Lecture0: Introduction

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Welcome!

- Electronic Circuits
  - Code: EC3207
  - Lecture 3, no experiment, credit 3
- Prerequisite
  - Electric Circuit Theory
- Instructor, Sung-Min Hong
  - School of Information and Communications (정보통신공학부)
  - Also with GIST College

Textbook

- Fundamentals of Microelectronics
  - An excellent book by B. Razavi
  - Second edition

- Coverage in this course
  - Ch. 2 ➔ Ch. 3 ➔ Ch. 6 ➔ Ch. 17 ➔ Ch. 4 ➔ Ch. 5 ➔ Ch. 8
  - After that, possibly Ch. 16.
  - CMOS first!

Lecture

- Basic information
  - Mon/Wed 13:00-14:15, GIST College Building A, Room 222
  - Handwriting on blackboard(/chalkboard)
  - Supplemented by slides (Just like this!)

- G-Class will be actively used.
  - Please check your e-mail address!

(Mandatory) office hour

- Office hour
  - My SIC office is Room 208, SIC Building A.
  - Special sessions are available by appointment.
  - *You have to visit my office once, at least. (I will give the plan two weeks later.)*

SIC Building A, Room 208

We are here.

Evaluation

- Attendance (20%)
  - Answering the review questions
  - In addition to 20%, there is the “2/3 rule”, dictated by the college.
- Homework (20%)
  - A few Homework sets & EDISON
- Midterm (30%)
- Final (30%)
  - Covering the whole semester

- (The weighting factors are subject to change.)

No lecture days

- Buddha's birthday (석가탄신일)
  - No lecture on May 25.
- In total, there will be 26 lectures.
- Final exam
  - June 10 (It's not June 15!)

Lecture plan

Mon	Tue	Wed	Thu	Fri	Sat	Sun
L1(3.2)		L2(3.4)				
L3(3.9)		L4(3.11)				
L5(3.16)		L6(3.18)				
L7(3.23)		L8(3.25)				
L9(3.30)		L10(4.1)				
L11(4.6)		L12(4.8)				
L13(4.13)		L14(4.15)				
Mid-term						
L15(4.27)		L16(4.29)				
L17(5.4)		L18(5.6)				
L19(5.11)		L20(5.13)				
L21(5.18)		L22(5.20)				
		L23(5.27)				
L24(6.1)		L25(6.3)				
L26(6.8)		**Final**				

Any questions?

- ???

Lecture1: Basic physics of semiconductor (1)

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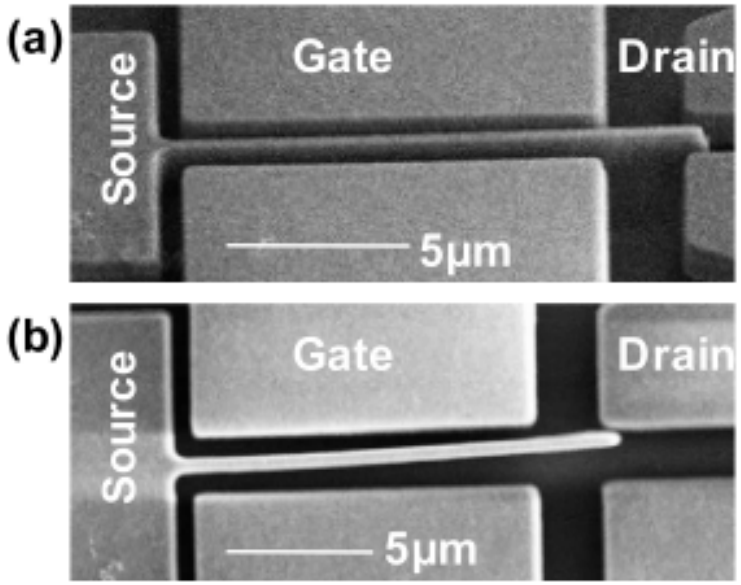
Electronic circuit

- Our course is not about the semiconductor physics.

- Why do we consider the basic physics of semiconductor?
  - Especially, silicon.

In principle,

- There can be various ways to realize a component in the electronic circuit.
  - Even without semiconductors!
- For example,
  - NEM relay



S. Chong et al., ICCAD, 2009

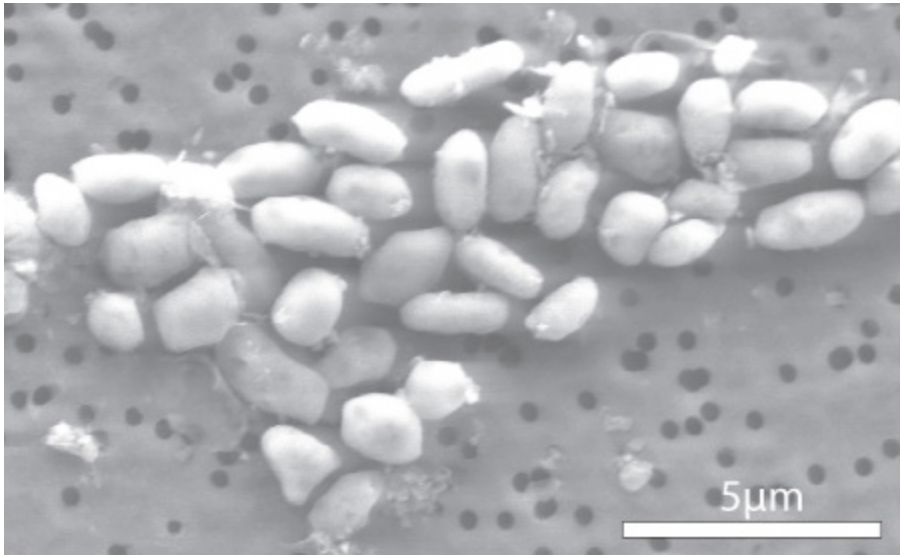
In reality,

- Currently, ***only semiconductor technologies*** can achieve the tough specifications required.
  - Performance
  - Power consumption
  - Reliability
  - Variability
  - And most importantly, cost!

- That's the reason why we first study the semiconductors.

Analogy

- SF writers sometimes imagine that the carbon-based life is not the only form of the living creature.

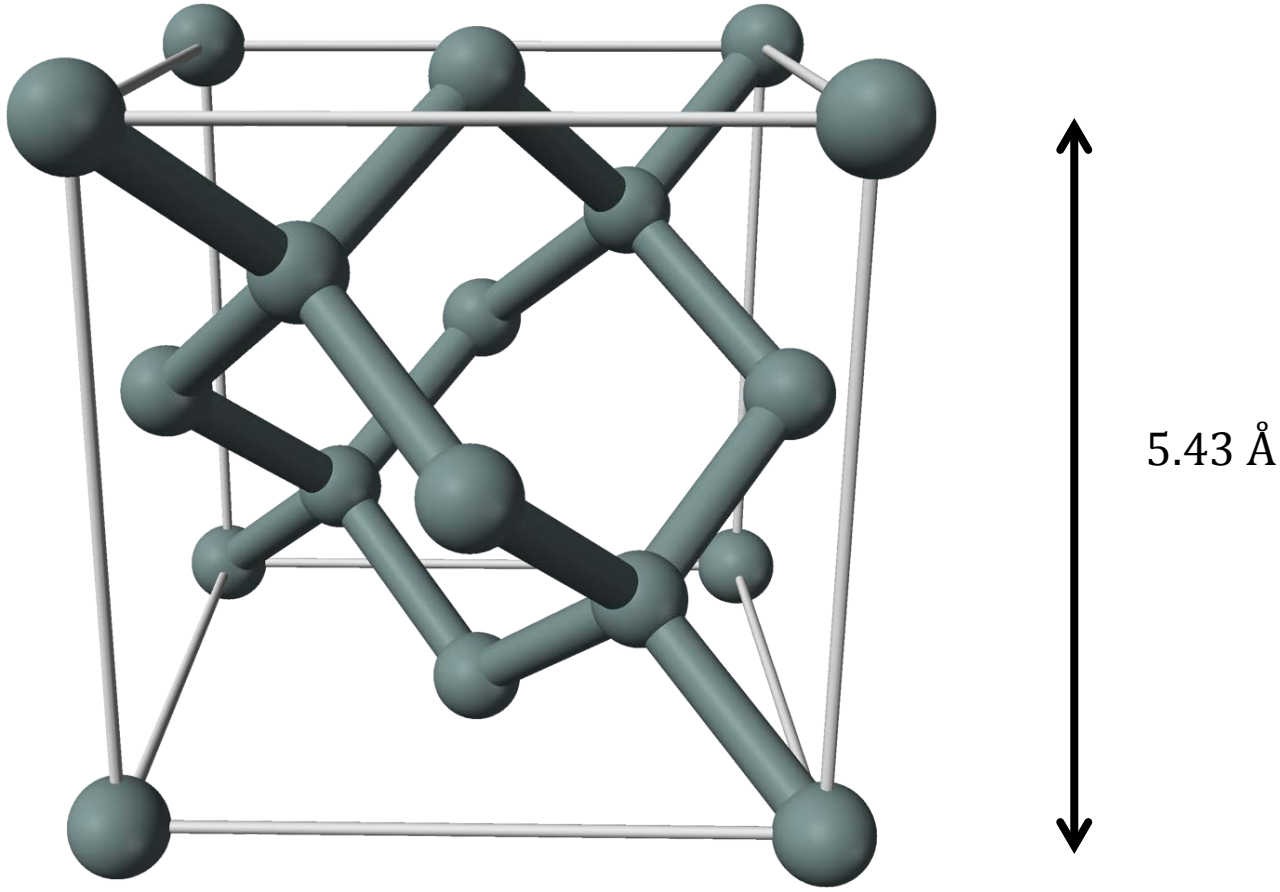


Magnified cells of bacterium GFAJ-1 (Wikipedia)

- However, in reality?

Crystal structure of Si

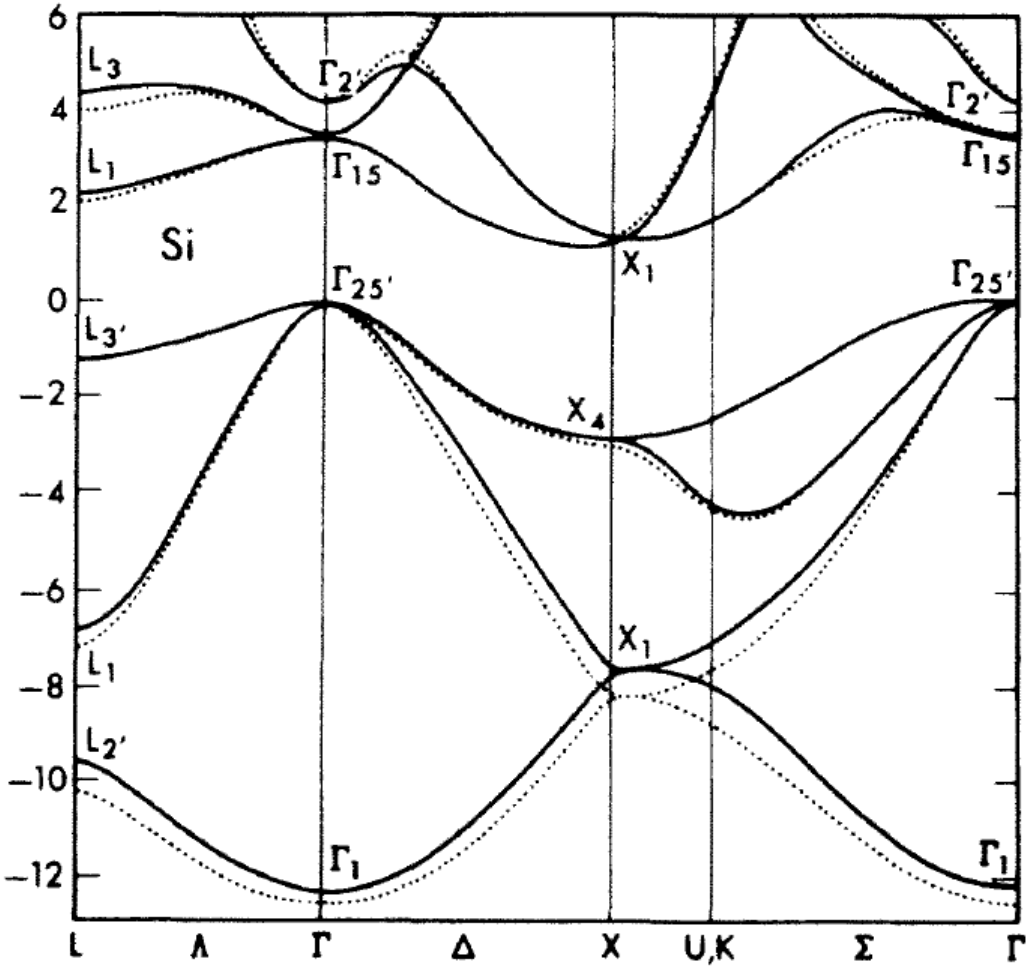
- Diamond cubic crystal structure



Taken from Wikipedia

Band structure

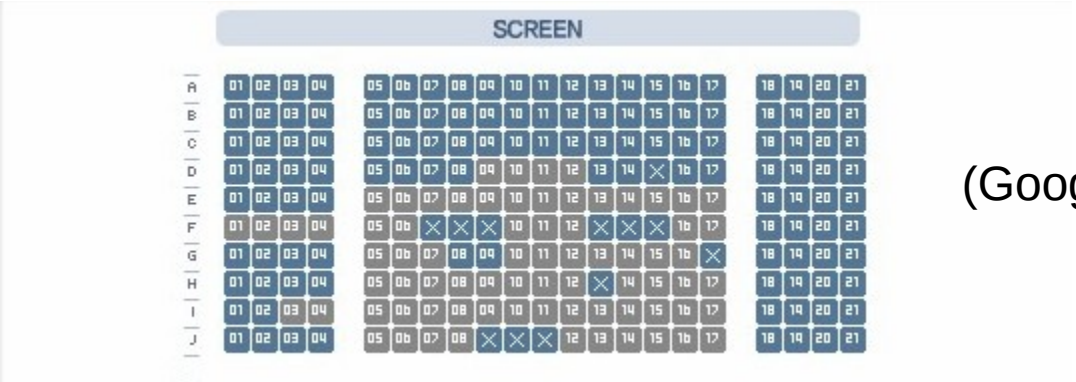
- Band structure of silicon (Band gap ~ 1.12eV)



(J. R. Chelikowsky and M. L. Cohen,
PRB, vol. 14, p. 556, 1976)

Reservation of seats

- In a movie theater,
  - Assume that you must reserve several movie tickets for your group members.
  - They are not rich at all.
  - Different seats with different prices!



(Google Image)

- In this analogy,
  - Price = energy

Thermal energy

- At higher temperatures, electrons gain thermal energy.
  - The covalent bonds are broken.
  - They act as free charge carriers.
- Concept of holes
  - When freed from a covalent bond, an electron leaves a “void” behind.
  - It – the void – is called a “hole.”

(Google Image)

Intrinsic carrier density

- What is the intrinsic carrier density, n_i?
  - How many “free” electrons are created at a given temperature?
  - (Assume the intrinsic material.)
- Expression of n_i

$$n_i = 5.2 \times 10^{15}\, T^{1.5} \exp\frac{-E_g}{2k_B T} \quad [electrons/cm^3]$$

  - Boltzmann constant, k_B