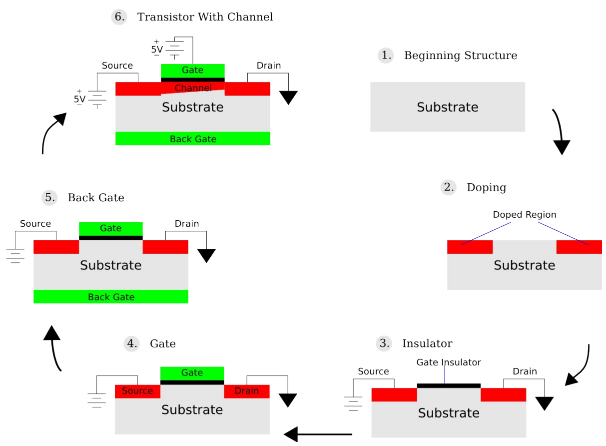
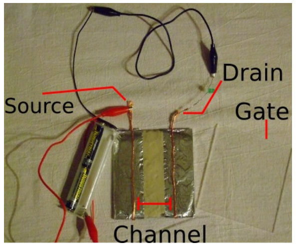
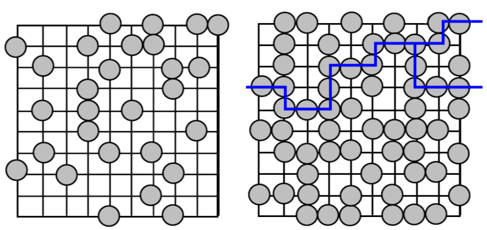
# Transistor Basics

Derrick Kearney
Michael McLennan
Abhijeet Paul
Saumitra Mehrotra

Network For Computational Nanotechnology
Purdue University





Alam / Lundstrom ECE-656 F07

Hands On Future Tech
Norfolk State University
August 23, 2008

# Electrical Conductor:

Material which allows electrons to easily flow through it.

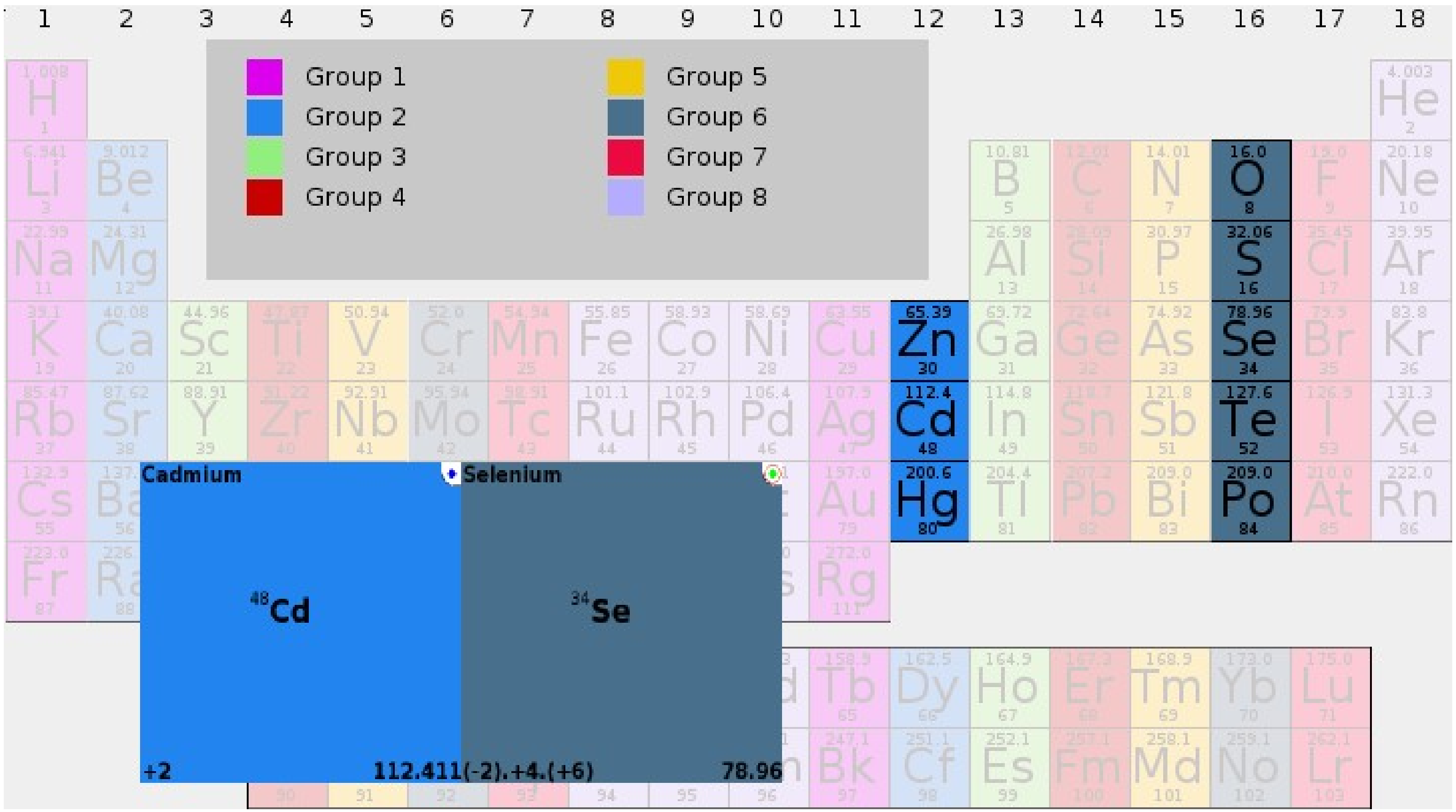
| Insulators | Semiconductors | Conductors |
| --- | --- | --- |

# Semiconductors on the Periodic Table

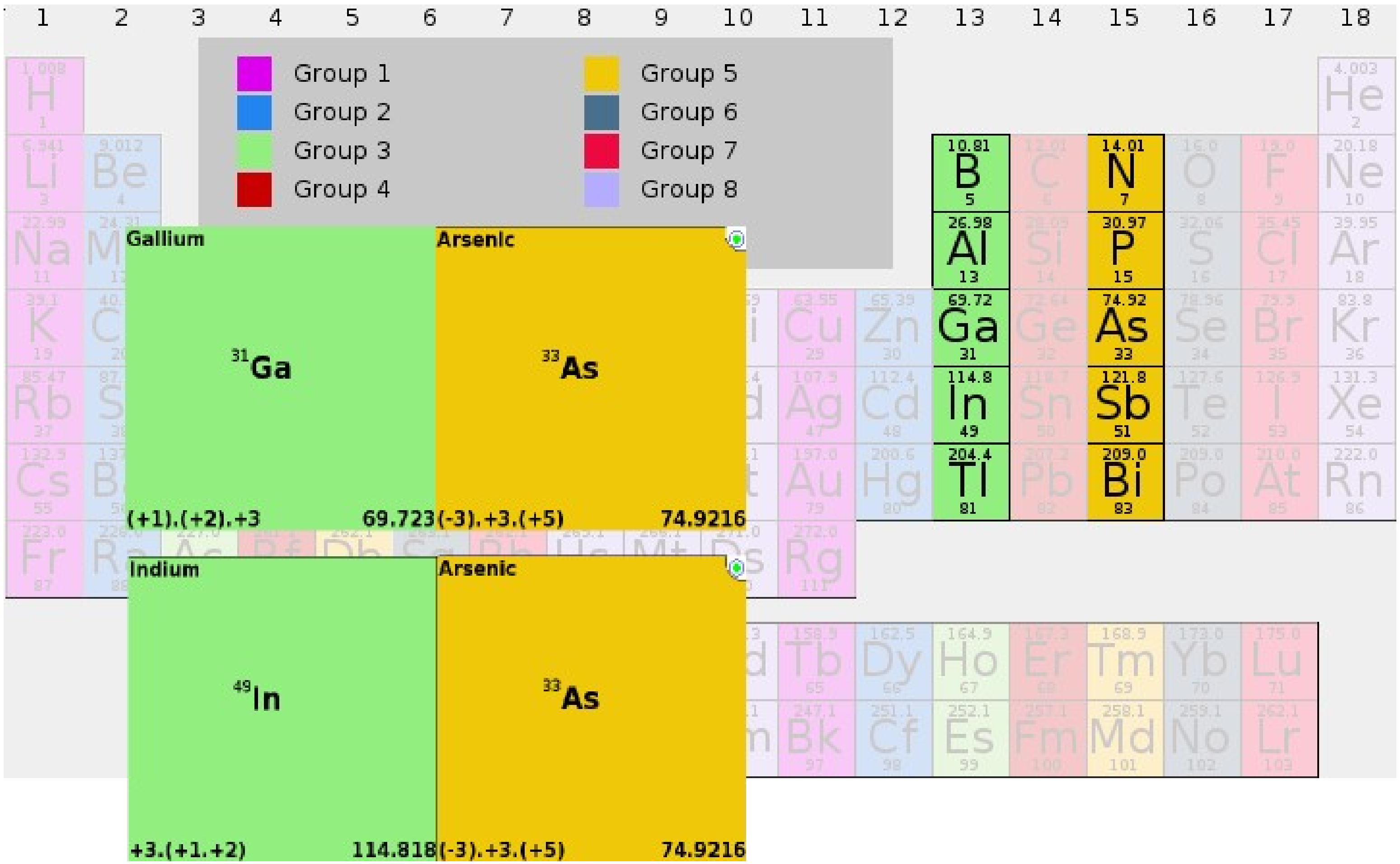
- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6
- Group 7
- Group 8

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.008 H 1 | | | | | | | | | | | | | | | | | 4.003 He 2 |
| 6.941 Li 3 | 9.012 Be 4 | | | | | | | | | | | 10.81 B 5 | 12.01 C 6 | 14.01 N 7 | 16.0 O 8 | 19.0 F 9 | 20.18 Ne 10 |
| 22.99 Na 11 | 24.31 Mg 12 | | | | | | | | | | | 26.98 Al 13 | 28.09 Si 14 | 30.97 P 15 | 32.06 S 16 | 35.45 Cl 17 | 39.95 Ar 18 |
| 39.1 K 19 | 40.08 Ca 20 | 44.96 Sc 21 | 47.87 Ti 22 | 50.94 V 23 | 52.0 Cr 24 | 54.94 Mn 25 | 55.85 Fe 26 | 58.93 Co 27 | 58.69 Ni 28 | 63.55 Cu 29 | 65.39 Zn 30 | 69.72 Ga 31 | 72.64 Ge 32 | 74.92 As 33 | 78.96 Se 34 | 79.9 Br 35 | 83.8 Kr 36 |
| 85.47 Rb 37 | 87.62 Sr 38 | 88.91 Y 39 | 91.22 Zr 40 | 92.91 Nb 41 | 95.94 Mo 42 | 98.91 Tc 43 | 101.1 Ru 44 | 102.9 Rh 45 | 106.4 Pd 46 | 107.9 Ag 47 | 112.4 Cd 48 | 114.8 In 49 | 118.7 Sn 50 | 121.8 Sb 51 | 127.6 Te 52 | 126.9 I 53 | 131.3 Xe 54 |
| 132.9 Cs 55 | 137.2 Ba 56 | 138.9 La 57 | 178.5 Hf 72 | 180.9 Ta 73 | 183.8 W 74 | 186.2 Re 75 | 190.2 Os 76 | 192.2 Ir 77 | 195.1 Pt 78 | 197.0 Au 79 | 200.6 Hg 80 | 204.4 Tl 81 | 207.2 Pb 82 | 209.0 Bi 83 | 209.0 Po 84 | 210.0 At 85 | 222.0 Rn 86 |
| 223.0 Fr 87 | 226.0 Ra 88 | 227.0 Ac 89 | 261.1 Rf 104 | 262.1 Db 105 | 263.1 Sg 106 | 262.1 Bh 107 | 265.1 Hs 108 | 266.1 Mt 109 | 271.0 Ds 110 | 272.0 Rg 111 | | | | | | | |
| | | | 140.1 Ce 58 | 140.9 Pr 59 | 144.2 Nd 60 | 146.9 Pm 61 | 150.4 Sm 62 | 152.0 Eu 63 | 157.3 Gd 64 | 158.9 Tb 65 | 162.5 Dy 66 | 164.9 Ho 67 | 167.3 Er 68 | 168.9 Tm 69 | 173.0 Yb 70 | 175.0 Lu 71 | |
| | | | 232.0 Th 90 | 231.0 Pa 91 | 238.0 U 92 | 237.0 Np 93 | 244.1 Pu 94 | 243.1 Am 95 | 247.1 Cm 96 | 247.1 Bk 97 | 251.1 Cf 98 | 252.1 Es 99 | 257.1 Fm 100 | 258.1 Md 101 | 259.1 No 102 | 262.1 Lr 103 | |

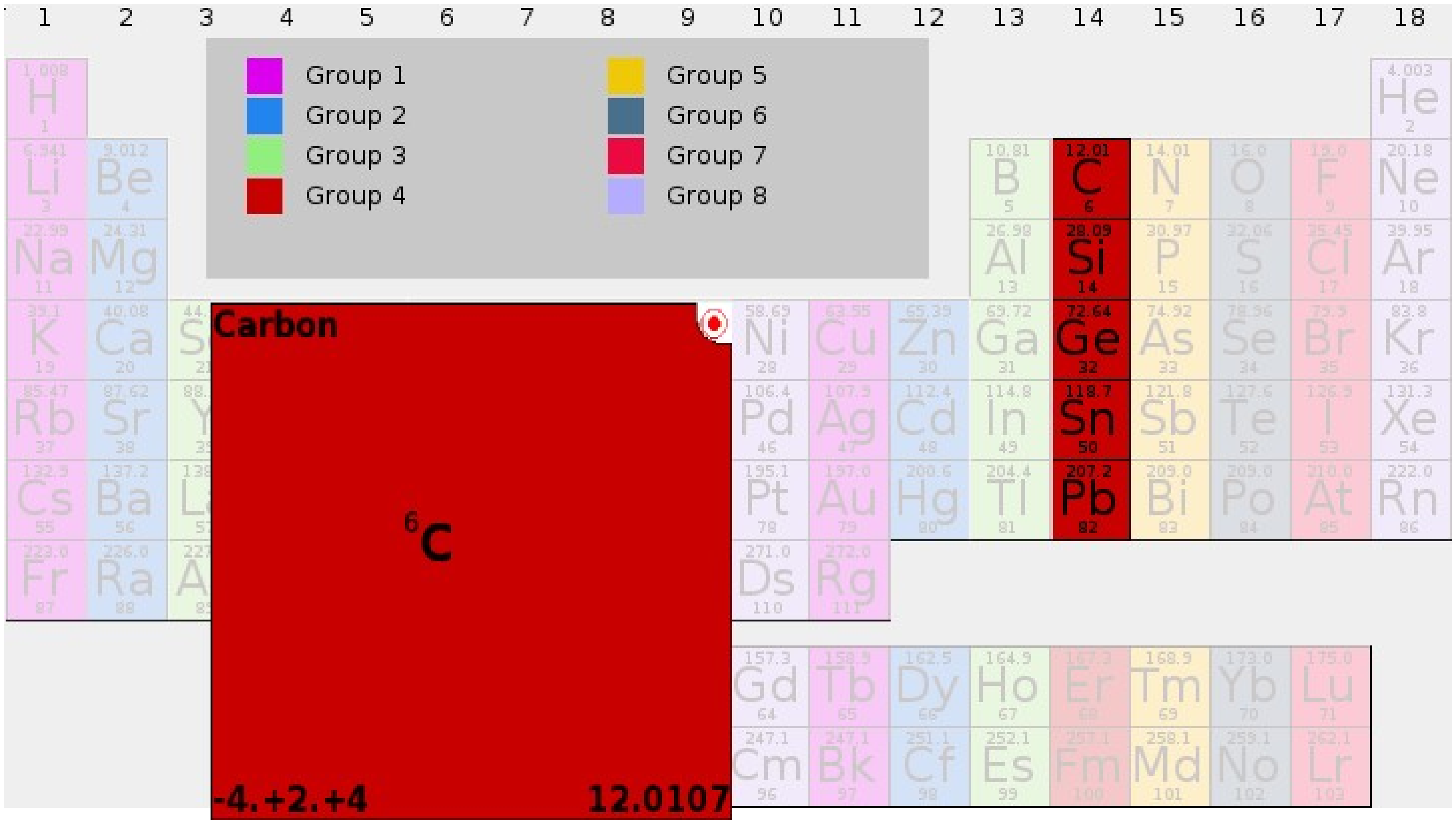
# Groups 2,6 Semiconductors



# Groups 3,5 Semiconductors



# Group 4 Semiconductors



# From Carbon to Carbon Nanotubes

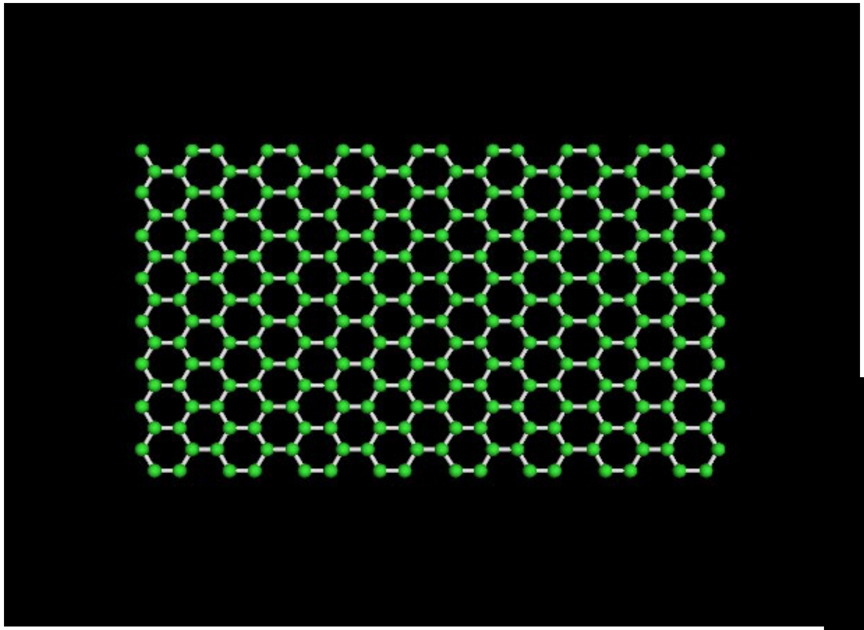


*Figure 1: An image of a graphene structure is shown on the left. Notice each molecule is in the shape of a hexagon.*

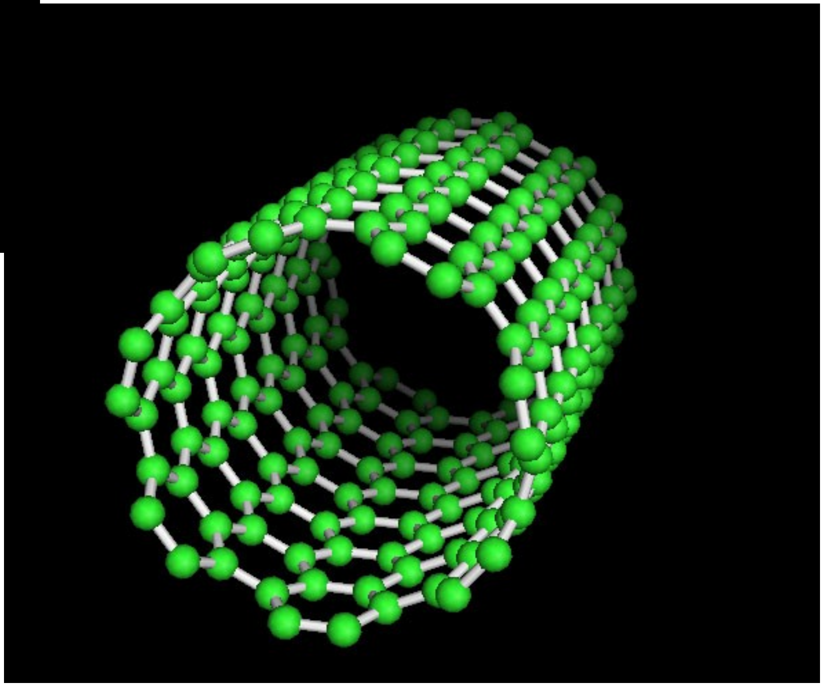
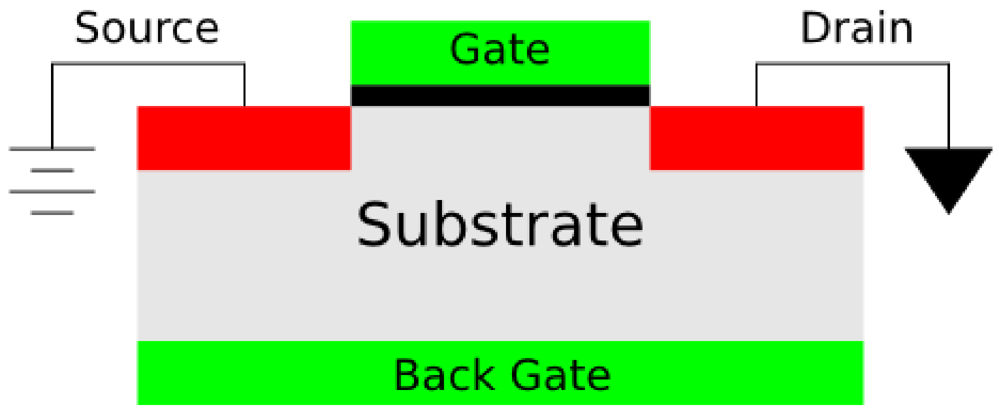


*Figure 2: A carbon nanotube image is shown on the right. A close view of the structure implies its connection with graphene.*

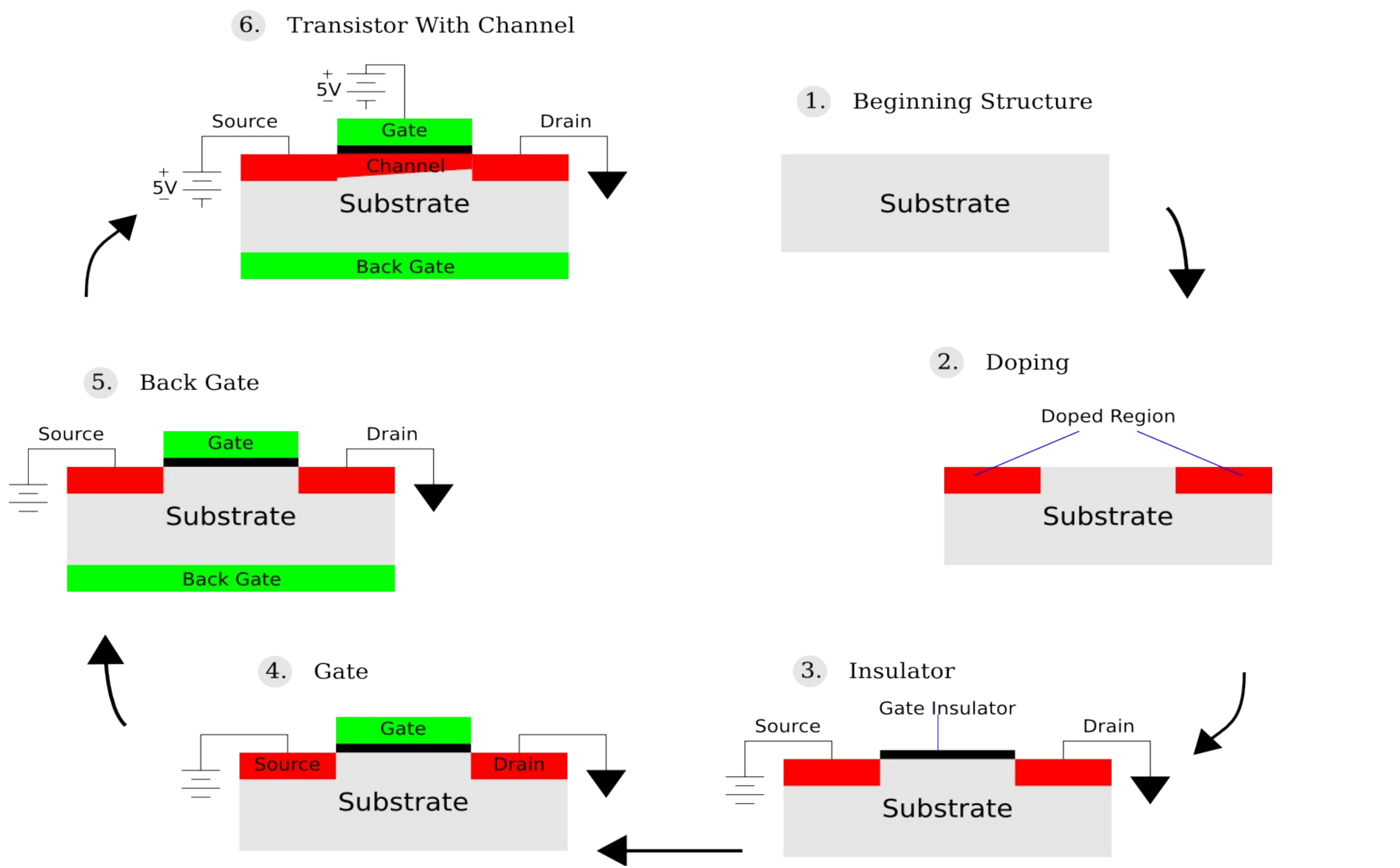
# Metallic vs. Semiconducting

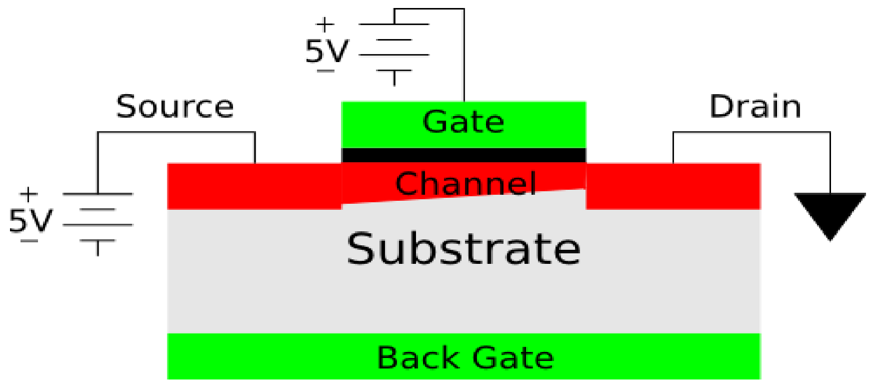
# Basic Structure of Transistors

- Semiconducting CNT's can make good Transistors
- Transistors act as digital switches
- Transistors are basics of all Computers



# Building a Transistor

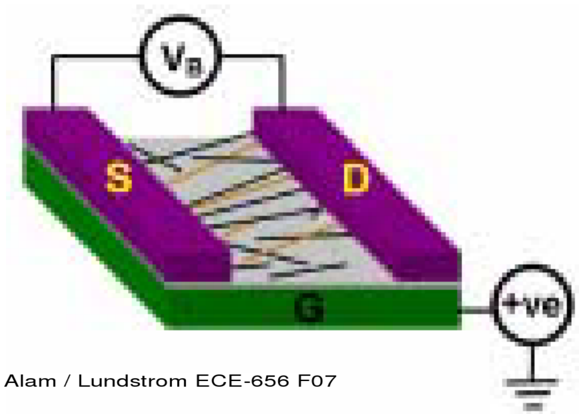




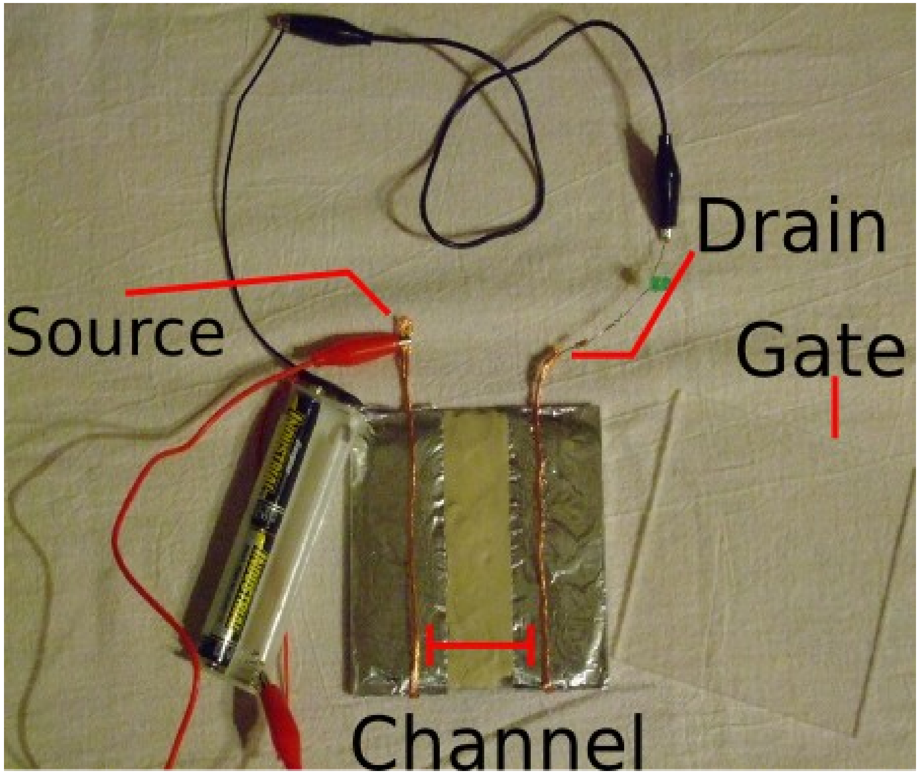

Thin-Film Transistors (TFTs) Advantages

- Lower Power, More Efficient Electronics
  - Solar Cells
  - Computer / TV Screens
- Electronics on Plastics
  - Light, Flexible E-Paper
  - Biosensors

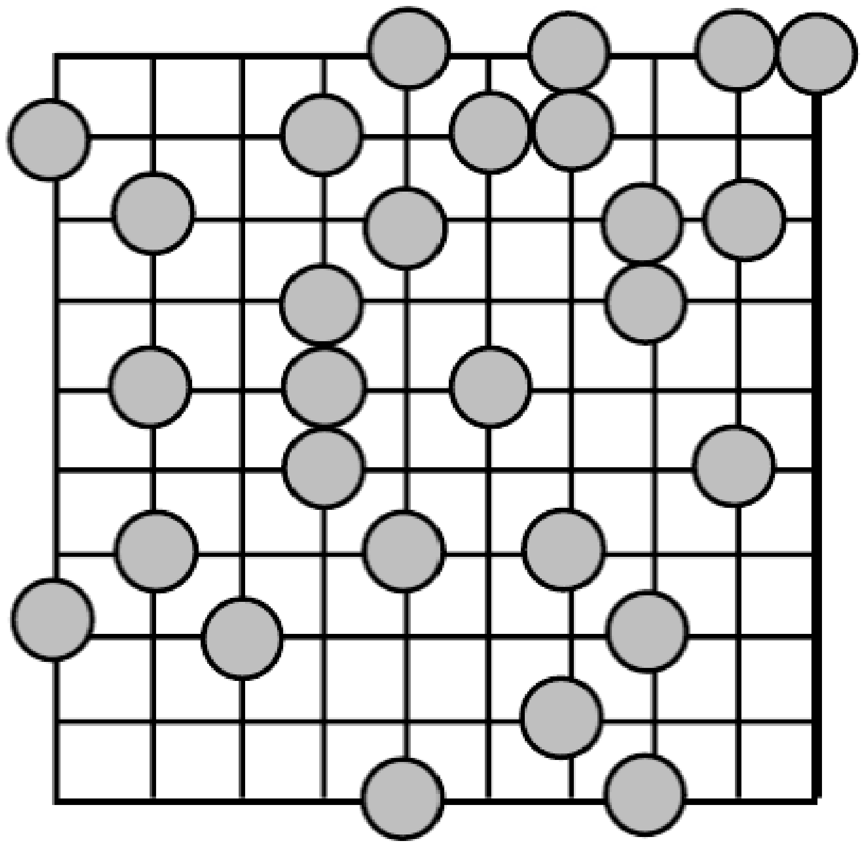
**Short Channel**




Alam / Lundstrom ECE-656 F07

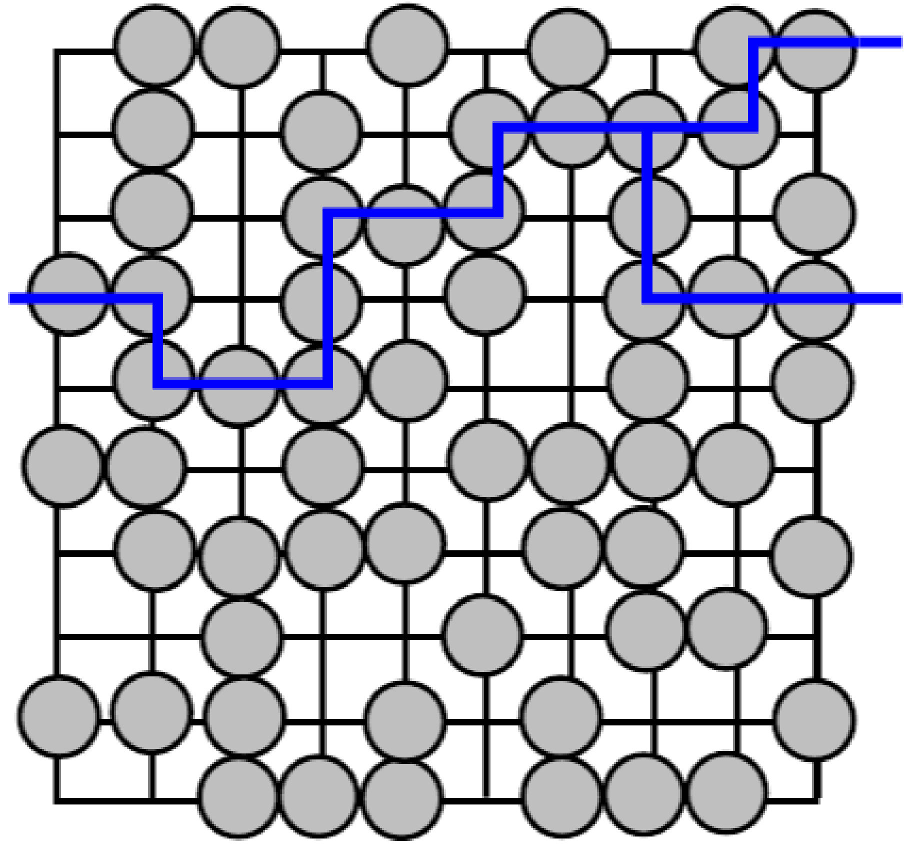


# Disk Percolation in Sparse System



Alam / Lundstrom ECE-656 F07

# Disk Percolation in Dense  System



Alam / Lundstrom ECE-656 F07

# Carbon Nanotube Thin-Film Transistors on nanoHUB.org

## NanoNet

Storage 94%

Tool | About | Questions?

**Contributor(s)** Ninad Pimparkar, Satish Kumar, Jayathi Murthy, Muhammad A. Alam
Purdue University, West Lafayette

**At a glance** NanoNET is a tool to simulate the Nanobundle Network Thin Film Transistors (NB-TFTs). Random networks of carbon nanotubes with thousands of tubes and random orientation can be simulated using this tool. The final answer can be compactly formulated in the formula shown in the picture. Here ID is current and LC and LS is channel length and tube length of the transistor and m is the current exponent. For a normal Si MOSFET, m = 1 and the current is simply inversely proportional to channel length. ...

**Screenshots**

**Description** NanoNET is a tool to simulate the Nanobundle Network Thin Film Transistors (NB-TFTs). Random networks of carbon nanotubes with thousands of tubes and random orientation can be simulated using this tool. The final answer can be compactly formulated in the formula shown in the picture. Here ID is current and LC and LS is channel length and tube length of the transistor and m is the current exponent.

5.5 RANKING
328 users, detailed statistics
1 review (Review this)
3 citations
0 questions (Ask a question)

nanoHUB.org
online simulations and more

# Carbon Nanotube Thin-Film Transistors on nanoHUB.org

NanoNet

Storage 94%

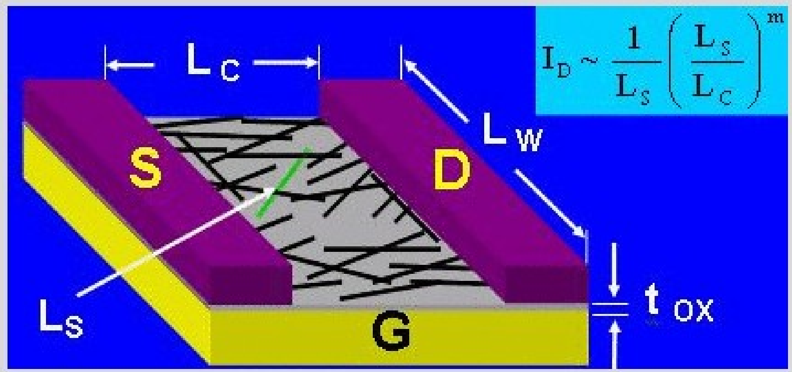
Tool | A

Contributor(s)

At a glance

Screenshots

Description




Options: Effect of alignment on network transistor

Tube Parameters | Device Geometry

Tube Density [ D ] ( 1/um^2 ): 12

Tube Length [ LS ]: 1um

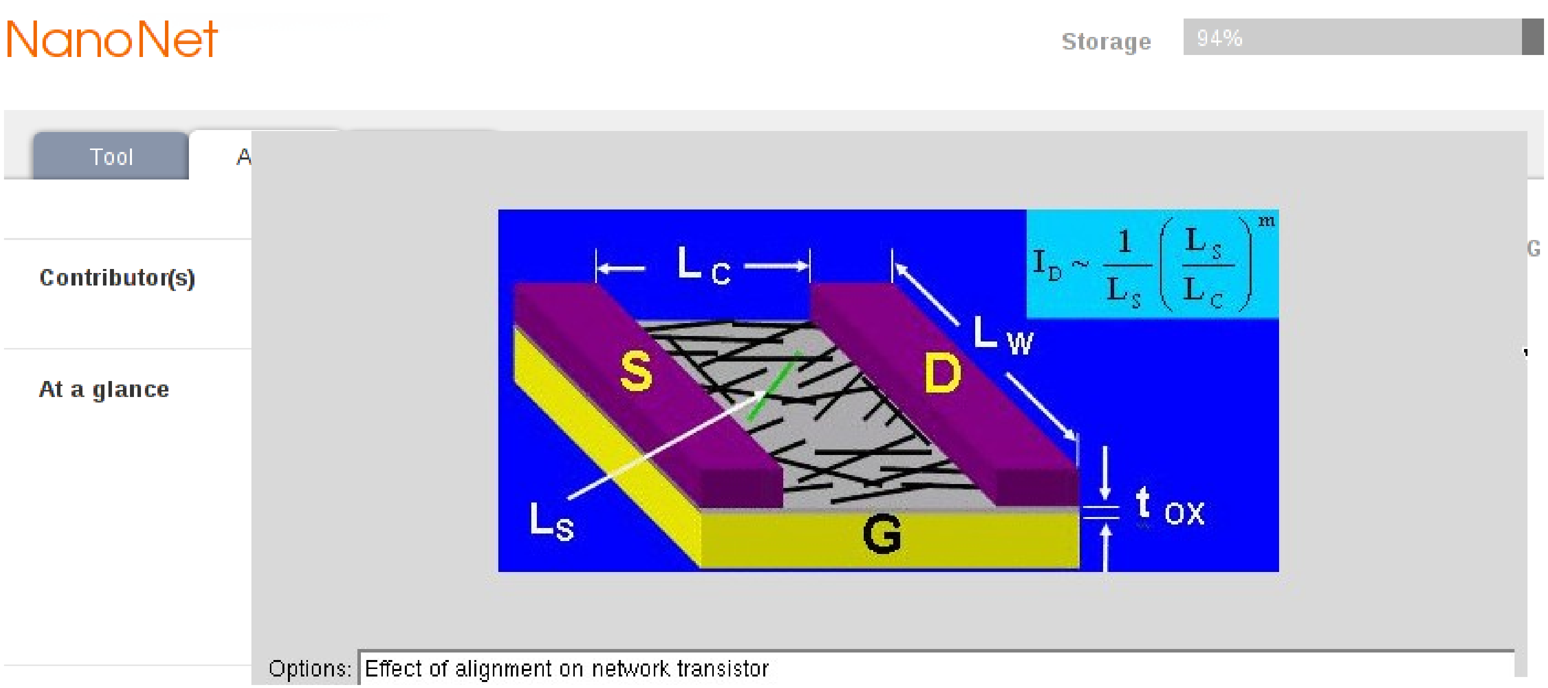
Tube Diameter [ d ]: 1nm

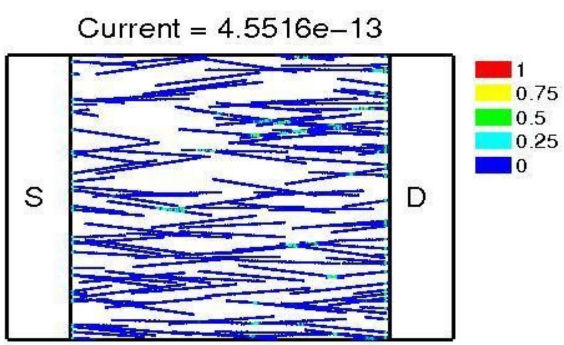
Coupling Parameter [Cij]: 1

Alignment Parameter: 10, 60, 90

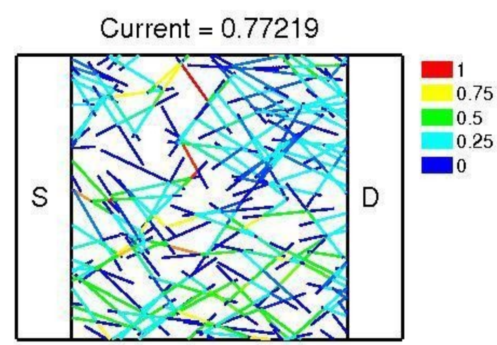
Simulate >

# Carbon Nanotube Thin-Film Transistors on nanoHUB.org

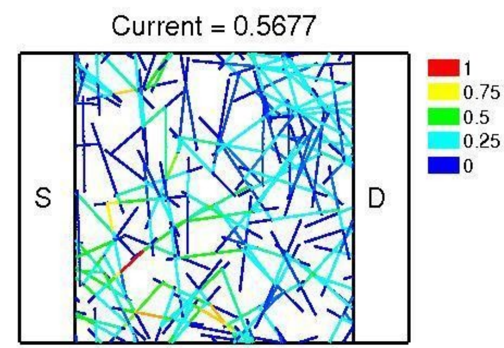



**Alignment = 10 Degrees**




**60 Degrees**

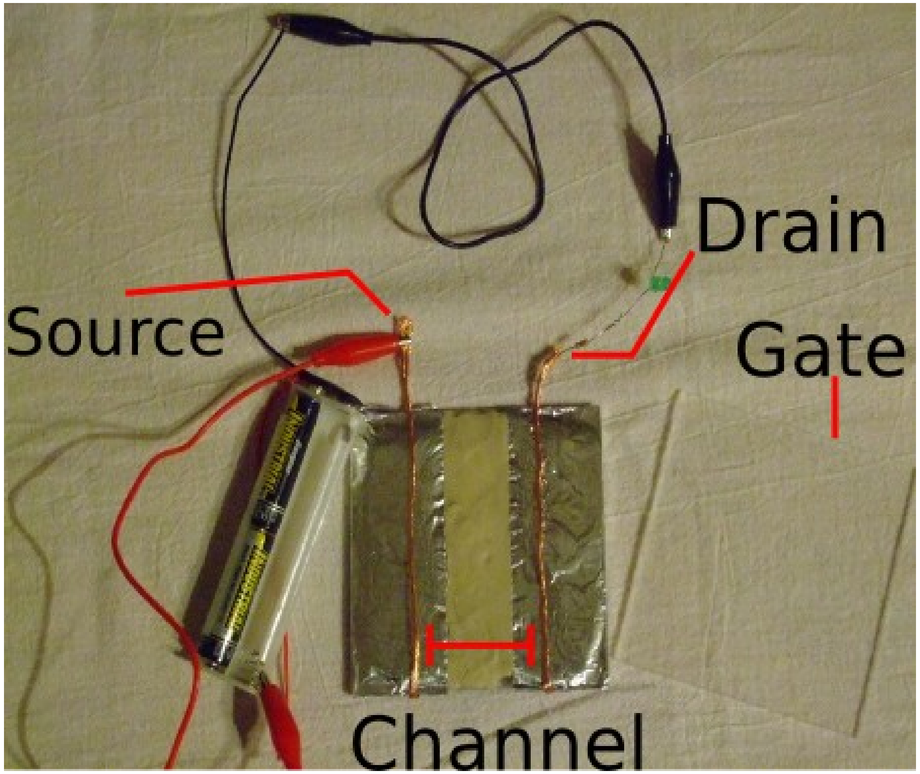



**90 Degrees**

# Building a Thin-Film Transistor

**Components**:

- 2 x Acrylic Sheet (Gates)
- Putty (Substrate)
- Speaker Wire (Source/Drain)
- 22 Ohm Resistor
- 2 Volt Green LED
- 2 AA Baitteries
- Alligator Clips
- Pencil lead




**Goal:** Use Percolation Theory to complete the transistor and the circuit.