Semiconductor Processing and Characterization Techniques

Lecture 1: An introduction….

Prof. Shannon Boettcher
University of Oregon Chemistry
and
The Materials Science Institute

Semiconductors and nano/microfabrication are at the heart of essentially all modern technologies

Basic questions we address in this course:

(1) How are semiconductors made?

(2) How do we control their physical properties?

(3) How do we shape them and wire them to create circuit elements and eventually complex devices such as microprocessors?

CMOS transistors

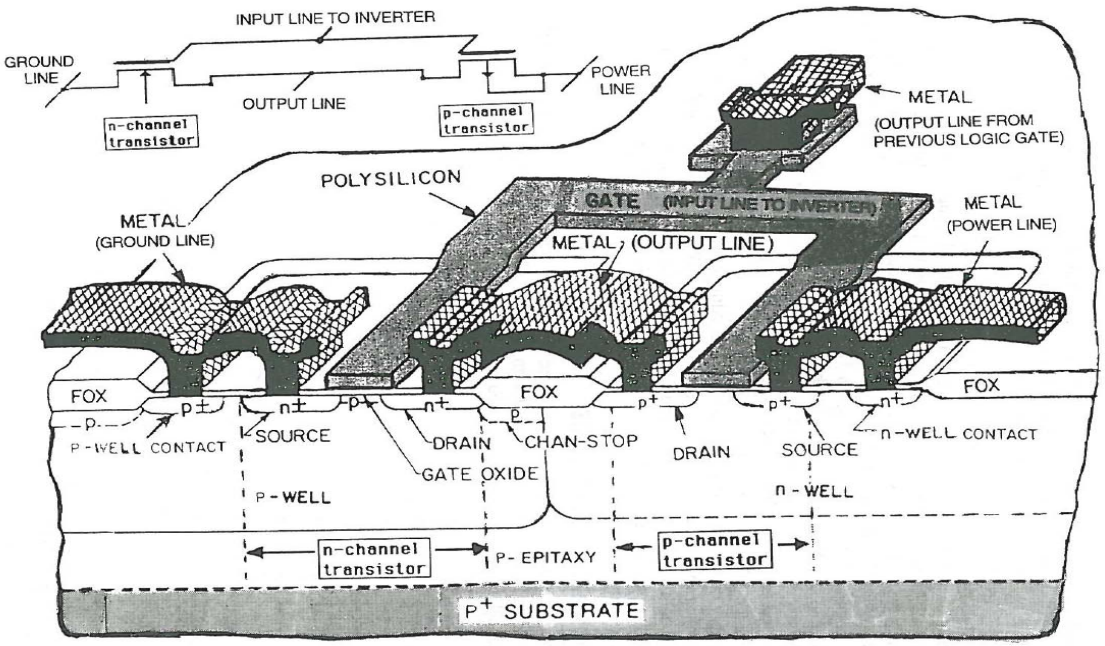
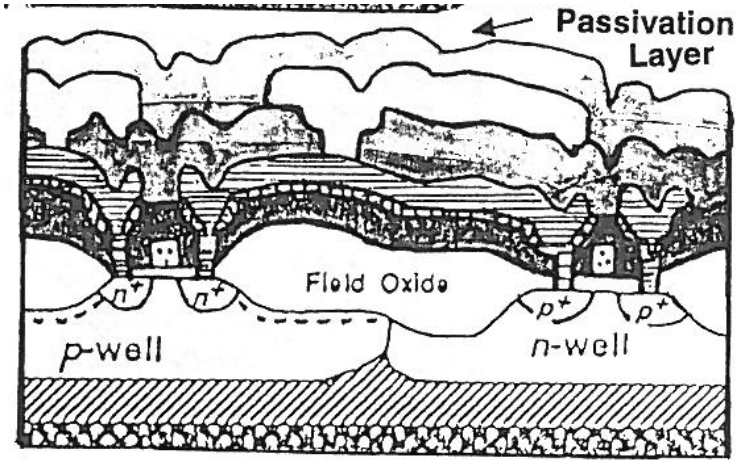


Fig. 16-2 CMOS inverter. (a) Circuit schematic. (b) Device cross section.

Multiple layers, materials, interfaces, How do you assemble?

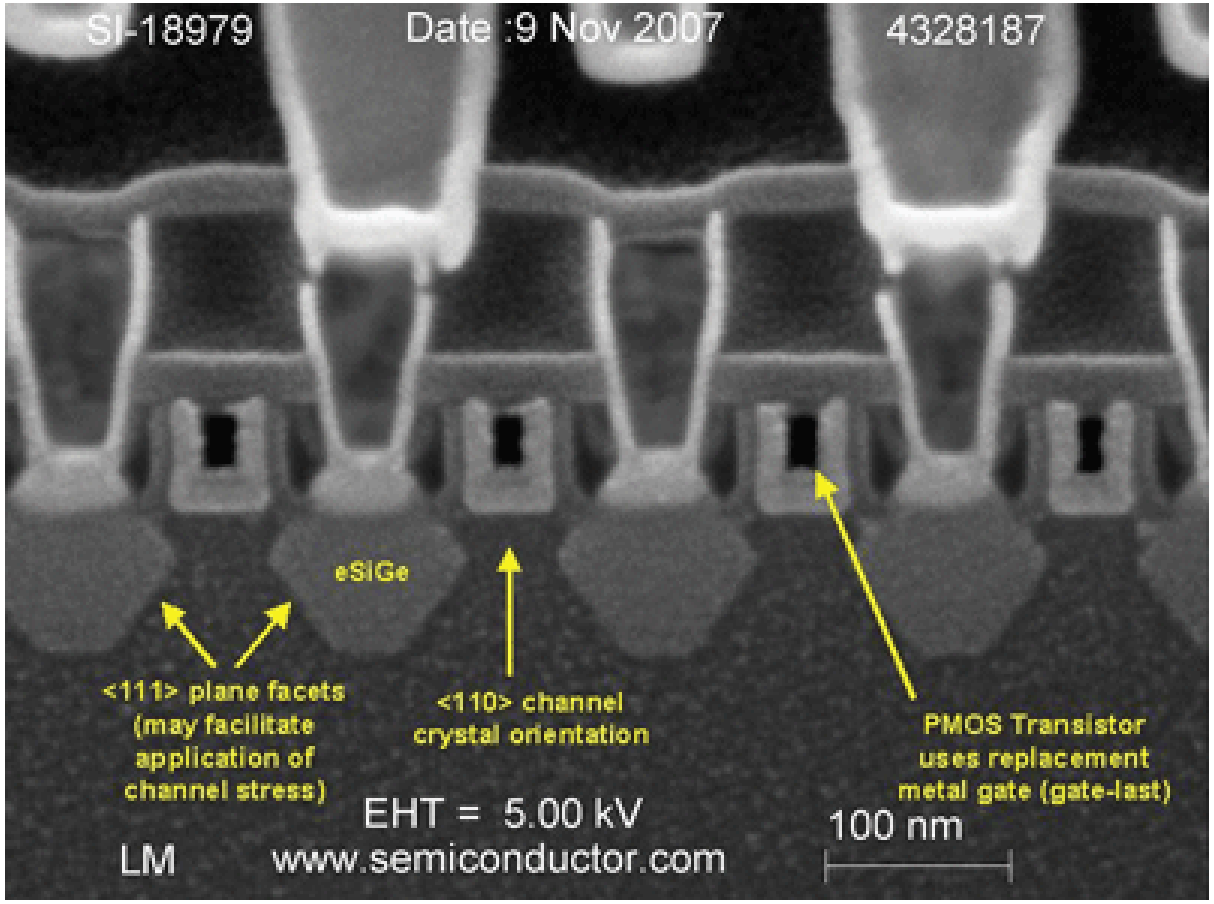
One processing step at a time….



Wolf Chapter 16: CMOS process Integration.

A gallery of engineered complex micro and nanoscale architectures

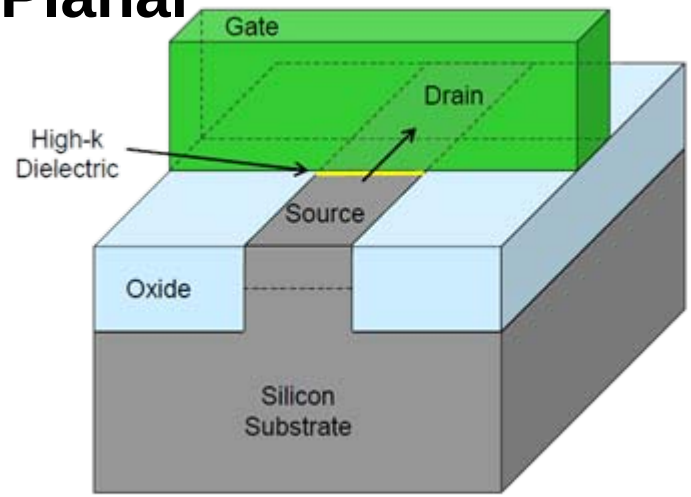
Transistor Design – Intel's 45 nm Platform



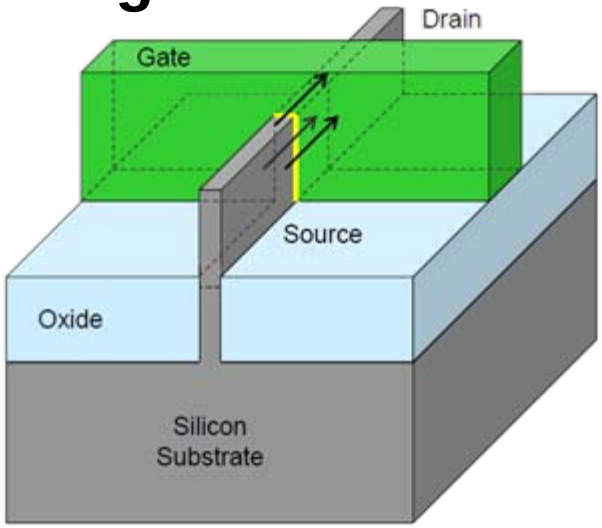
Intel's 45-nm technology: HfO_2 high-k dielectric material, TiN for the NFET replacement gate, and TiN barrier alloyed with a work function metal for the PFET replacement gate. SiGe strain layer.

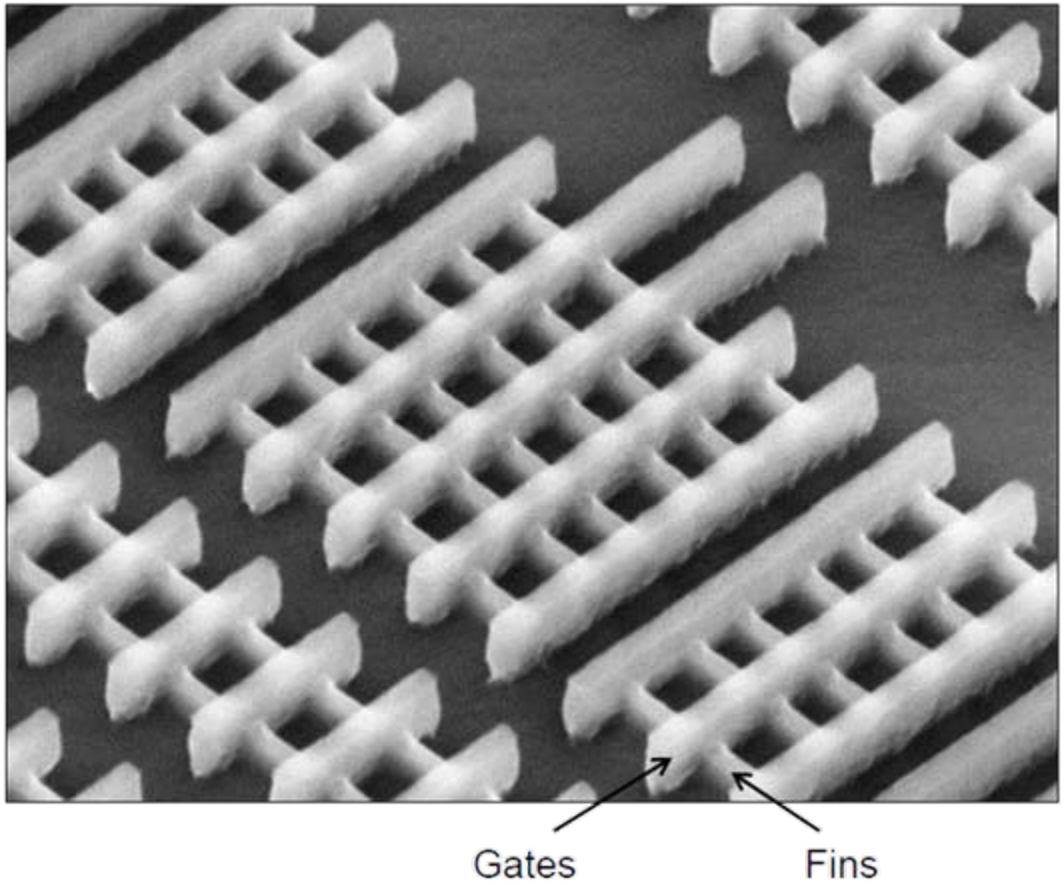
Transistor Design – Intel's 22 nm 3D Platform

Planar



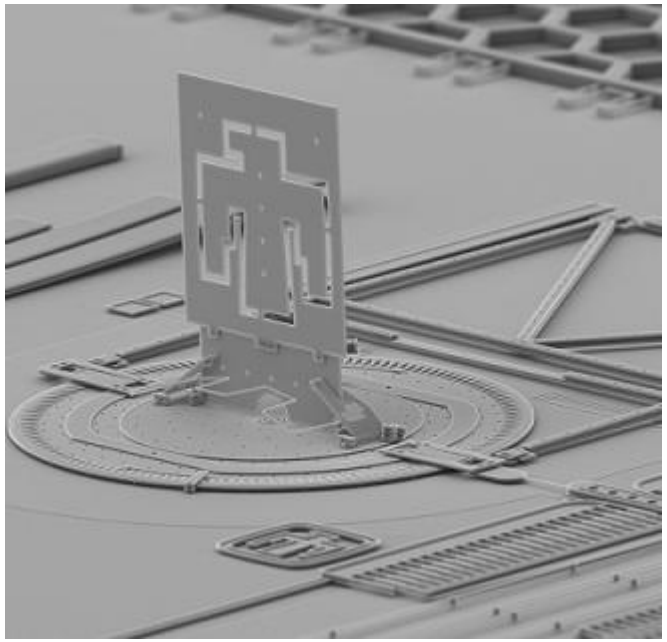
3D Tri-gate



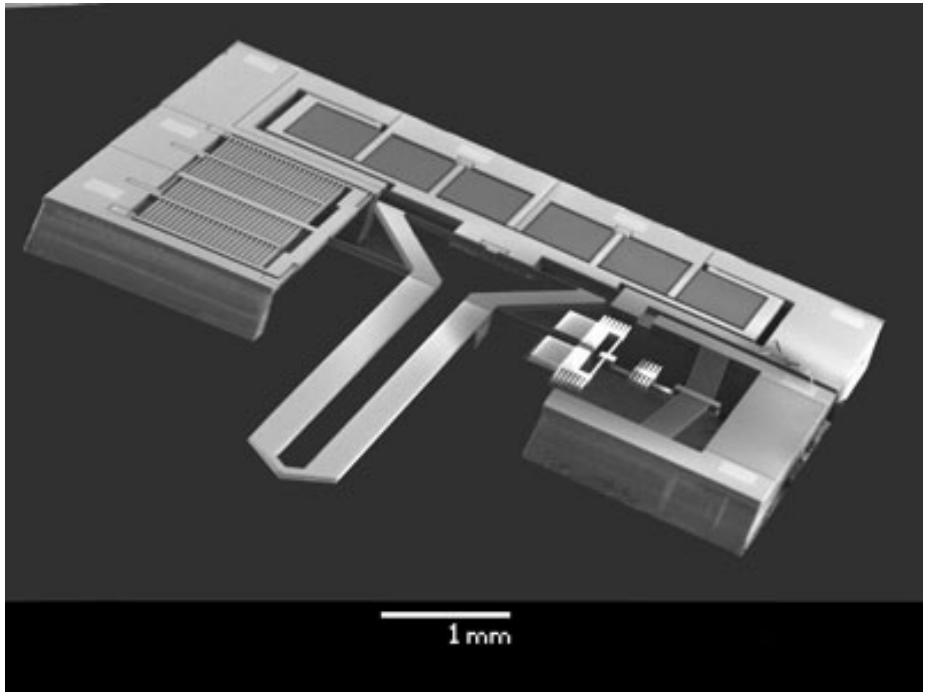


http://download.intel.com/newsroom/kits/22nm/pdfs/22nm-Details_Presentation.pdf

MEMs – Microelectromechanical devices



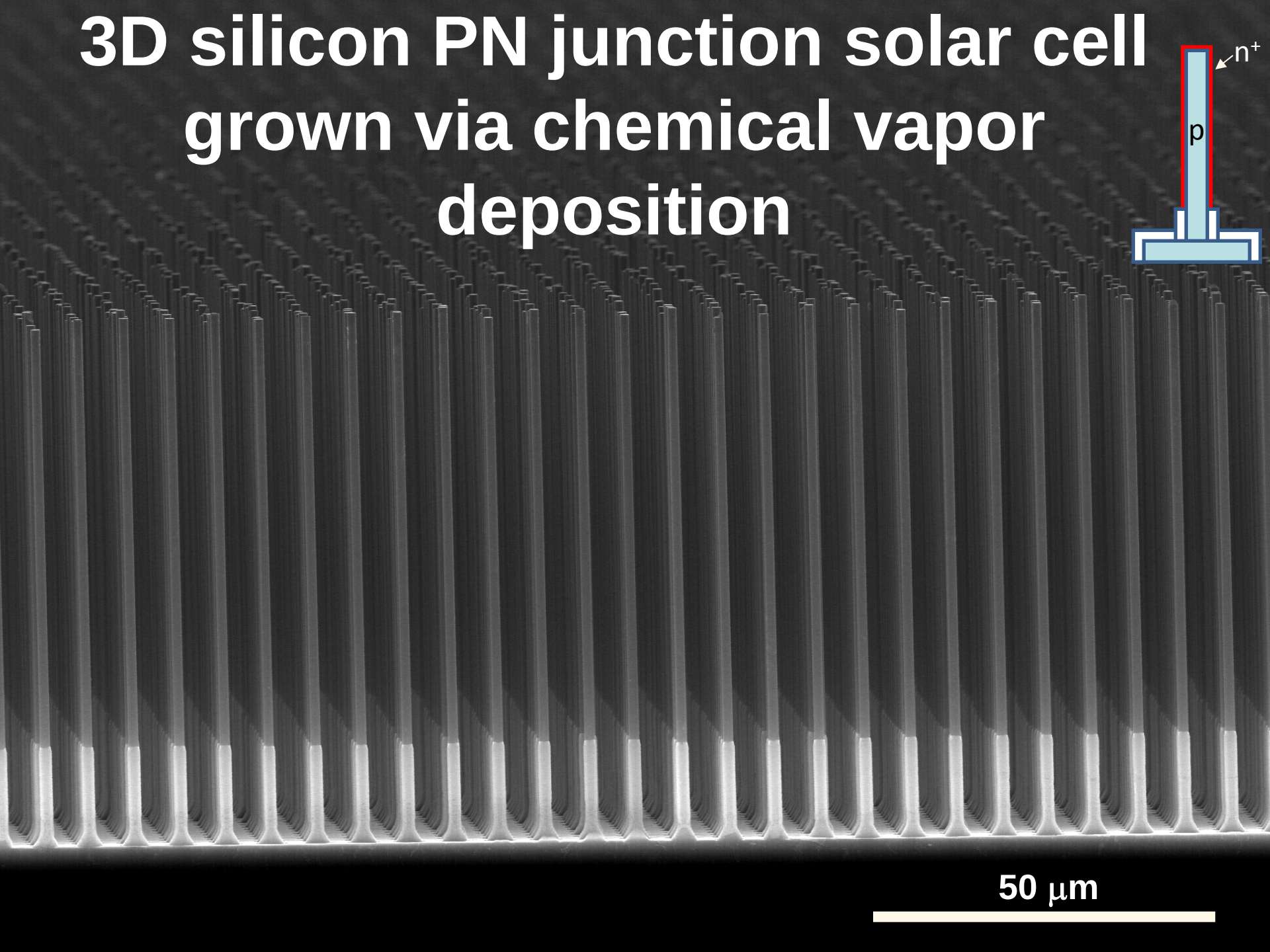
Integrated force sensor



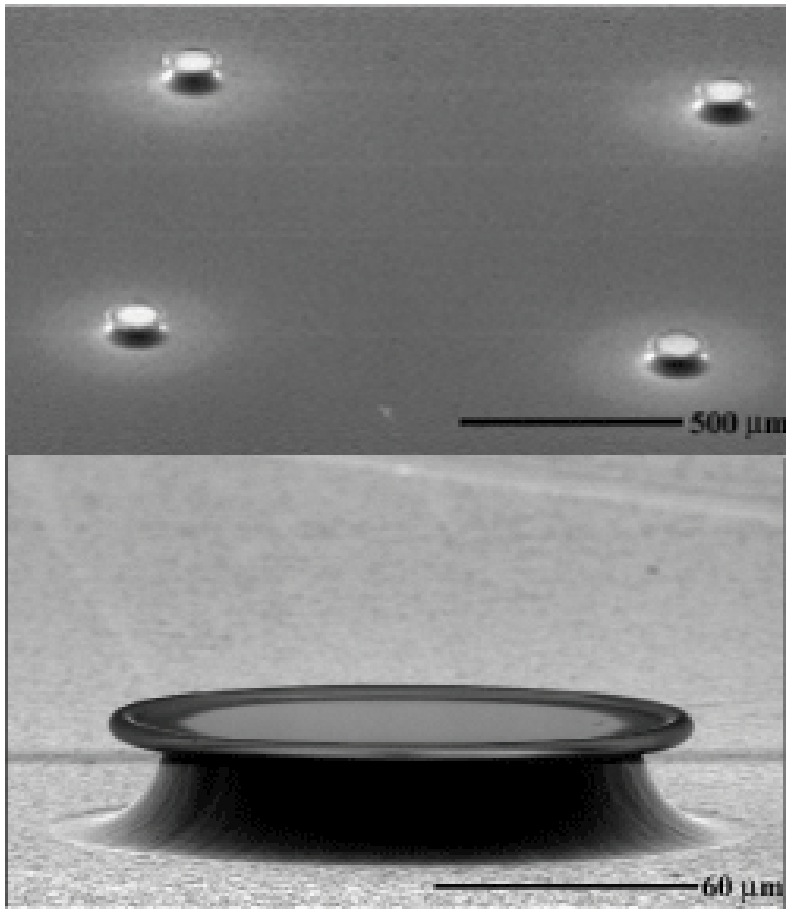
MEMS-based microgripper with integrated two-axis force sensor. (Image: Dr. Sun)

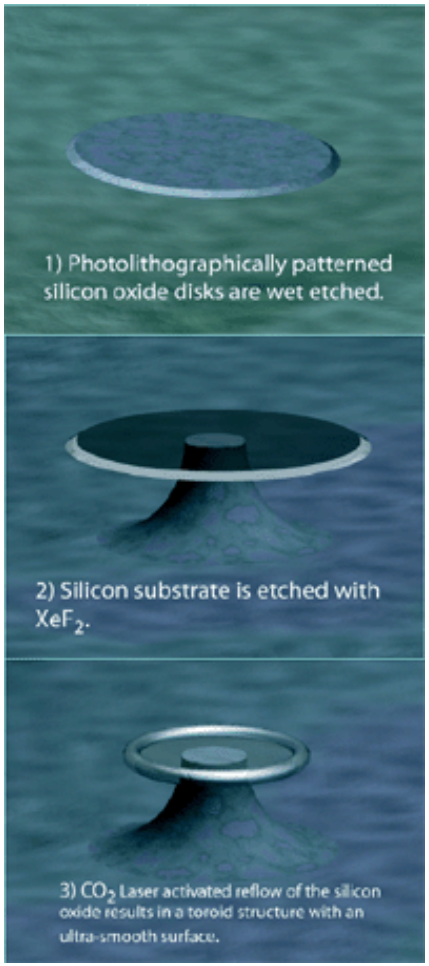
Journal of Micromechanics and Microengineering ("Nanonewton force-controlled manipulation of biological cells using a monolithic MEMS microgripper with two-axis force feedback"

3D silicon PN junction solar cell grown via chemical vapor deposition



High Q – optical microresonator



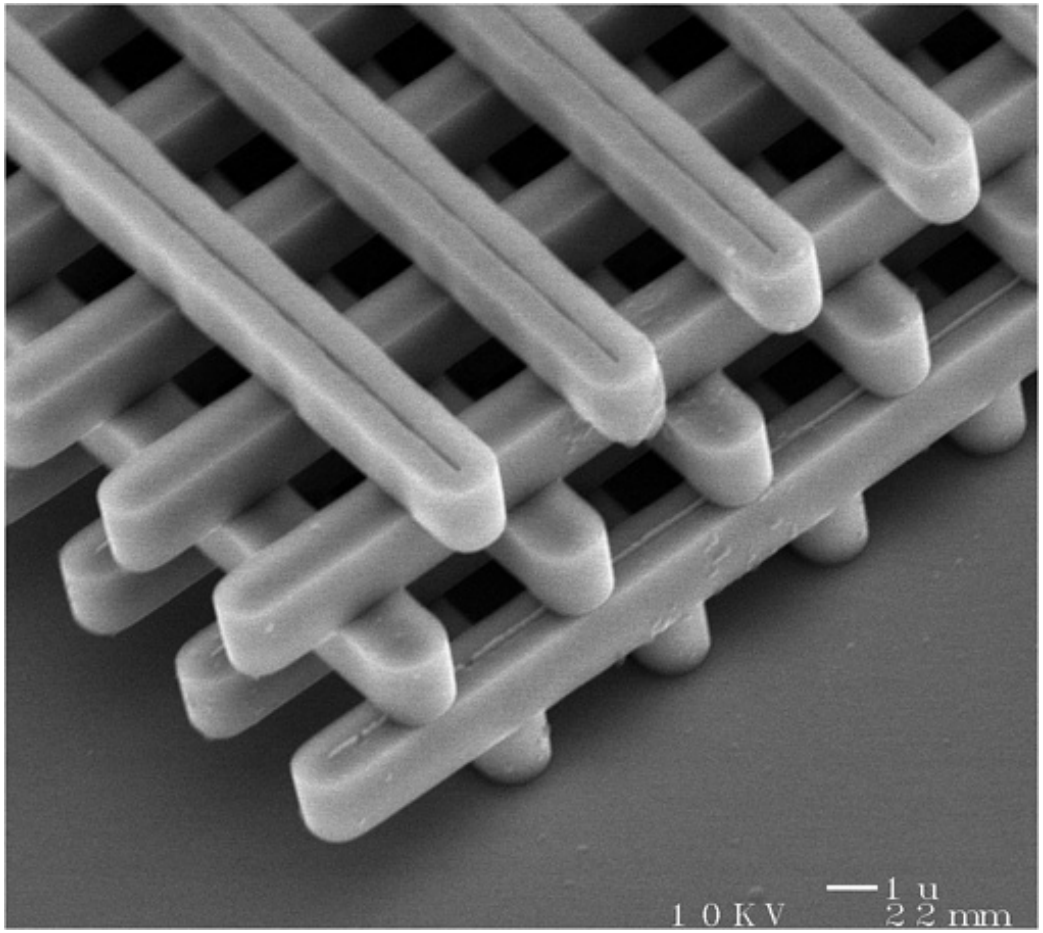


Q > 10^8

D. K. Armani, T. Kippenberg, S. M. Spillane and K. J. Vahala
"Ultra-high-Q toroid microcavity on a chip"
Nature, vol. 421, pp. 925-929, 27 February 2003.

Enables applications in optical sensing, an quantum information.
Enables new physics of light matter interactions to be explored.

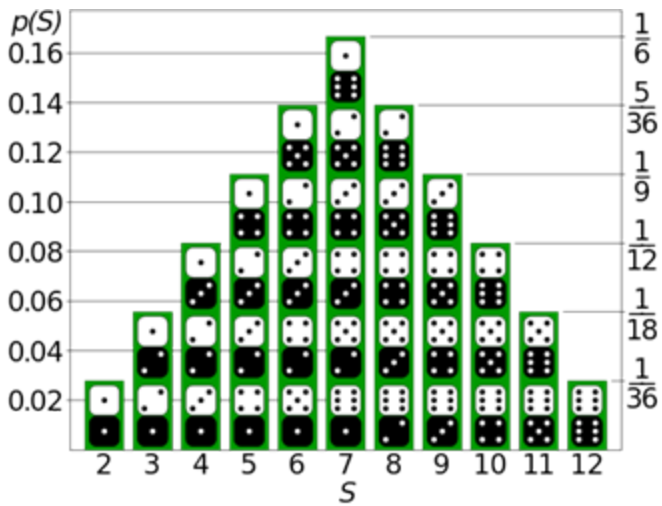
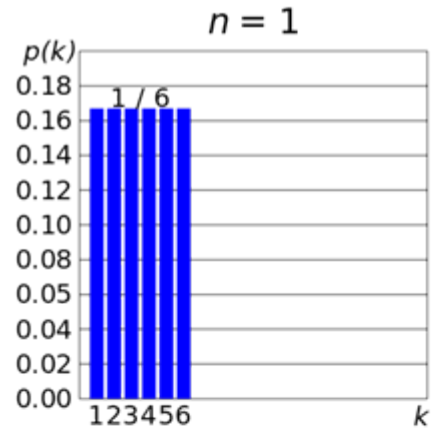
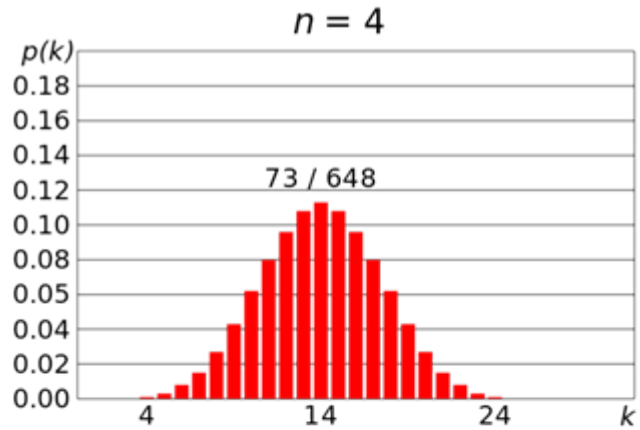
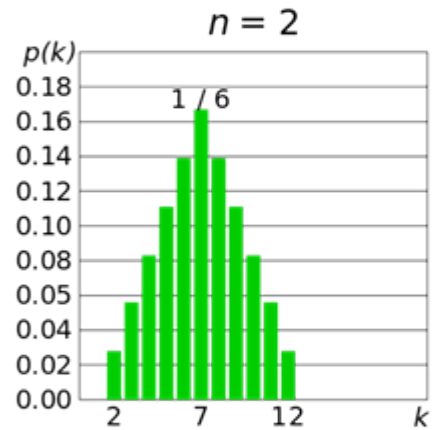
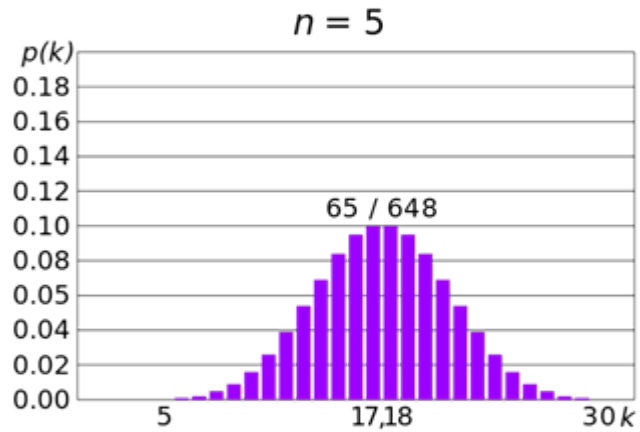
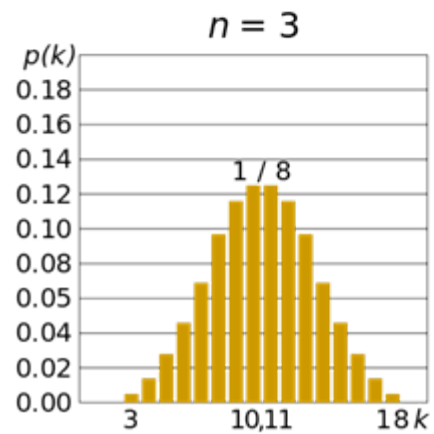
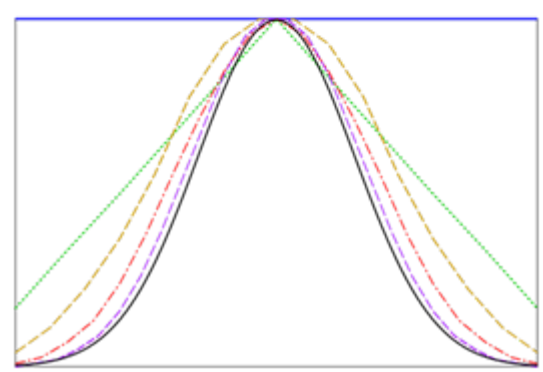
3D “photonic” crystal



- Optical band gap, like electronic band gap in semiconductors
- Potential uses: low-energy lasers, photonic computers, communications

http://www.sandia.gov/media/photonic.htm

Take-home messages

- Semiconductor processing enables new devices – faster and with new functions
- Advances in semiconductor processing are happening – the field is not static
- **Approach: learn fundamental science behind basic processing skills/strategies and problem solving approaches to apply in diverse scenarios.**

Throwing multiple die: