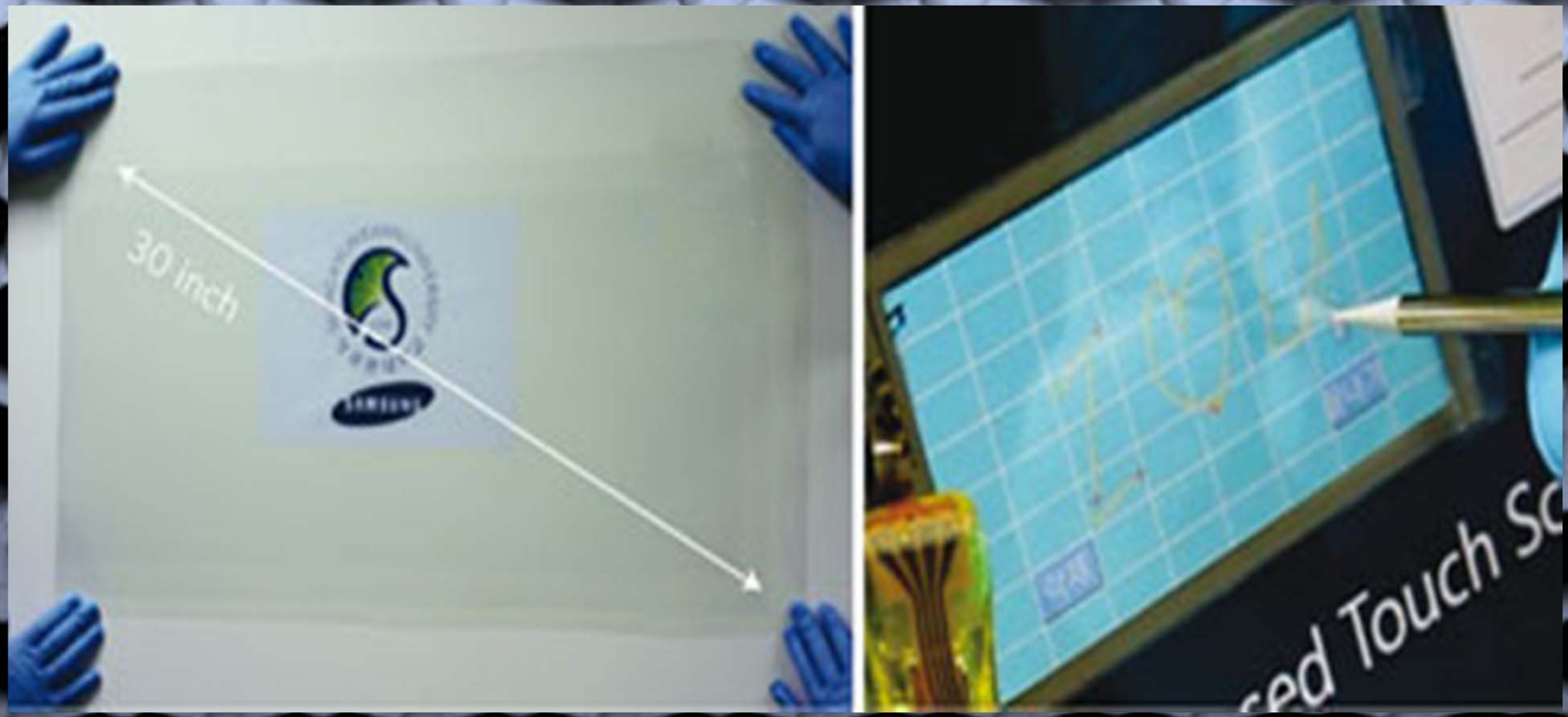
picture taken from SPIE newsroom




IBM graphene transistor

picture taken from Nature.com

# Graphene used for Touch Screen




Picture taken from Royal Society of Chemisty(RSC)

# Touch Screen

- A fabrication method for 30 in rolls of graphene was recently created
- Creates monolayer's of graphene with resistivity of 125Ω, optical transparency of 97.4%
- Then putting 4 layers together, the sheet resistance drops to 30Ω, optical transparency of ~90%
  - This is a third of the resistance of current ITO films

# Quantum Computer

- Graphene used to make spin Qubits, basic building block of a quantum computer
- The longer spin lifetime means longer data storage
- However, normal graphene cuts don’t have energy differences in parallel and antiparrallel

# References


- Background image
  - Gopaultech.com
- Wikipedia
- Nature.com lots of articles
- EE times
- Dr. Phillip First
- Physorg.com