VE320 – Summer 2022

Introduction to Semiconductor Devices

Instructor: Yaping Dan （但亚平）
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Chapter 0. Course Information and Preview

Outline

- **Course Information**
- Preview

Course Information

Time:	Monday	10:00-11:40
	Wednesday	10:00-11:40
	Friday	10:00-11:40 (even weeks)

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

- Office Hour: 9am-10am Monday, Wednesday (online in our Feishu classroom)

- Teaching Assistants:

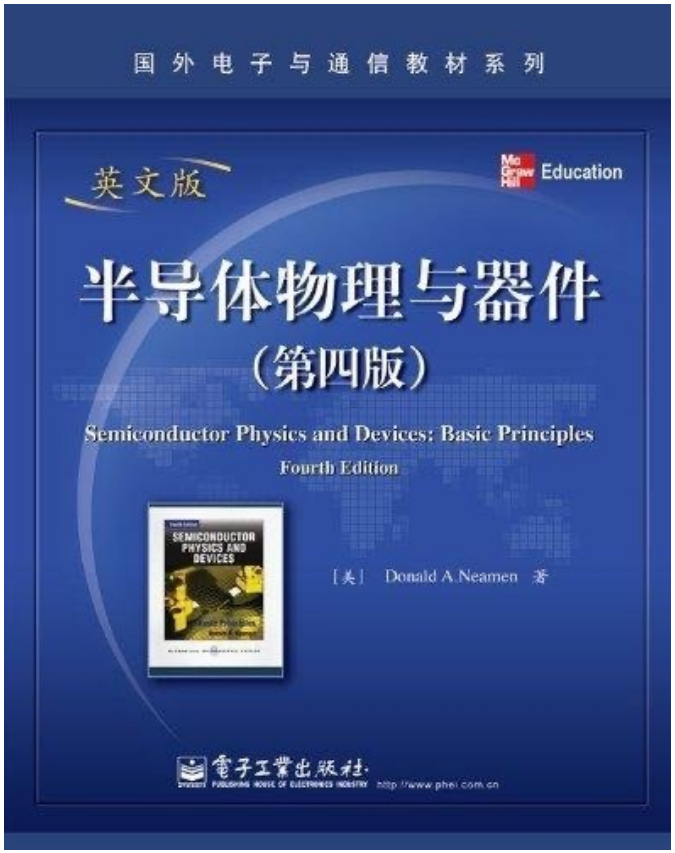
  - Ziyi Wang, ziyi.wang@sjtu.edu.cn

  - Yucheng Huang, hyc391@sjtu.edu.cn

  - Yukun Lou, louyukun@umich.edu

Reference textbook

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



Grading Policy and Assignments

Grading Policy

- Assignments 8%
- Participation 7%
- Midterm1 25%
- Midterm2 30%
- Final 30%

- Curve to be centered at B+ or A-.
- Assigned weekly on Friday, due on the following Friday.
- Approximately eight problems each assignment.

Unethical Conducts

- 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 close-book (can be changed to open book depening on survey).
- Standard cheating papers will be consulted with and published to all students, and distributed in the closed-book exams.

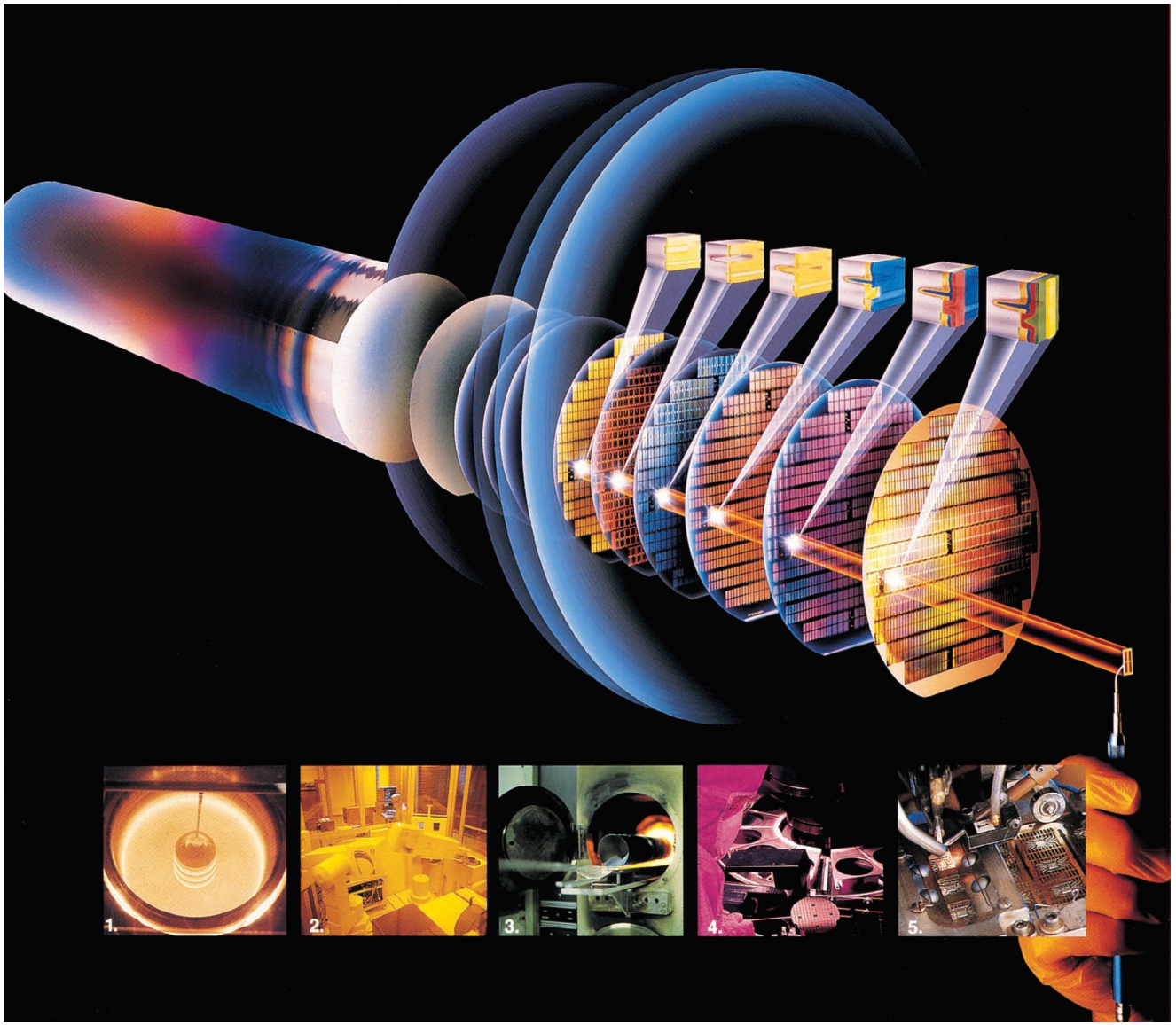
Changes in policy based on feedbacks

1) Reduce the hard line from 50 to 40.
2) Curve to a higher average GPA (from B to B+ or A-).
3) Reduce the load to ~ 8 problems /homework.
4) Remove the quizzes. Give Assignments a higher weight (8%).
5) Activity (ask questions, 2%) in class and Piazza, and attendance of class (open camera, 5%), total: 7%
6) Increase the example problems instructed during the lecture.
7) Remove some advanced topics and focus more on basics.

Outline

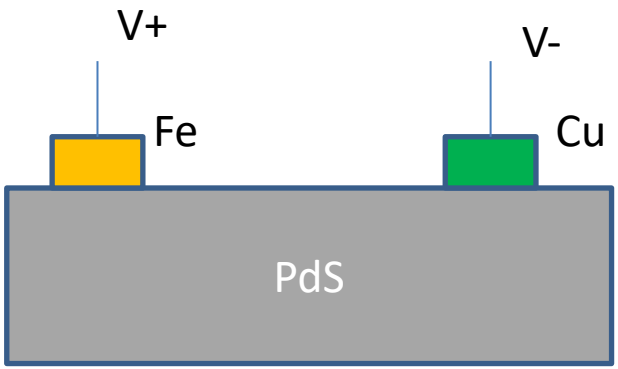
- Course Information
- **Preview**

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

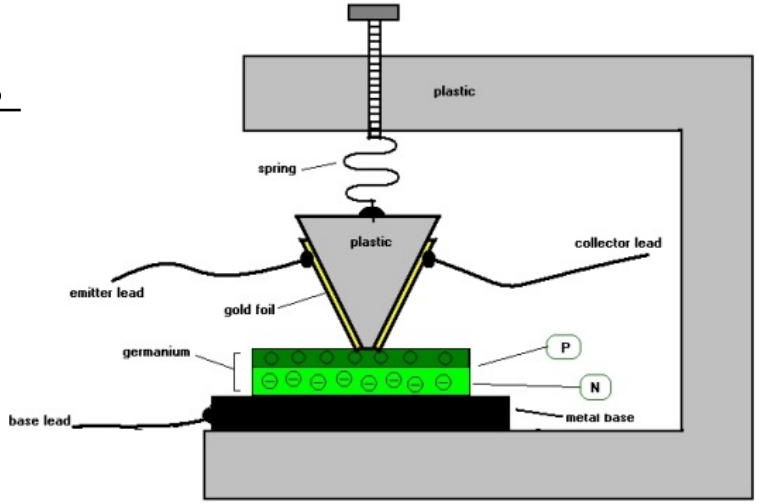
(1900 - 1950s)

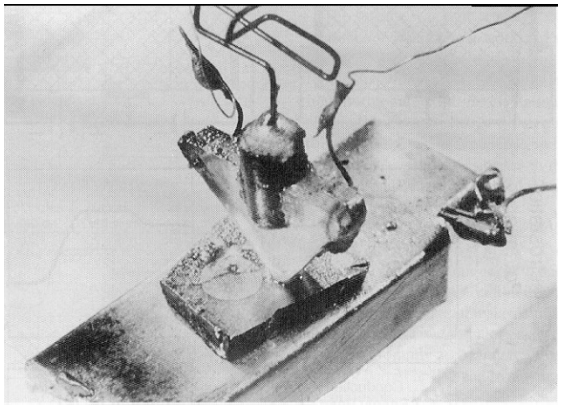
Max Planck, Niels Bohr, Werner Heisenberg, Louis de Broglie, Arthur Compton, Albert Einstein, Erwin Schrödinger, Max Born, John von Neumann, Paul Dirac, Enrico Fermi, Wolfgang Pauli, Max von Laue, Freeman Dyson, David Hilbert, Wilhelm Wien, Satyendra Nath Bose, Arnold Sommerfeld, and others.

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

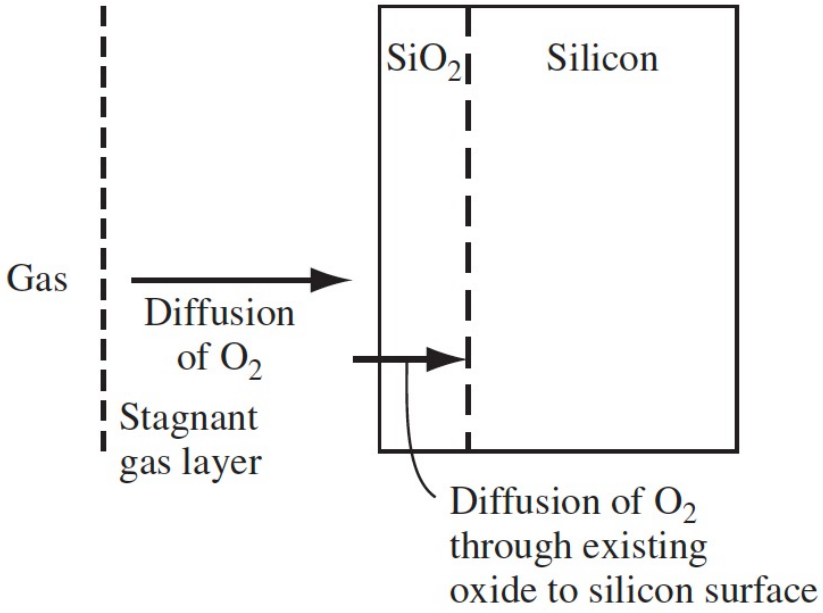
Silicon Valley

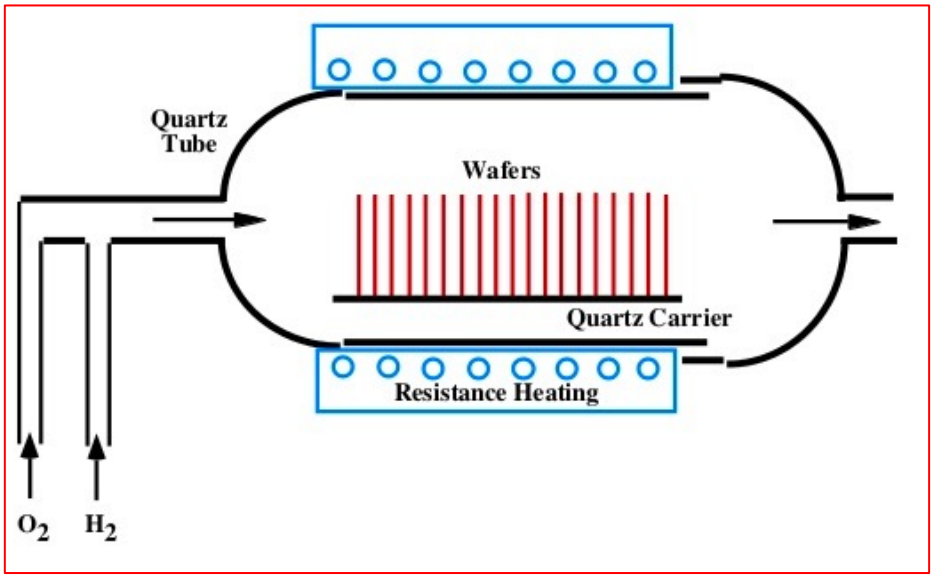
Bell Lab, New Jersey

Original site at California

Preview: Fabrication of Integrated Circuits

Thermal oxidation

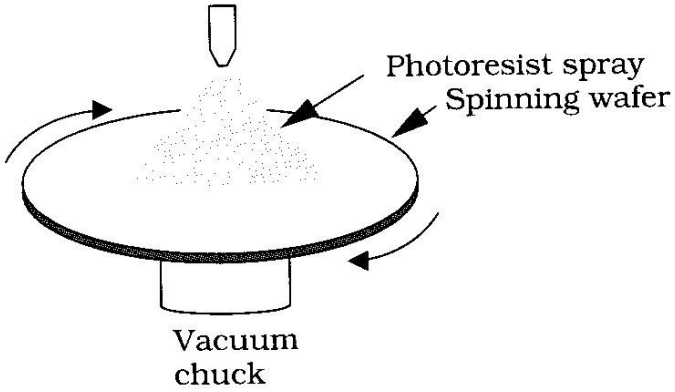




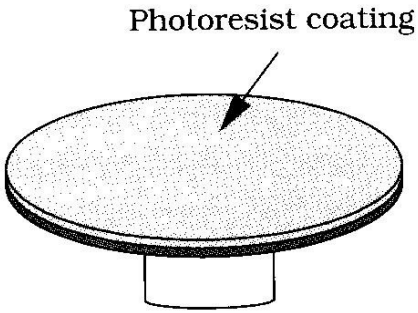
SiO_2: high quality electrical insulator

Preview: Fabrication of Integrated Circuits

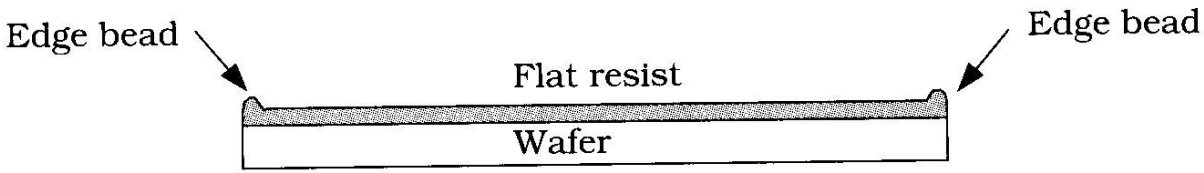
Photoligthography



(a) Resist application



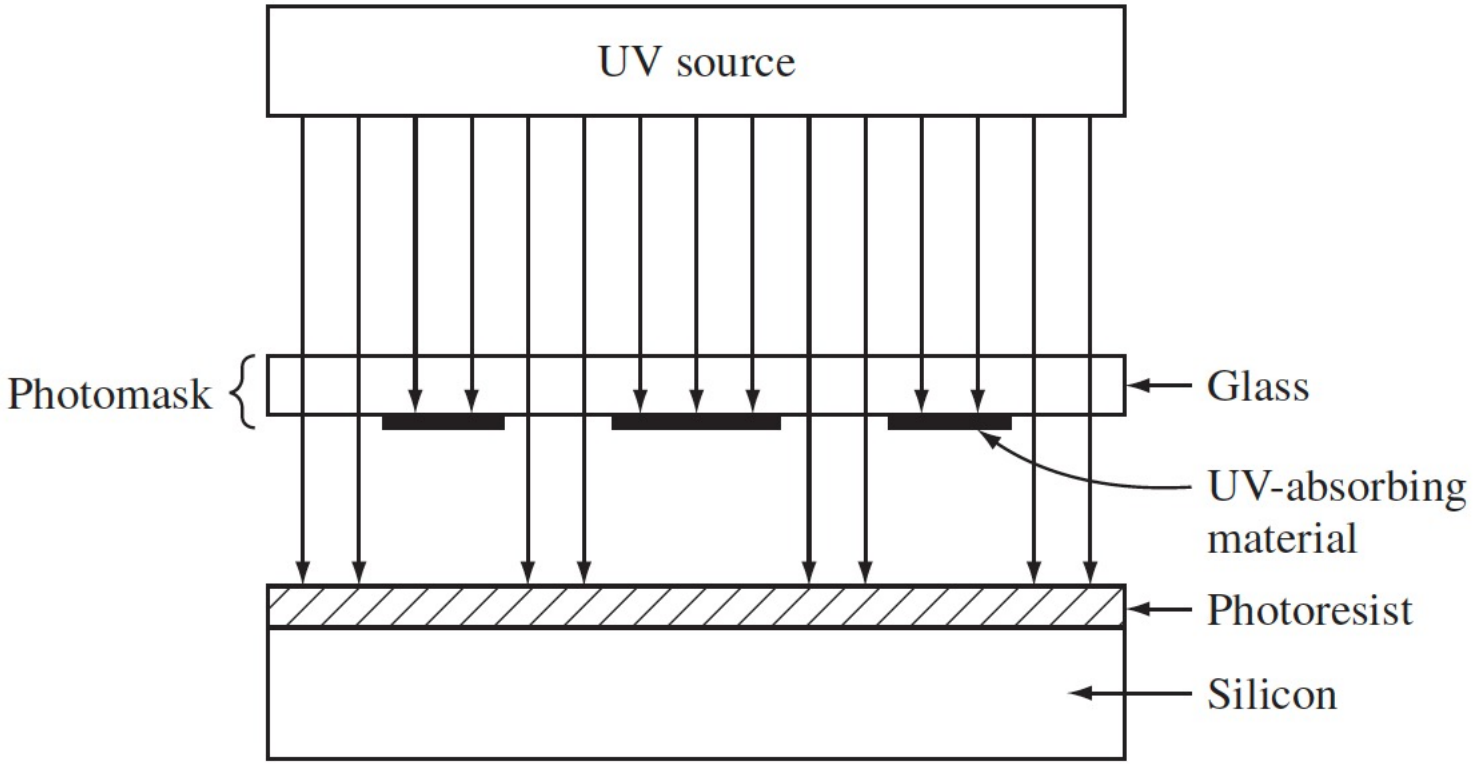
(b) Coated wafer



(c) Beading

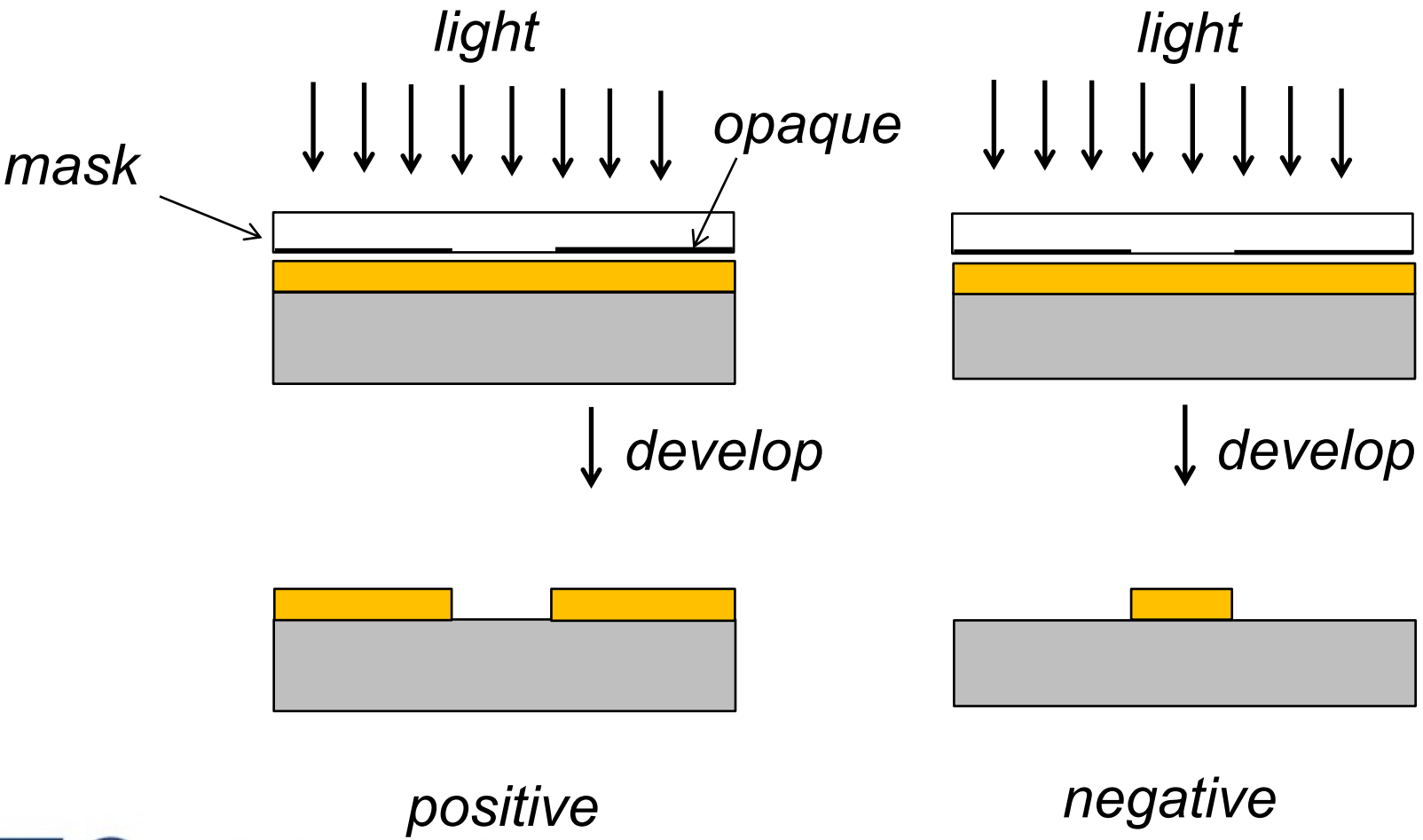
Preview: Fabrication of Integrated Circuits

Photoligthography



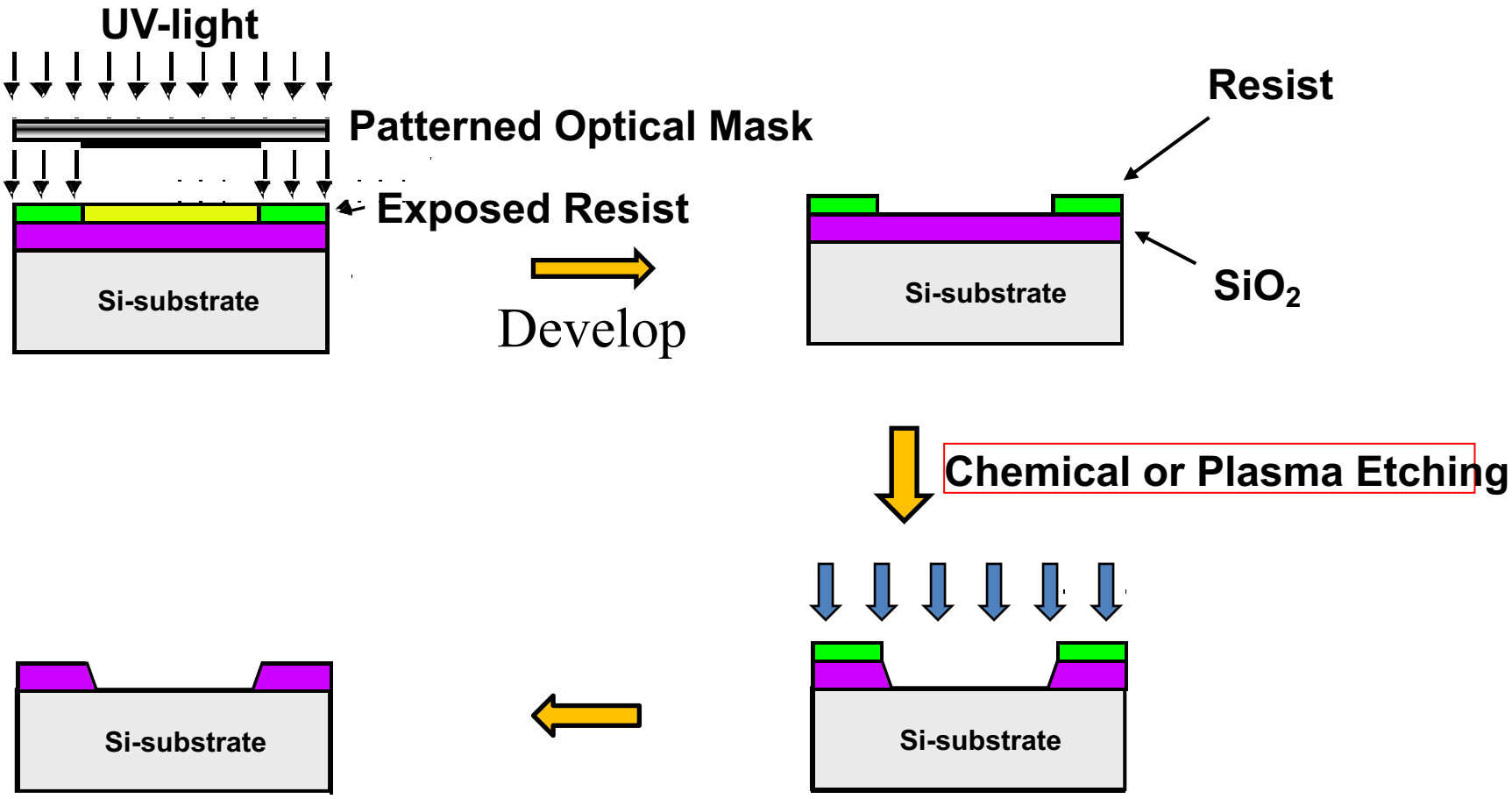
Preview: Fabrication of Integrated Circuits

Photoligthography



Preview: Fabrication of Integrated Circuits

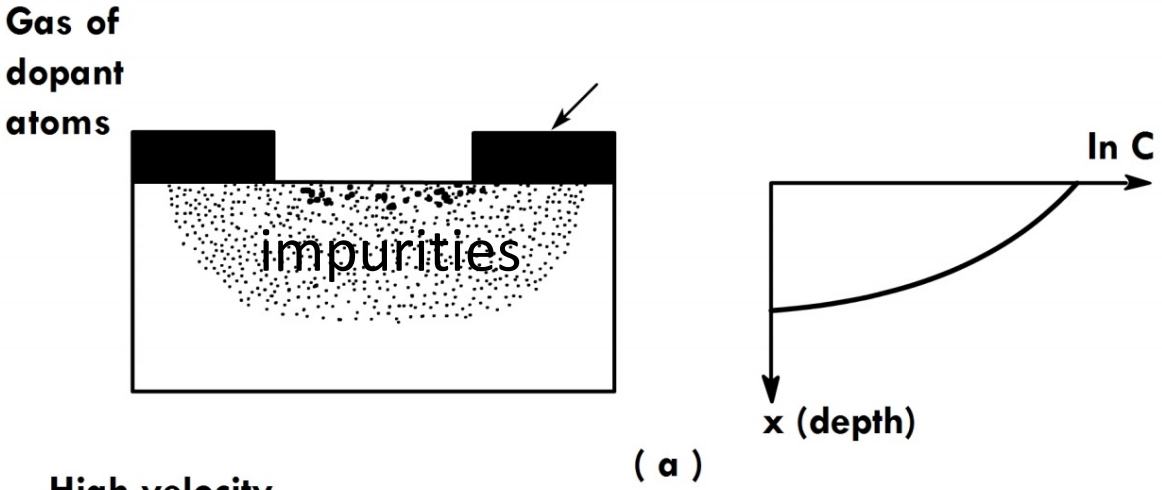
Etching



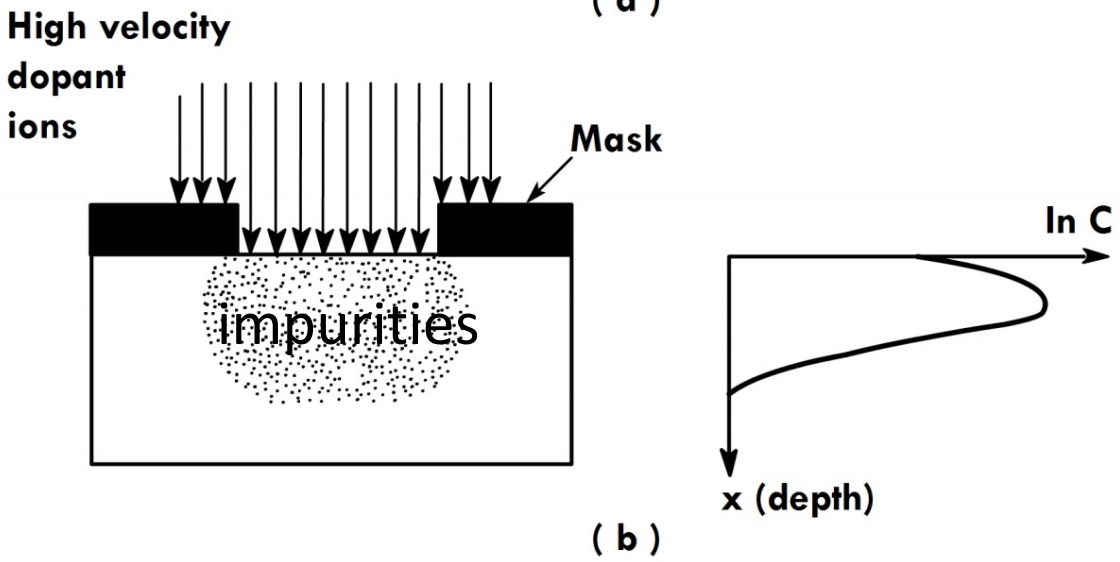
Preview: Fabrication of Integrated Circuits

Doping

Thermal diffusion

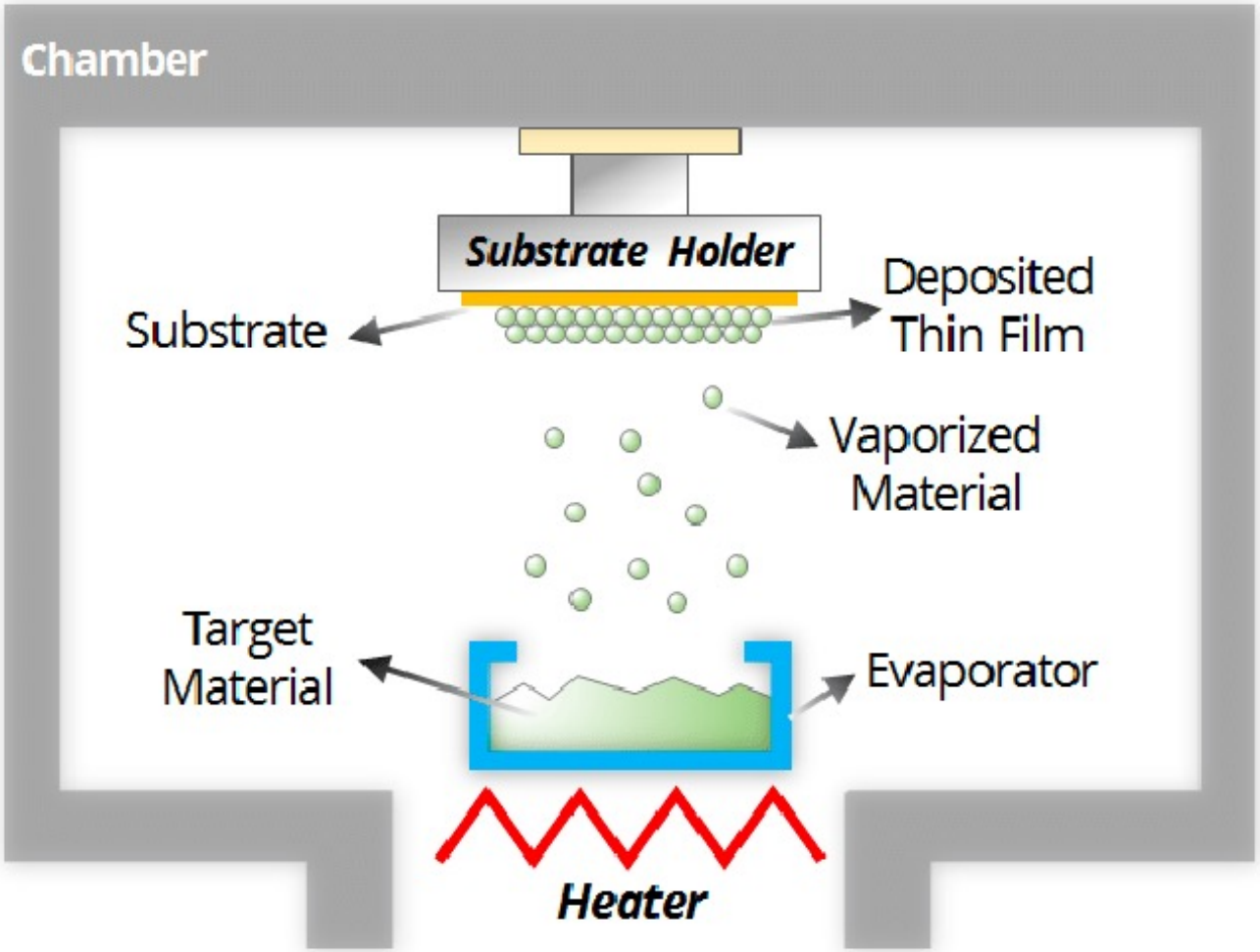


Ion implantation



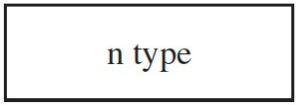
Preview: Fabrication of Integrated Circuits

Metallization (metal deposition)

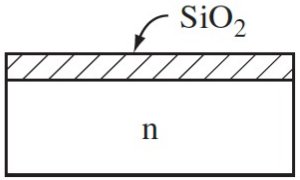


Preview: Fabrication of Integrated Circuits

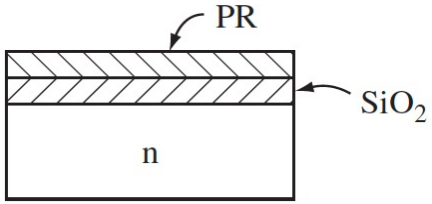
Simple Fabrication Process



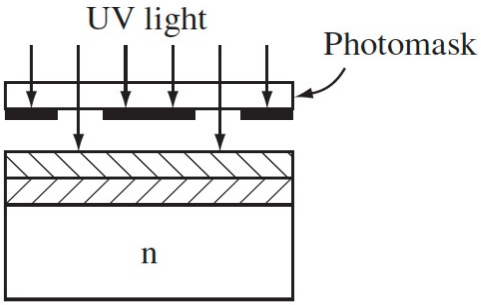
1. Start with n-type substrate



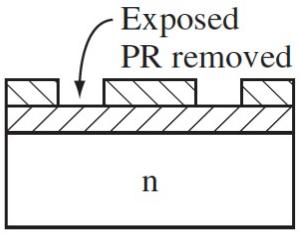
2. Oxidize surface



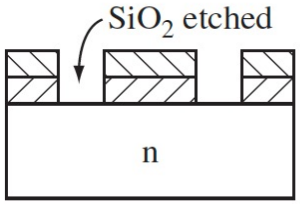
3. Apply photoresist over SiO_2



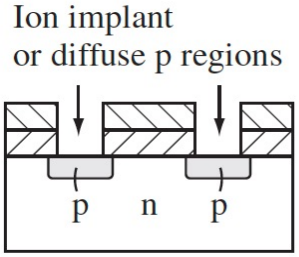
3. Expose photoresist through photomask



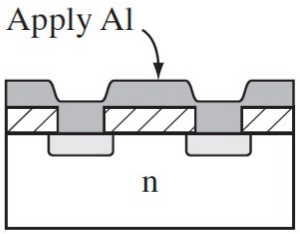
4. Remove exposed photoresist



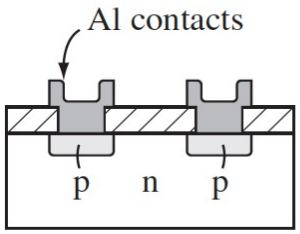
5. Etch exposed SiO_2



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