VE320 – Summer 2024

Introduction to Semiconductor Devices

Instructor: Yaping Dan （但亚平）
yaping.dan@sjtu.edu.cn

Chapter 0. Course Information and Preview

Outline

- **Course Information**
- Preview

Course Information

- Time: Tuesday 16:00-17:40
  Thursday 16:00-17:40
  Friday 16:00-17:40 (odd weeks)

- Instructor: Professor Dan, Yaping
  JI New Building Office 516
  Email: yaping.dan@sjtu.edu.cn

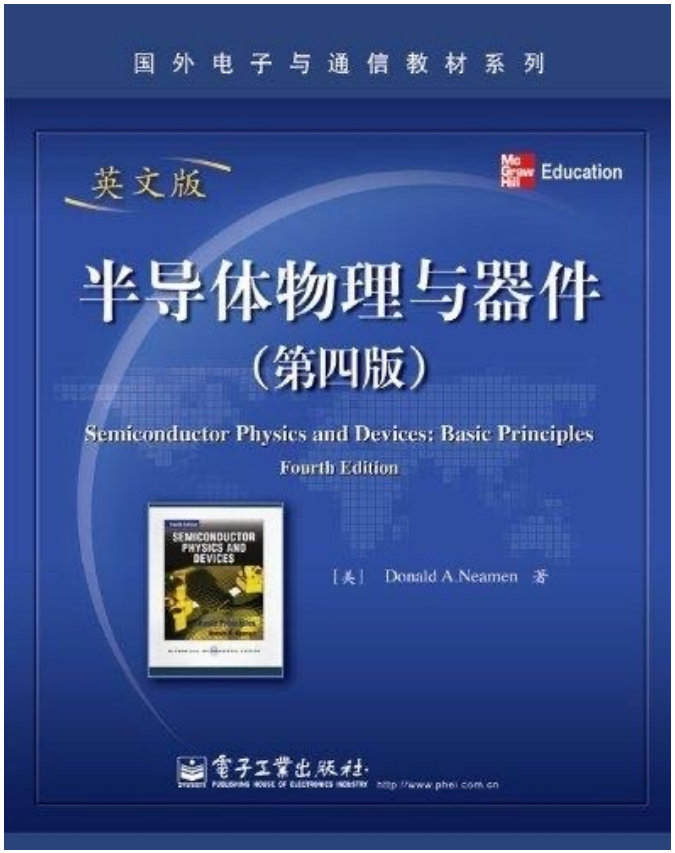
- Office Hour: 10am-12pm Tuesday, Thursday

- Teaching Assistants:

  - Zhou, Zhiyu : 020507zzy@sjtu.edu.cn
  - Chen, Zhuojia: chenzhuojia@sjtu.edu.cn
  - Zhou, Yuhao: zhouyuhao@sjtu.edu.cn

Reference textbook

Semiconductor Physics and Devices: Basic Principles 4th ed.
Donald A. Neamen
Publishing house of electronic industry



Grading Policy and Assignments

Grading Policy

• Activity & attendance in class and Piazza	7%
• Assignments	8%
• Midterm1(open book)	25%
• Midterm2(open book)	25%
• Final(open book)	35%
	100%

- Overall score lower than 40 is F
- Bonus: one-on-one QA for those above 40 10%
- Curve to be centered at B+ or A- for those above 40.

Assignments and Unethical Conducts

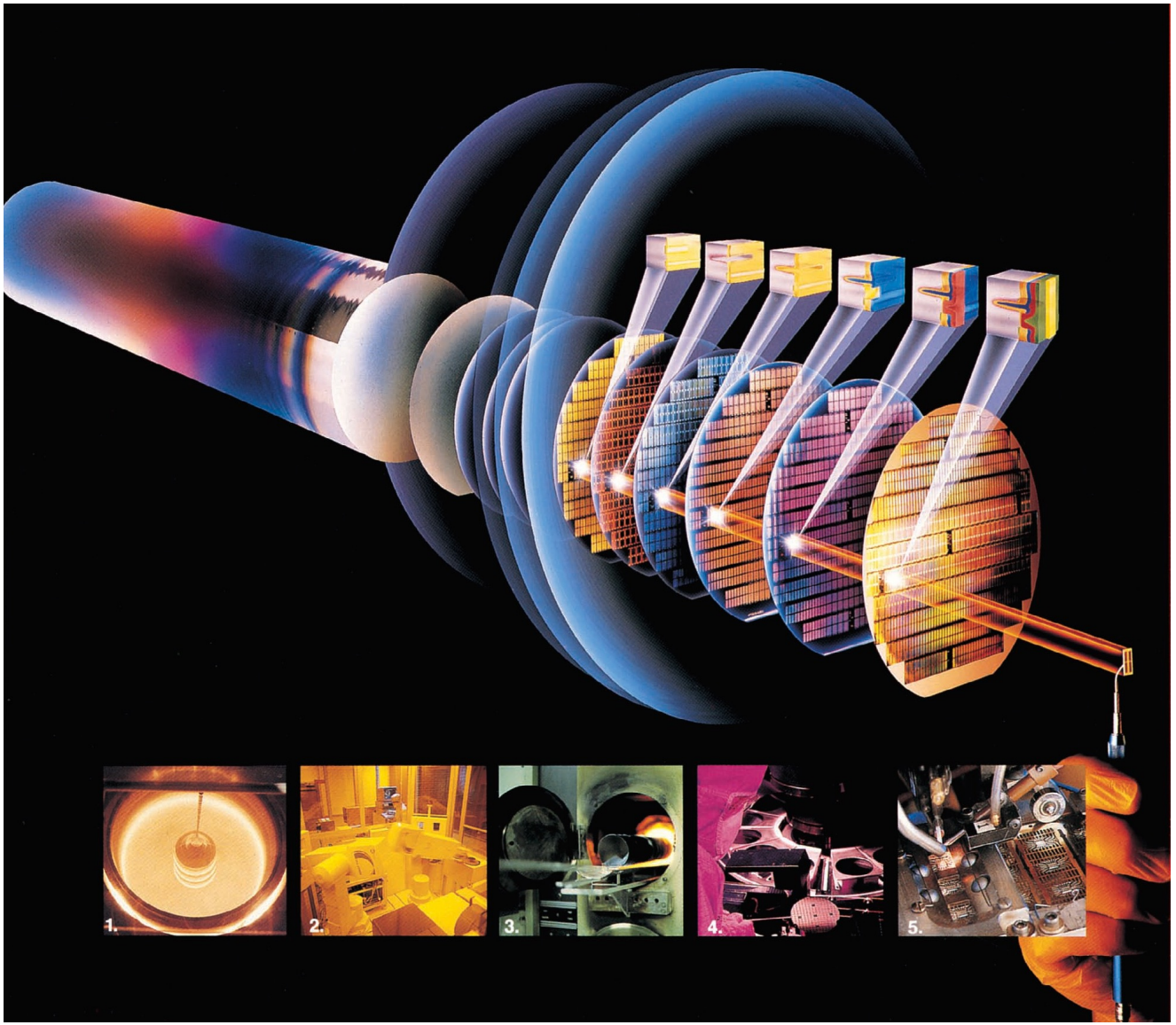
- Assigned weekly and due on the following week.
- Approximately seven problems each assignment.

- You are free to discuss homework with each other. But the work you submit must be your own.
- Any suspicious violation of the honor code will be reported to the honor council.
- Midterm and final exams are open-book.
- No internet access and no discussion during the exams.

Outline

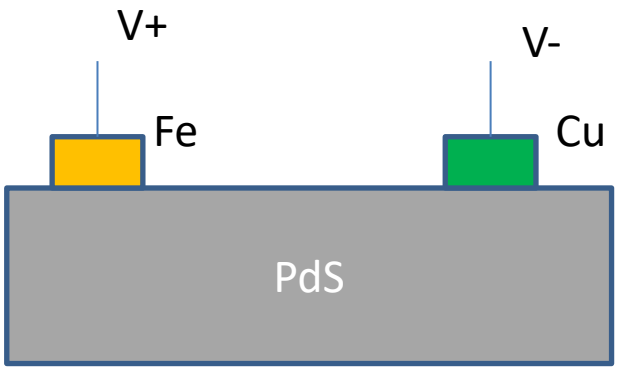
- Course Information
- **Preview**

Preview: Semiconductors and Integrated Circuits



Preview: Semiconductors and Integrated Circuits

The first semiconductor device:



Braun in 1874

Karl Ferdinand Braun

Shared the 1909 Nobel Prize in Physics with Guglielmo Marconi
“ for their contributions to the development of wireless telegraphy"

Preview: Semiconductors and Integrated Circuits

Quantum Mechanics → Semiconductor Physics

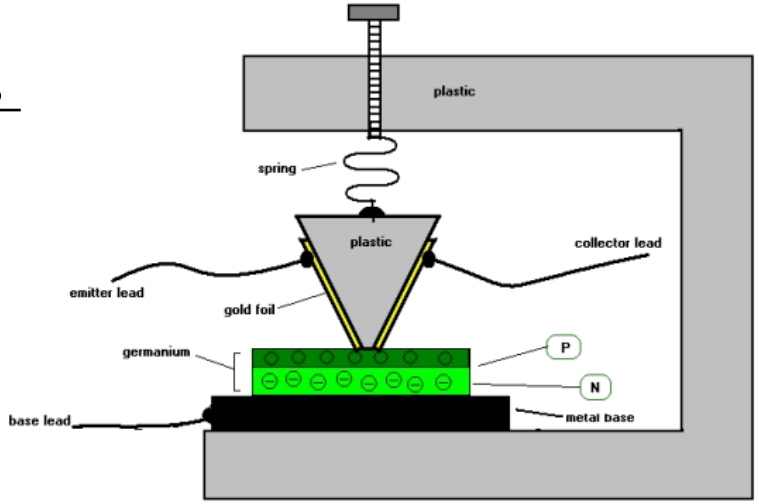
(1900 - 1950s)

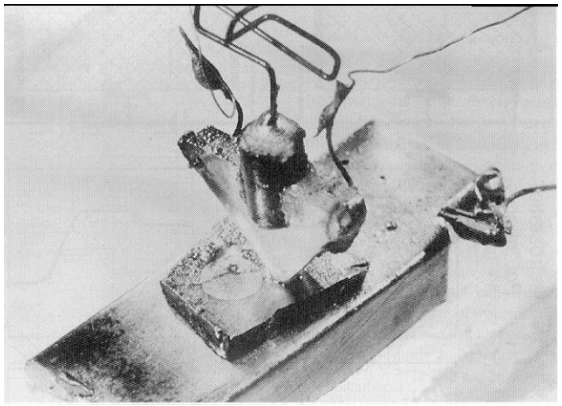
Max Planck, Niels Bohr, Werner Heisenberg, Louis de Broglie, Arthur Compton, Albert Einstein, Erwin Schrödinger, Max Born, John von Neumann, Paul Dirac, Enrico Fermi, Wolfgang Pauli, Max von Laue, Freeman Dyson, David Hilbert, Wilhelm Wien, Satyendra Nath Bose, Arnold Sommerfeld, and others.

Preview: Semiconductors and Integrated Circuits

Explosion of integrated circuits

John Bardeen, William Shockley, and Walter Brattain at Bell Labs, 1948





First transistor Bell Labs, 1948
Based on Ge (锗)

Preview: Semiconductors and Integrated Circuits

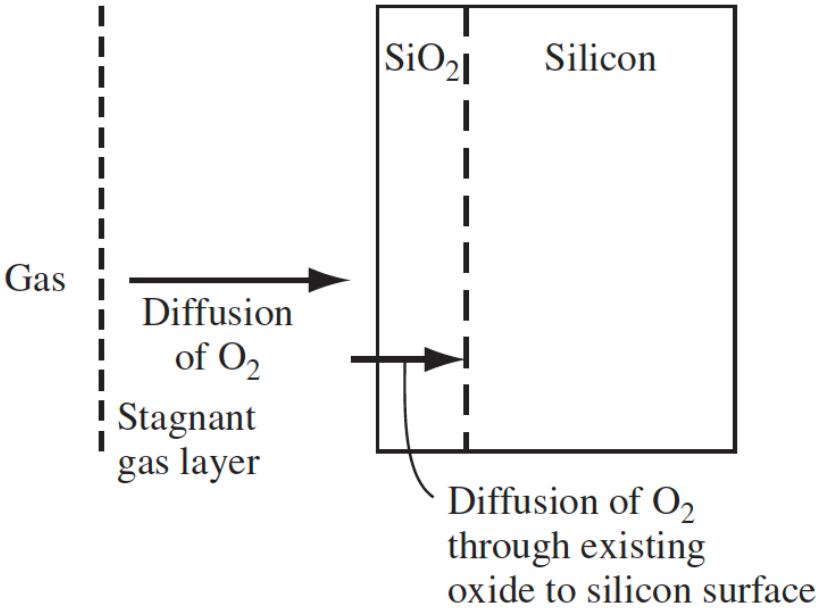
Silicon Valley

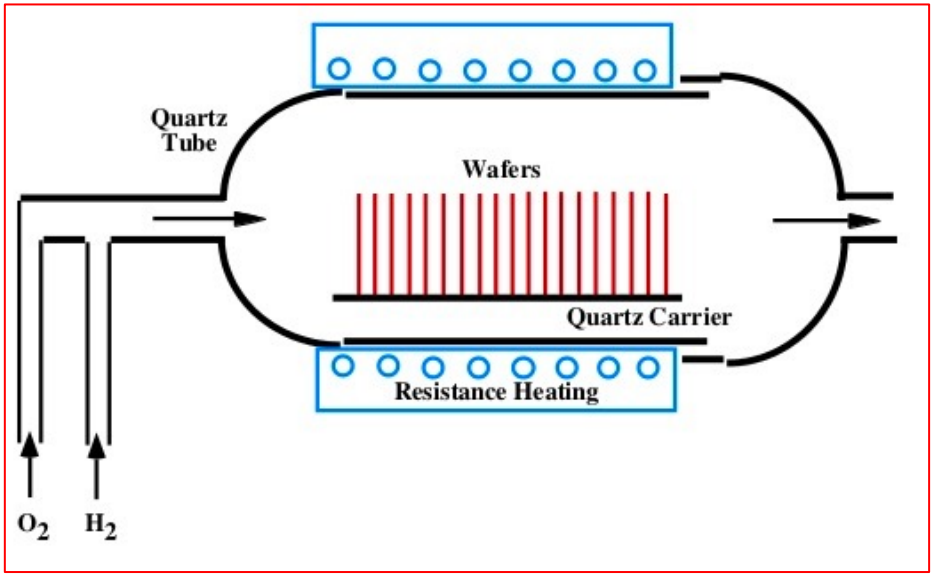
Bell Lab, New Jersey

Original site at California

Preview: Fabrication of Integrated Circuits

Thermal oxidation

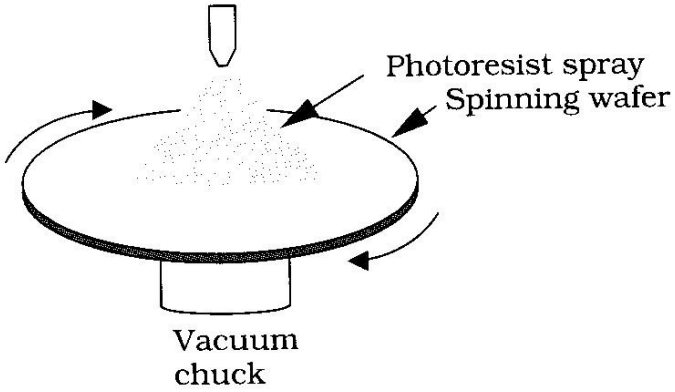




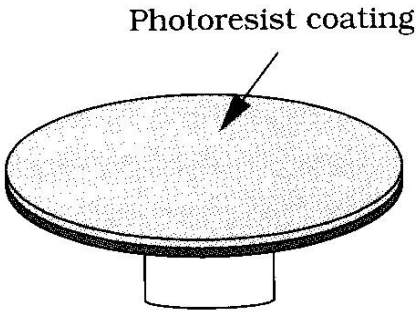
SiO_2: high quality electrical insulator

Preview: Fabrication of Integrated Circuits

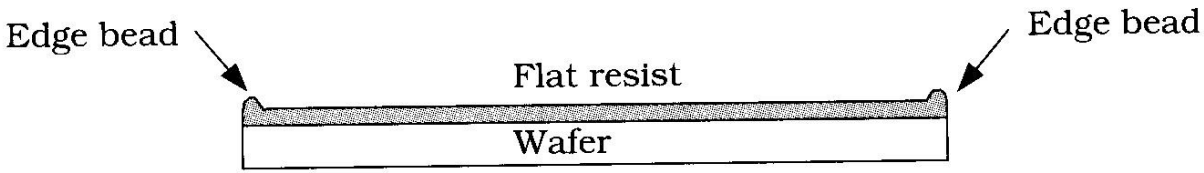
Photoligthography



(a) Resist application



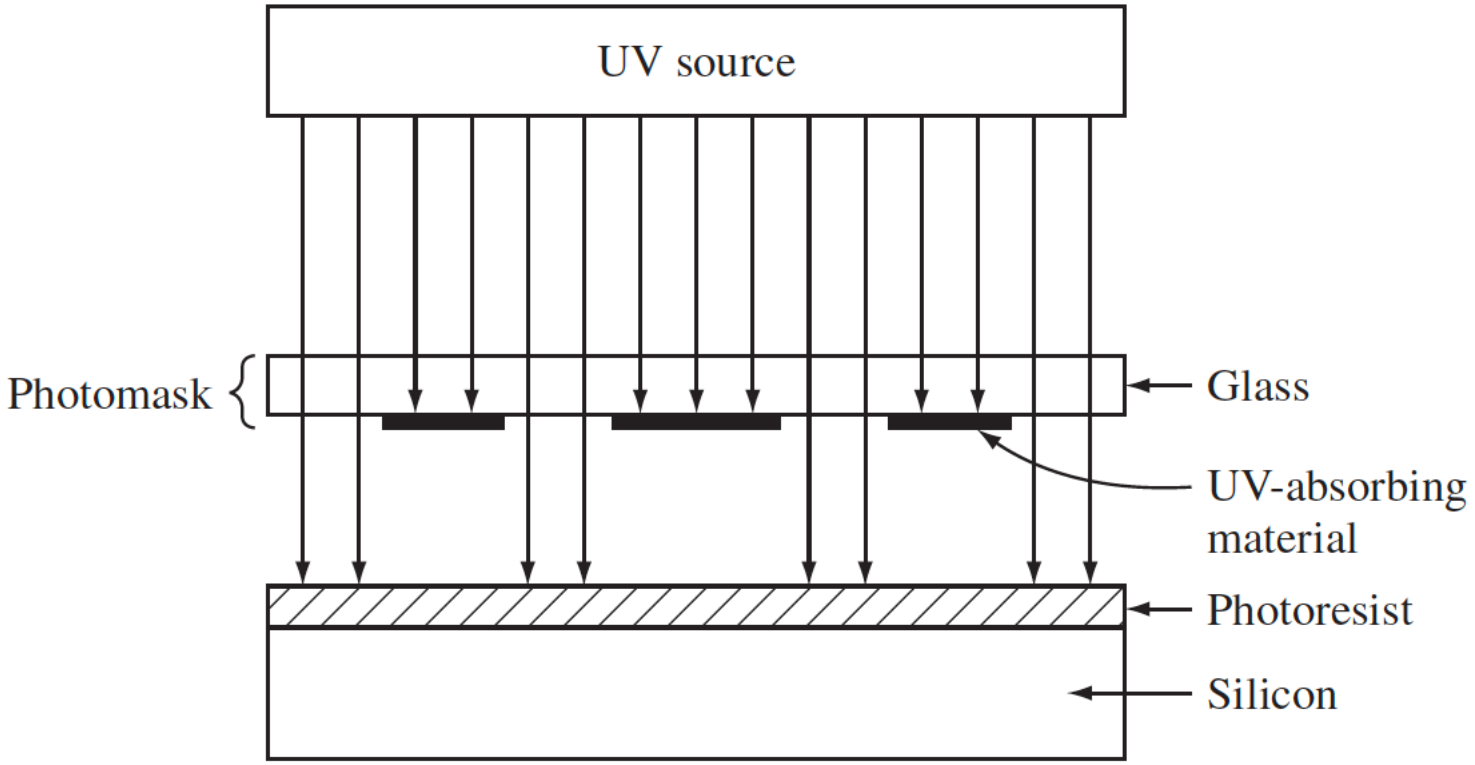
(b) Coated wafer



(c) Beading

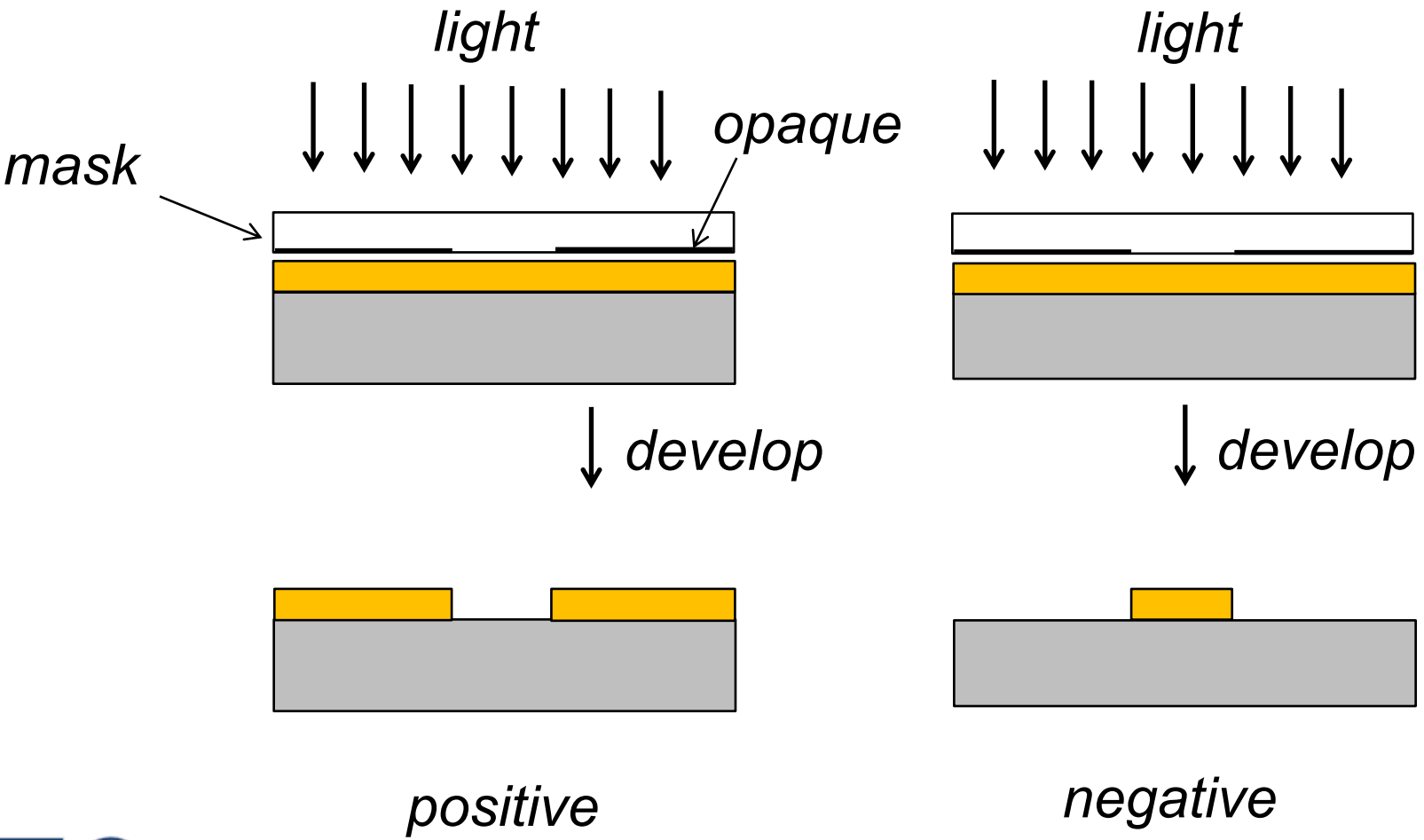
Preview: Fabrication of Integrated Circuits

Photoligthography



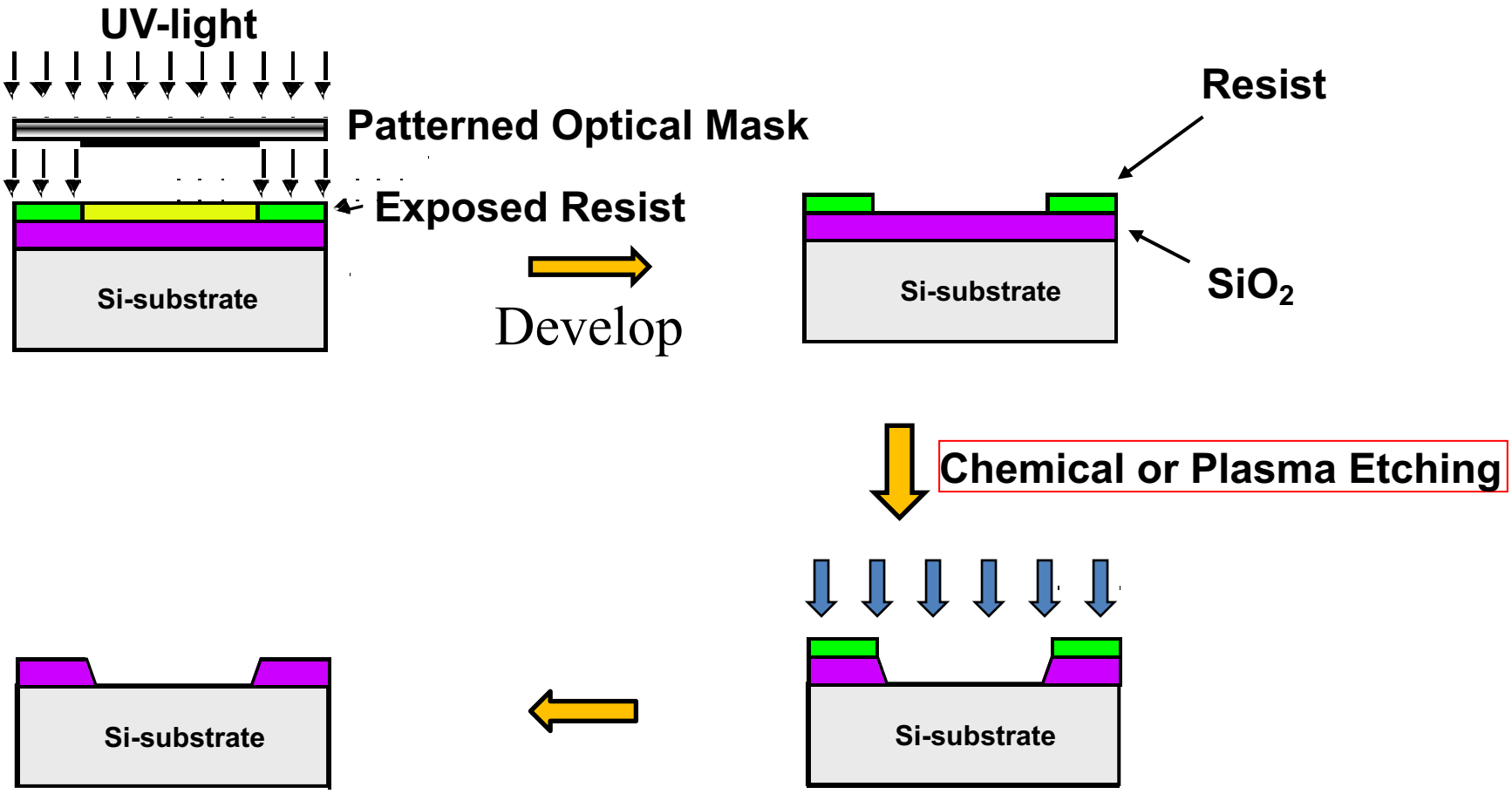
Preview: Fabrication of Integrated Circuits

Photoligthography



Preview: Fabrication of Integrated Circuits

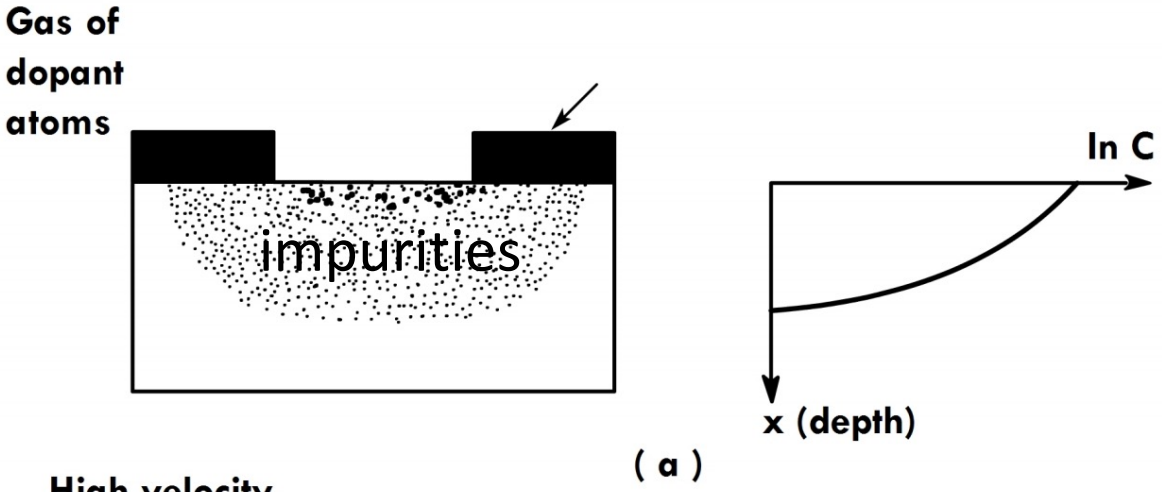
Etching



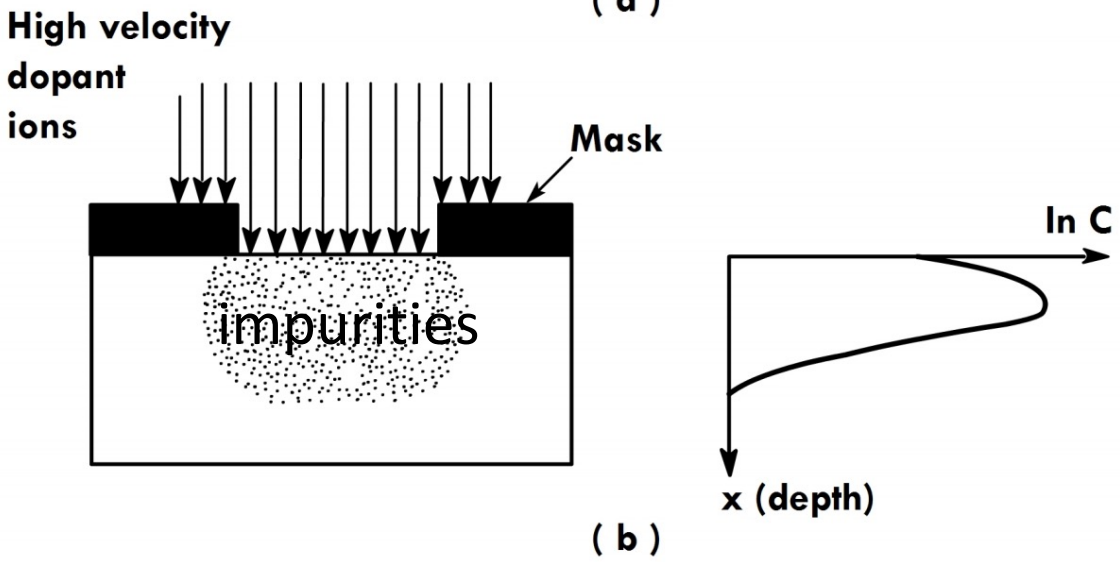
Preview: Fabrication of Integrated Circuits

Doping

Thermal diffusion

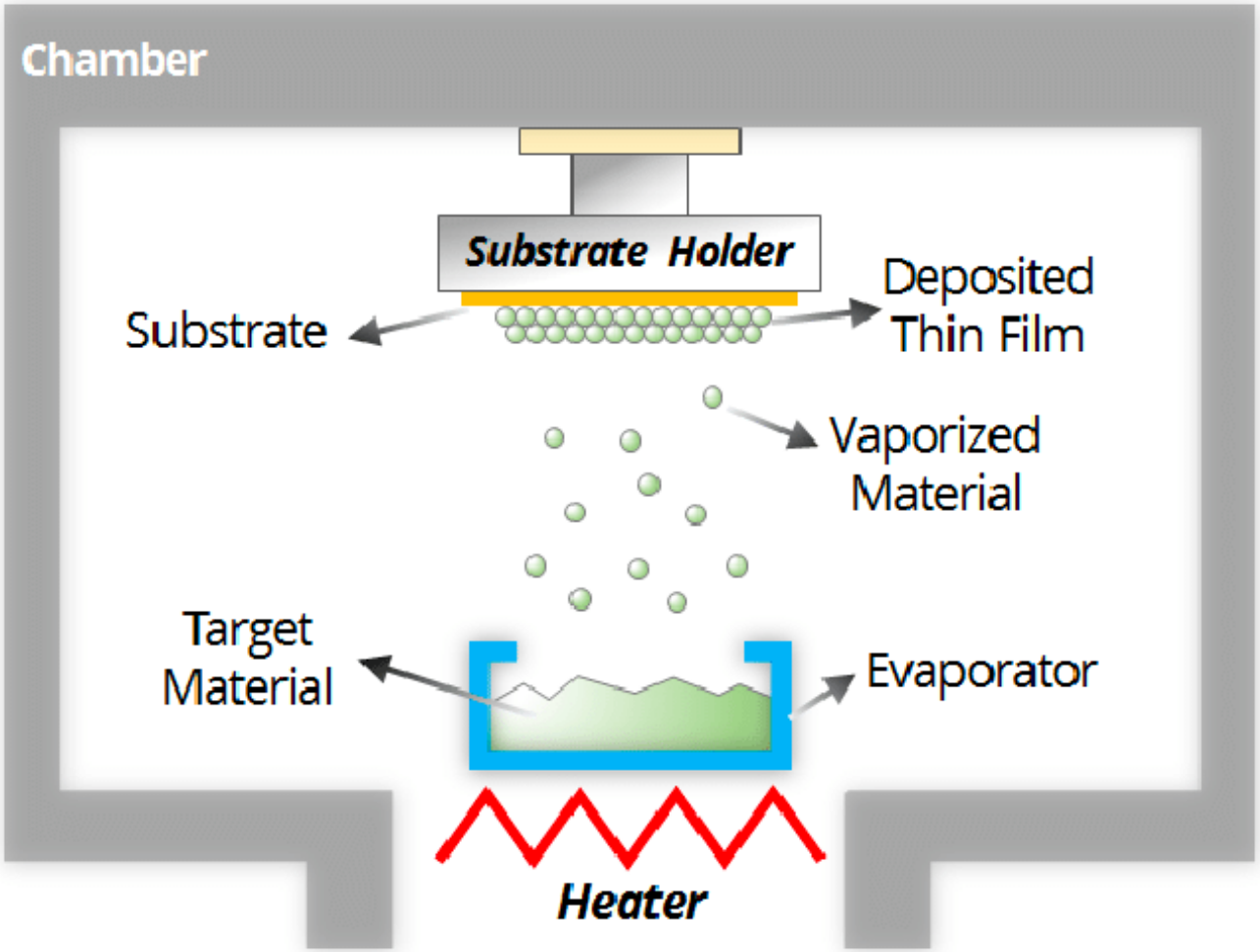


Ion implantation



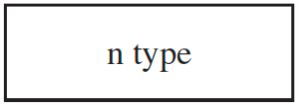
Preview: Fabrication of Integrated Circuits

Metallization (metal deposition)

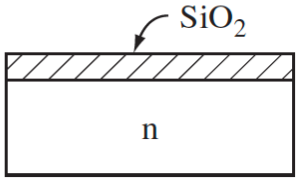


Preview: Fabrication of Integrated Circuits

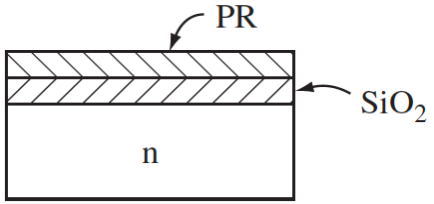
Simple Fabrication Process



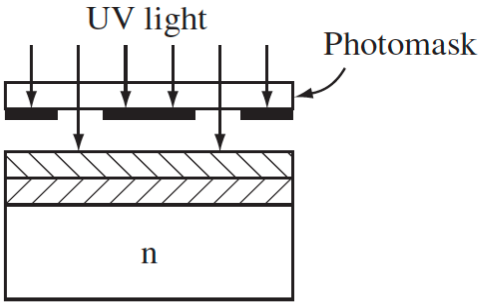
1. Start with n-type substrate



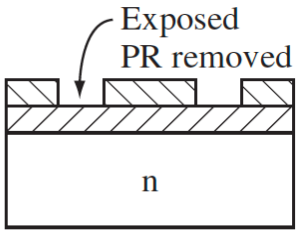
2. Oxidize surface



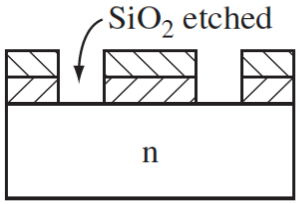
3. Apply photoresist over SiO_2



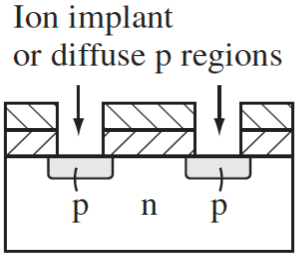
3. Expose photoresist through photomask



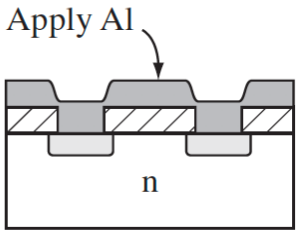
4. Remove exposed photoresist



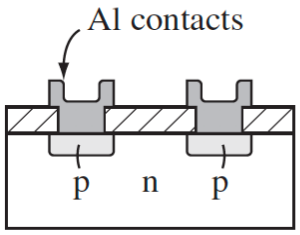
5. Etch exposed SiO_2



6. Ion implant or diffuse boron into silicon



7. Remove PR and sputter Al on surface



8. Apply PR, photomask, and etch to form Al contacts over p regions

Preview: Fabrication of Integrated Circuits