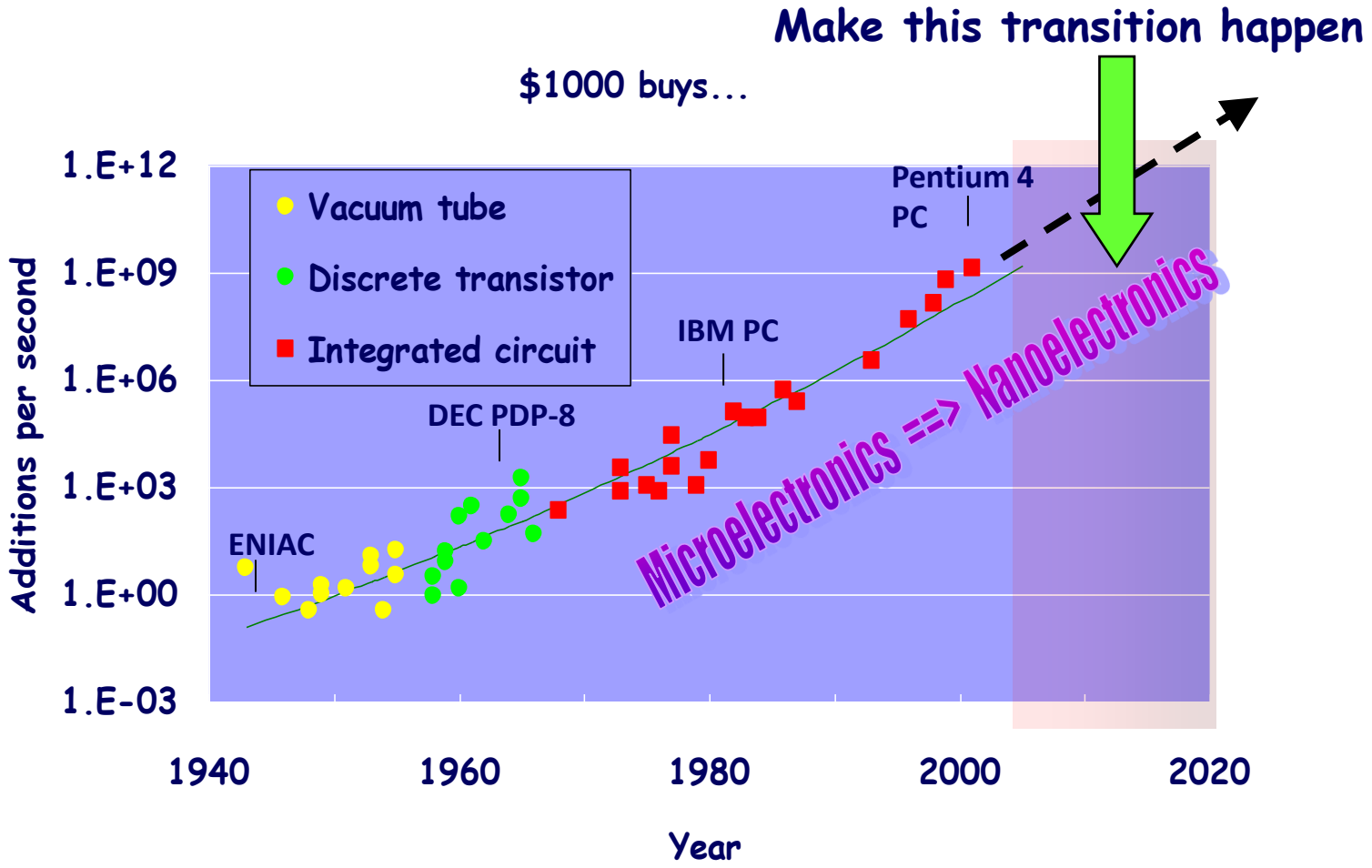
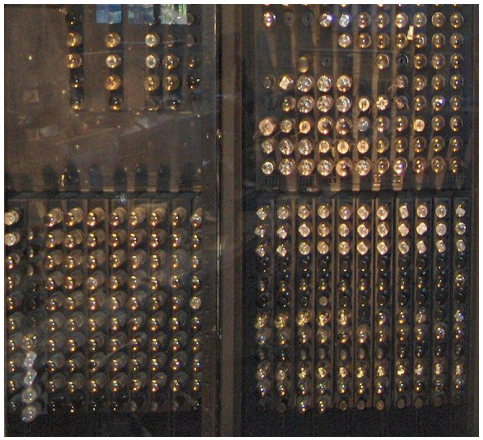


… and the other applications that are enabled by nanoscale science and technology

Evolution of Electronics

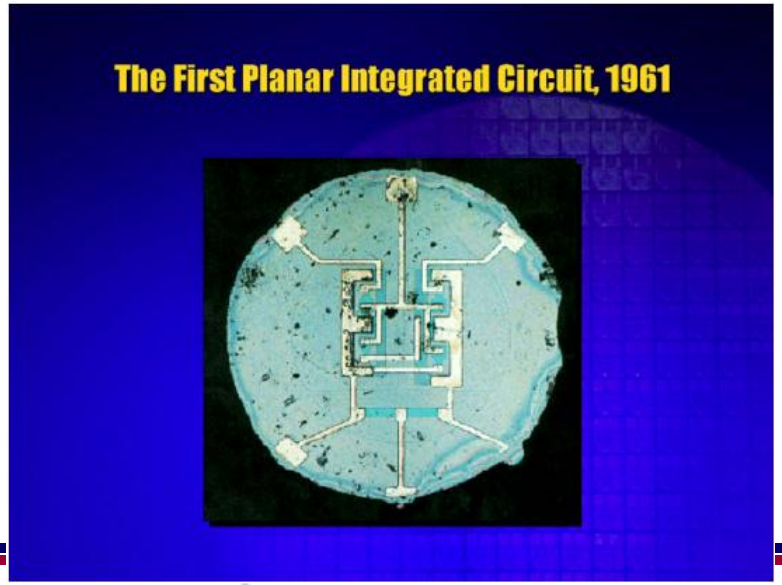


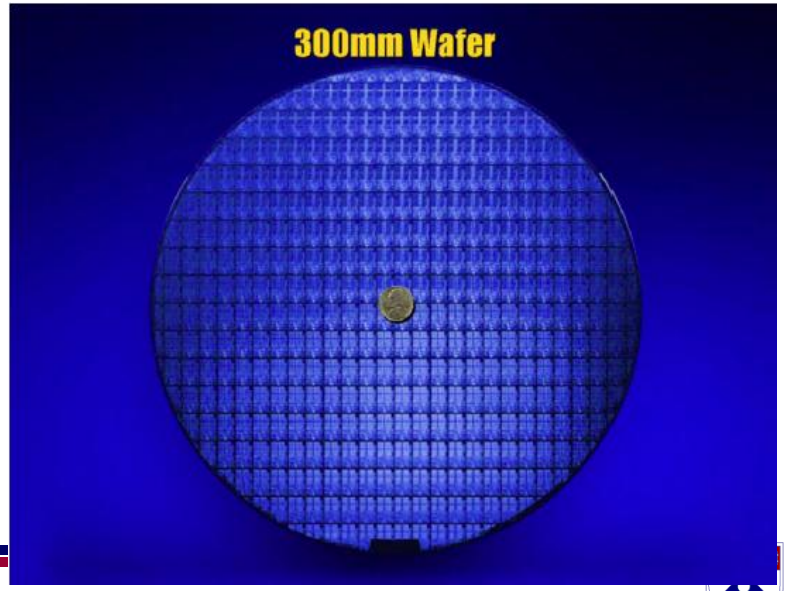
Vacuum tube

ENIAC = Electronic Numerical Integrator and Computer

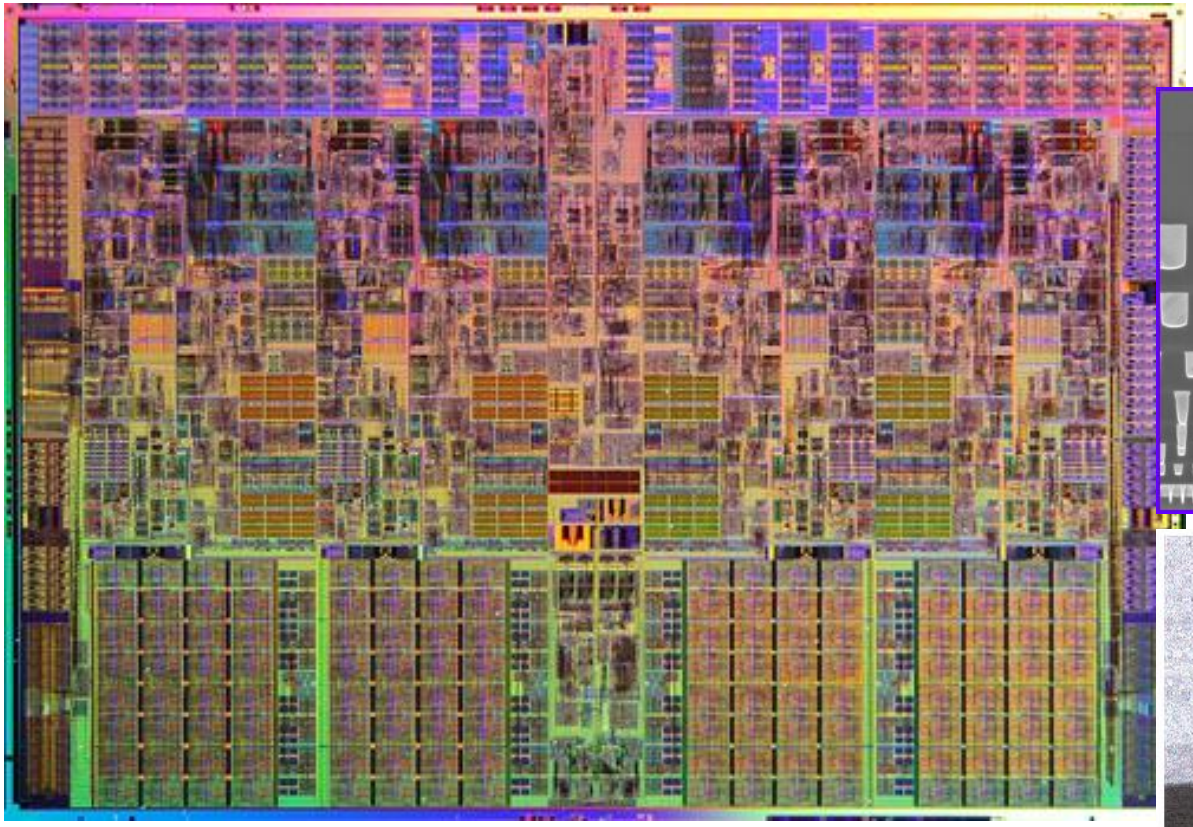
First Transistor, 1947 Bell Labs

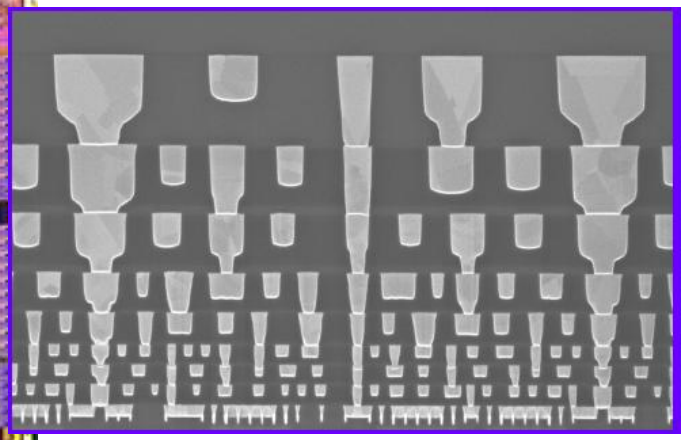
Discrete Transistor

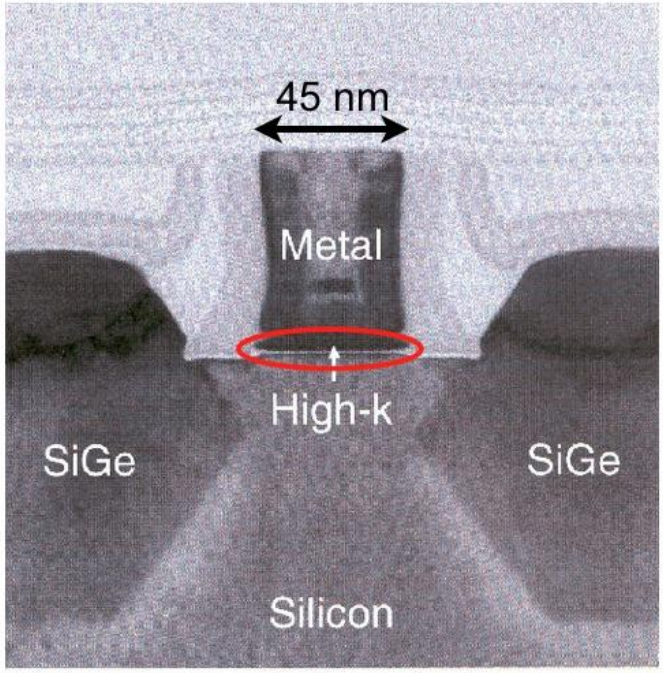




Intel Core i7 Processor with 45 nm Transistors

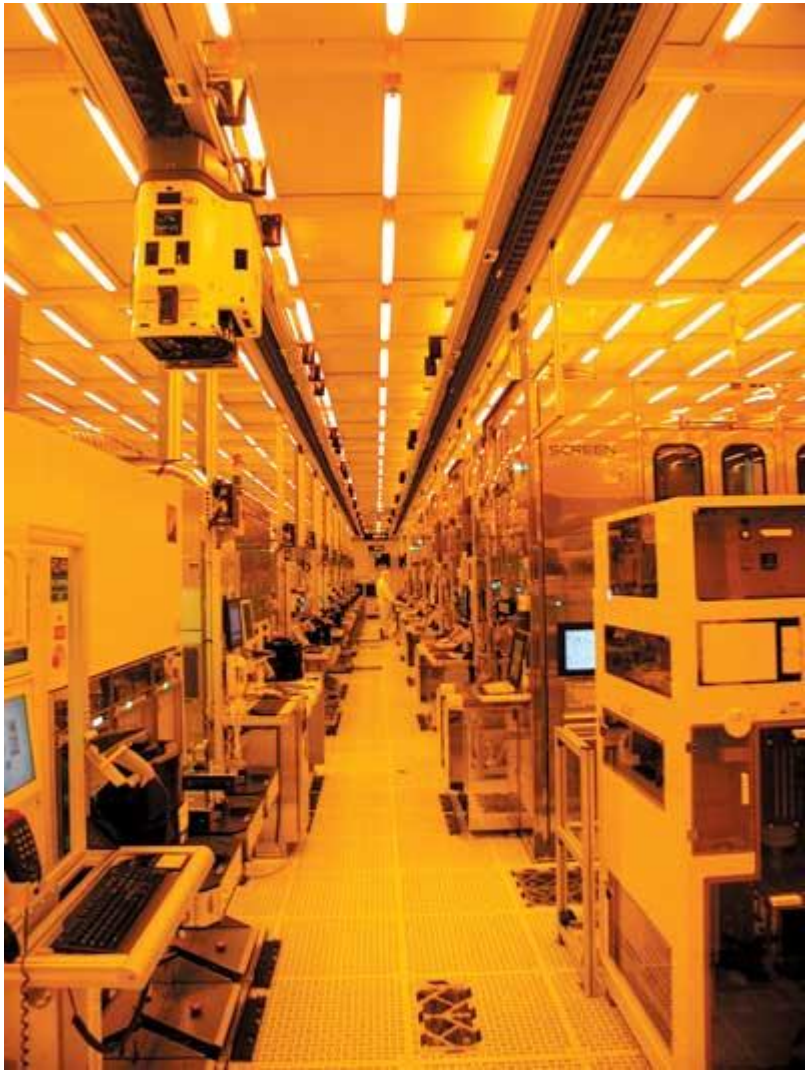






The Fabrication Facility of Today

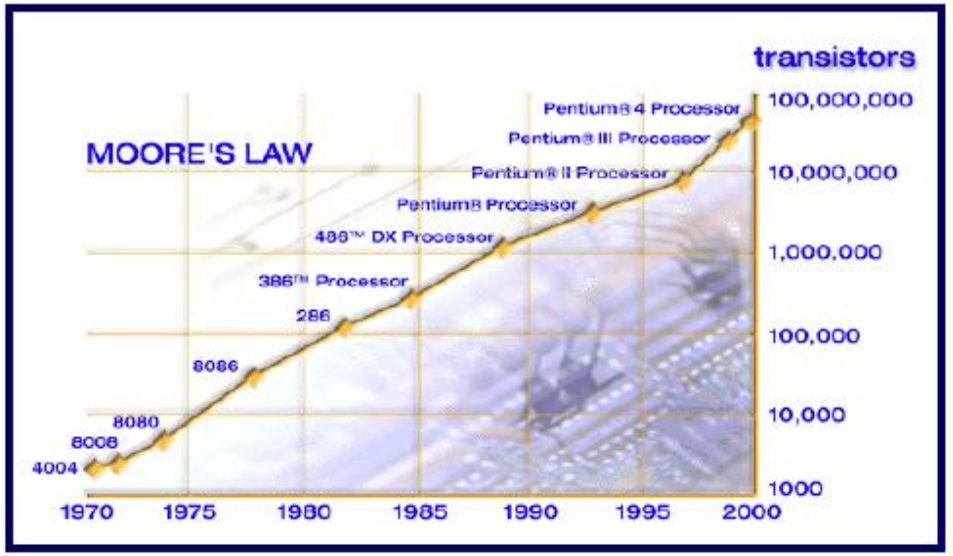
300 mm wafer Fabrication
http://www.youtube.com/watch?v=inoOAOOMjHo



Intel

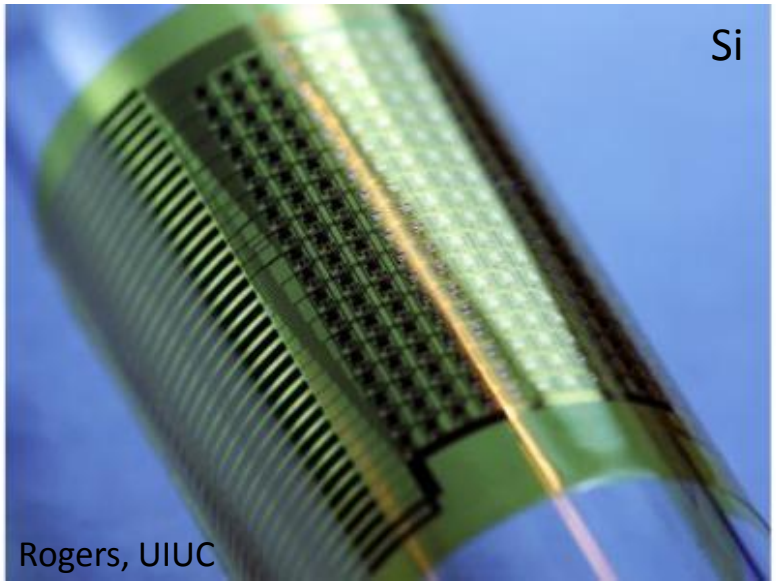
Moore's Law

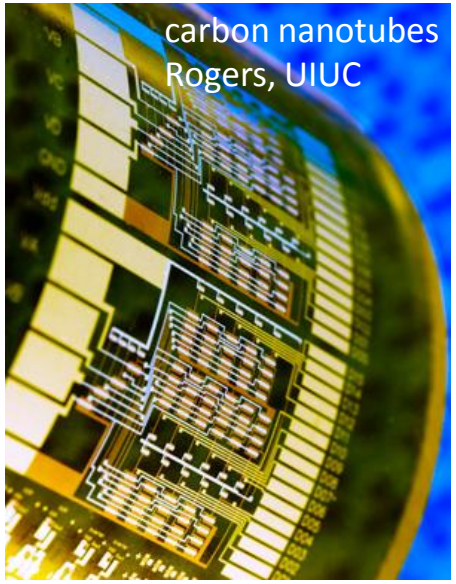
Intel Co-Founder
Gordon E. Moore



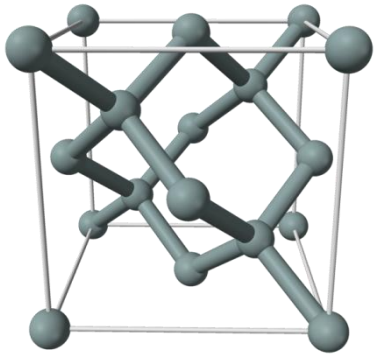
"Cramming More Components Onto Integrated Circuits"
Author: Gordon E. Moore
Publication: Electronics, April 19, 1965

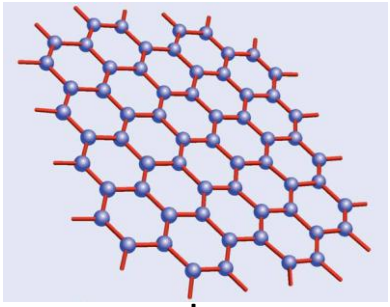
Other Electronic Applications = “More than Moore”
Silicon and New Materials



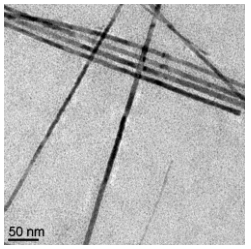


Si

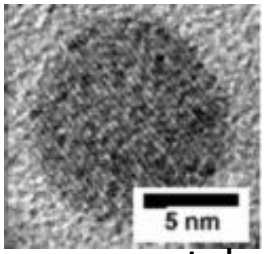




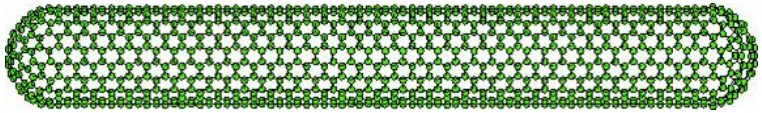
graphene



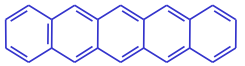
nanowires



nanocrystals



carbon nanotubes

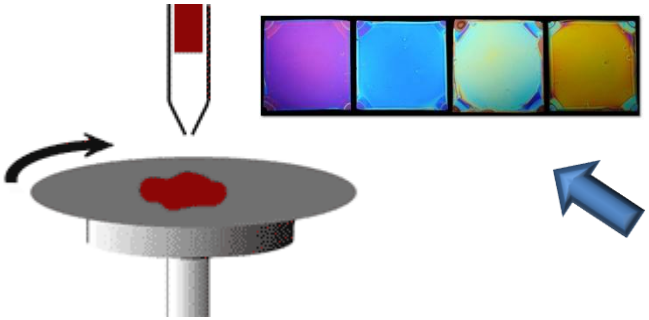


organic materials

Alternative, Low-Cost Fabrication

Printable Electronics – Spin, Dip, Spray, Print, Imprint …. From Solution

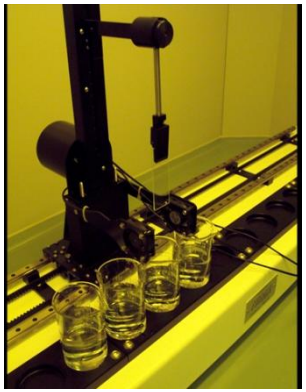
Spin-coating



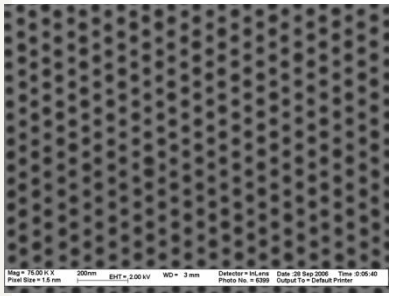
Printing

Krebs, Denmark

Dip-coating



Imprinting

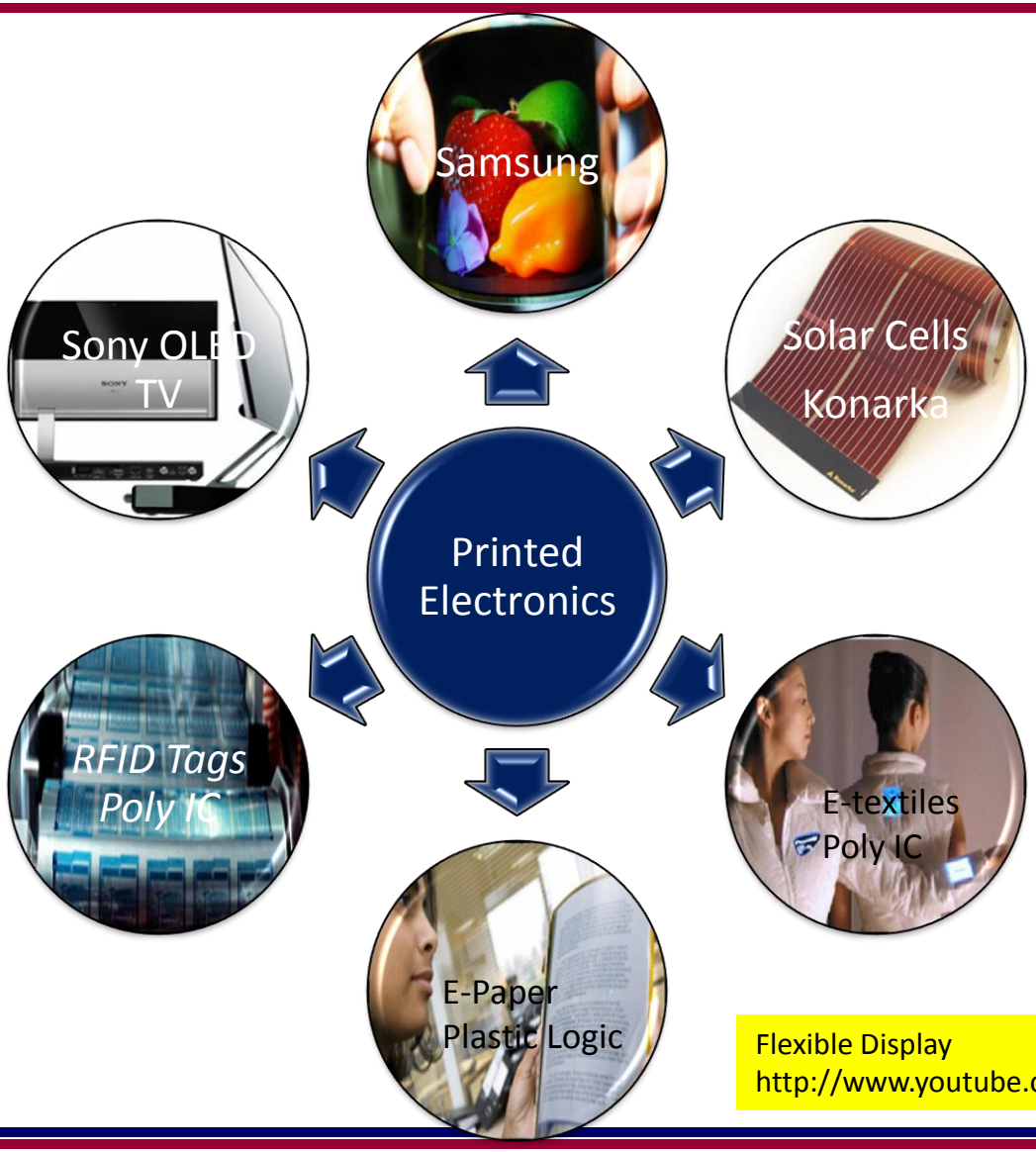


Example: nanocrystals
In general for solutions

Mesopotamian Templates
600 AD

25 nm holes

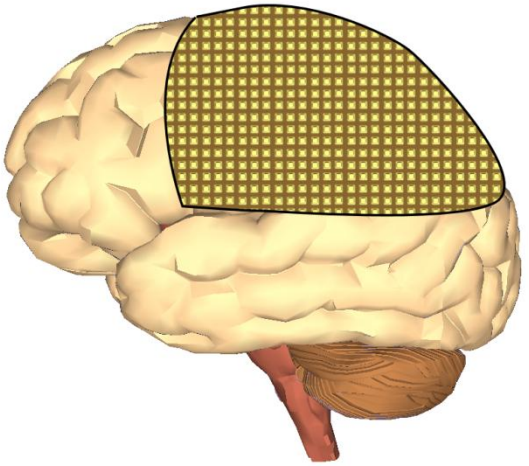
Examples of Some Electronic and Optoelectronic Applications

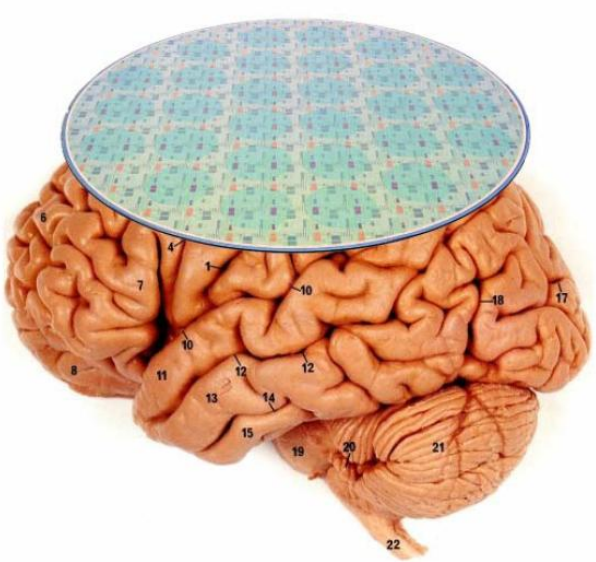


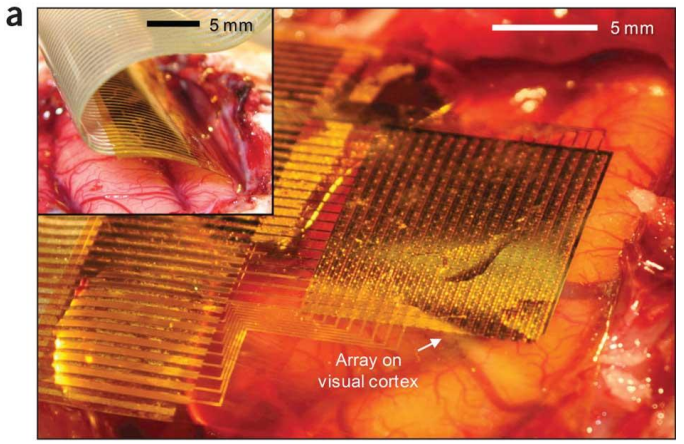
Flexible Display
http://www.youtube.com/watch?v=-k6r2HQY9Ws

BioElectronics

Utah Electrode Array
10 x 10 array of electrodes
¼" x ¼" in size

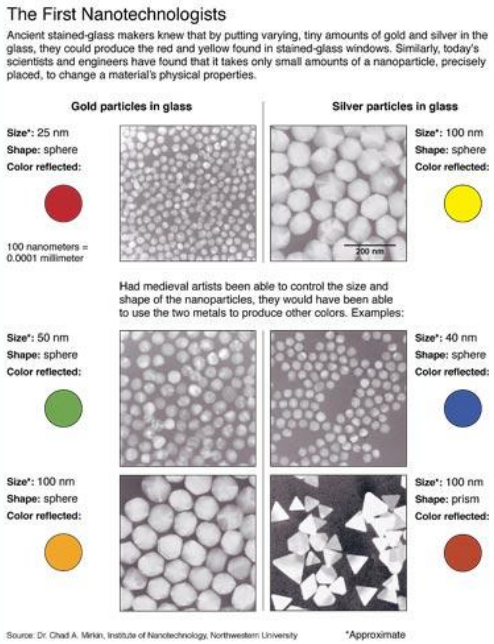


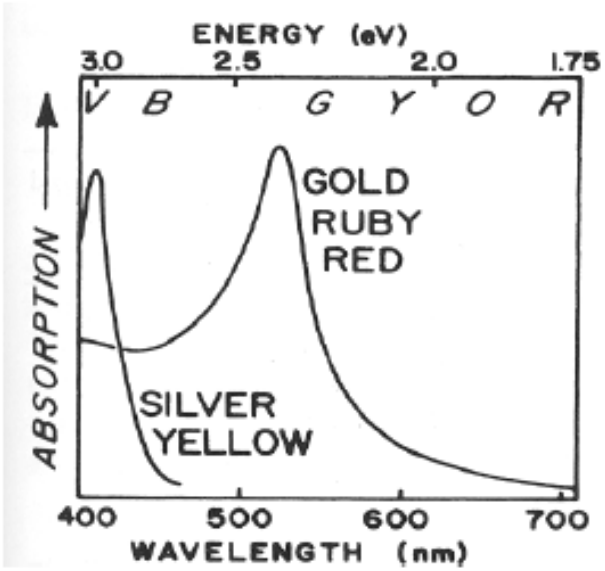


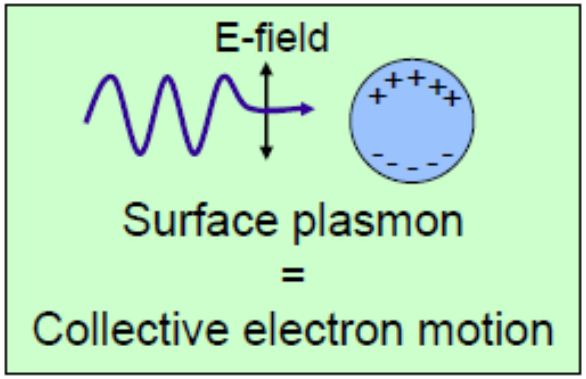


Litt, Penn and Rogers, UIUC

Light at the Nanoscale

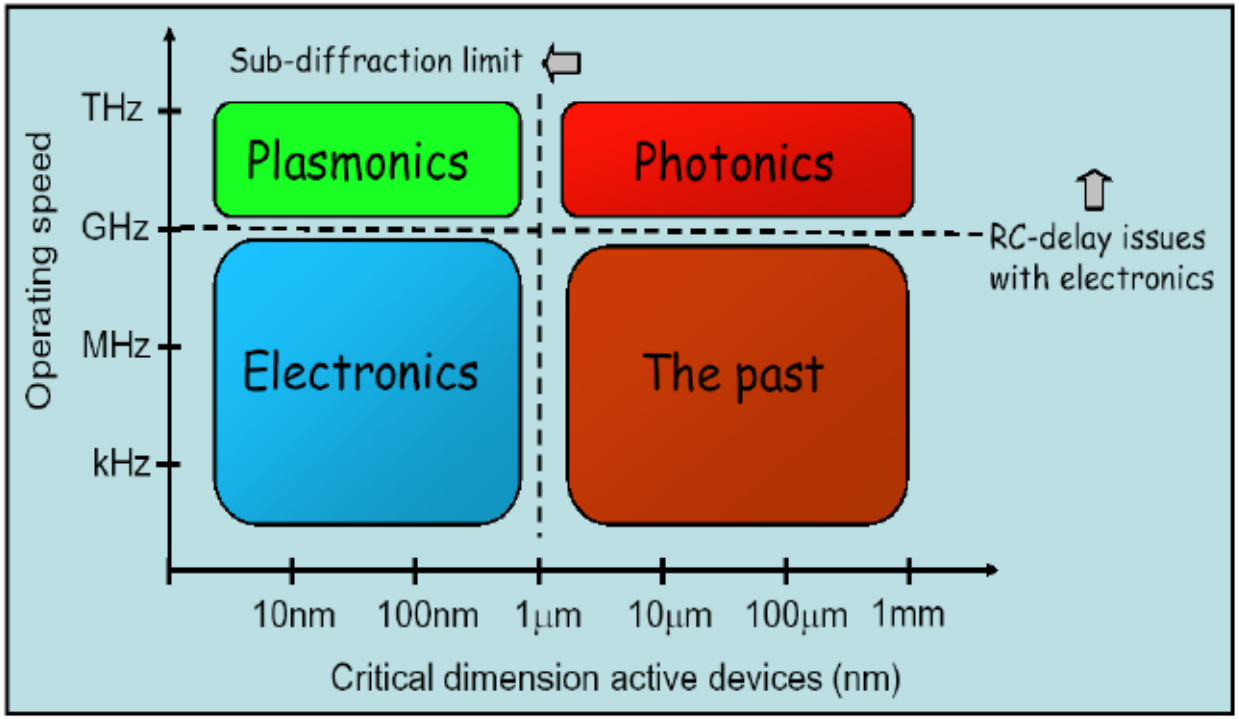






Nanophotonics and Plasmonics

- Graph of the operating regimes of different technologies

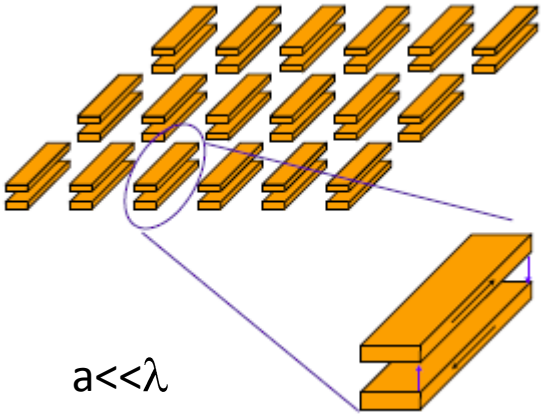


- Plasmonics will enable an improved synergy between electronic and photonic devices
  - ⇨ Plasmonics naturally interfaces with similar size electronic components
  - ⇨ Plasmonics naturally interfaces with similar operating speed photonic networks

Courtesy of M. Brongersma

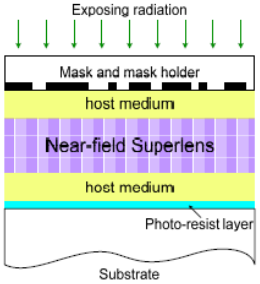
Metal Nanoparticle Assemblies as Building Blocks for Optical Metamaterials

Designing composite materials with electromagnetic properties not found in nature and not observed in the constituent materials

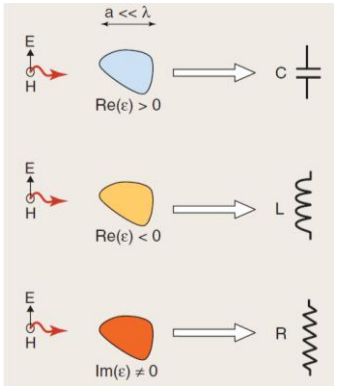


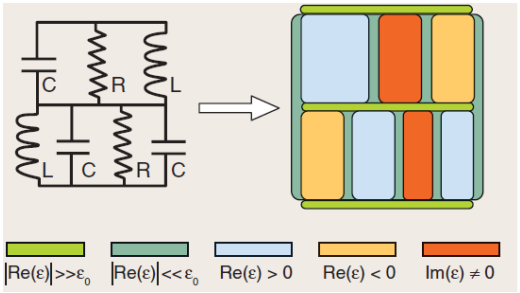
Effective medium Description using Maxwells equation

cloaking



superlenses
sensors
lithography





metatronics = optical nanocircuits

Samsung Galaxy