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**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

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- **Course Information**
- Preview

# Course Information

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- 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](mailto:yaping.dan@sjtu.edu.cn)
- Office Hour:   10am-12pm Tuesday, Thursday
- Teaching Assistants:
  - Zhou, Zhiyu : [020507zzy@sjtu.edu.cn](mailto:020507zzy@sjtu.edu.cn)
  - Chen, Zhuojia: [chenzhuojia@sjtu.edu.cn](mailto:chenzhuojia@sjtu.edu.cn)
  - Zhou, Yuhao: [zhouyuhao@sjtu.edu.cn](mailto:zhouyuhao@sjtu.edu.cn)

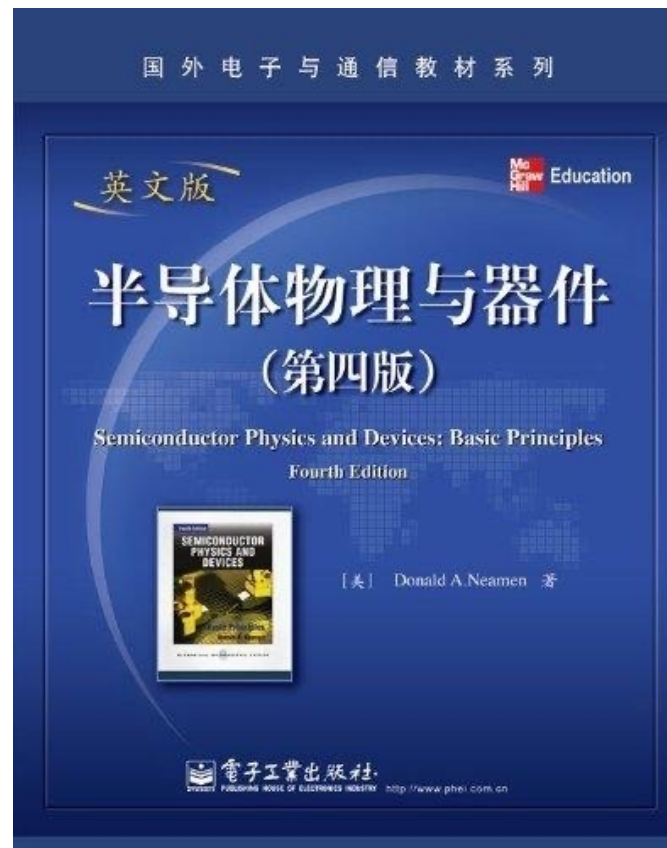
# Reference textbook

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Semiconductor Physics and Devices: Basic Principles 4<sup>th</sup> ed.

Donald A. Neamen

Publishing house of electronic industry



# Grading Policy and Assignments

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## Grading Policy

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

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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

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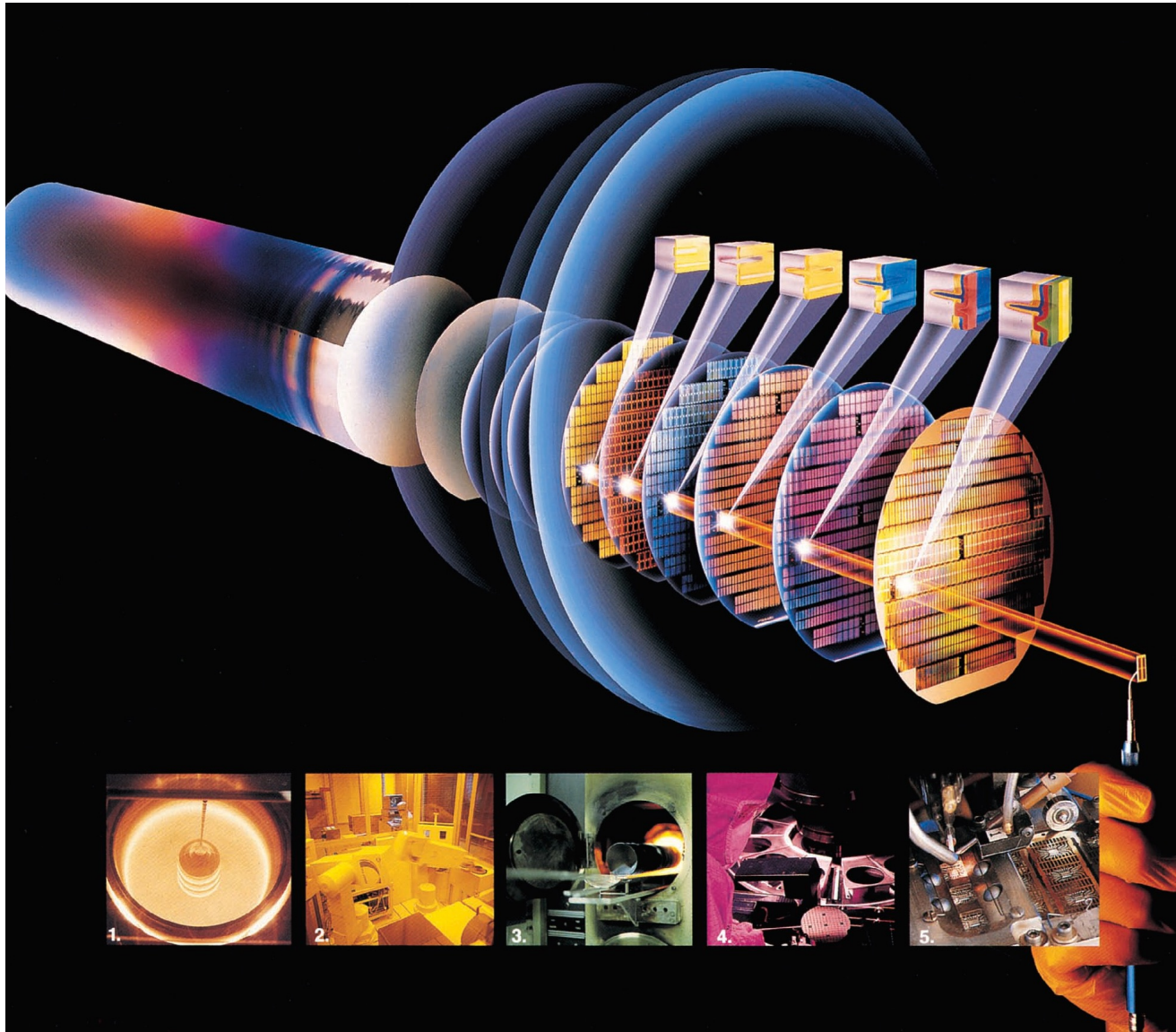
- Assigned weekly and due on the following week.
- Approximately seven problems each assignment.
- You are free to discuss homework with each other. But the work you submit must be your own.
- Any suspicious violation of the honor code will be reported to the honor council.
- Midterm and final exams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

# Outline

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- Course Information
- **Preview**

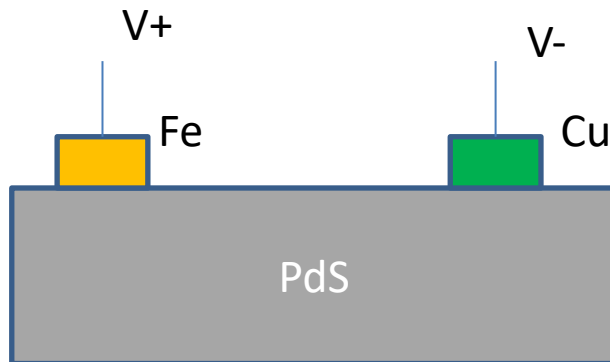
# Preview: Semiconductors and Integrated Circuits





# 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

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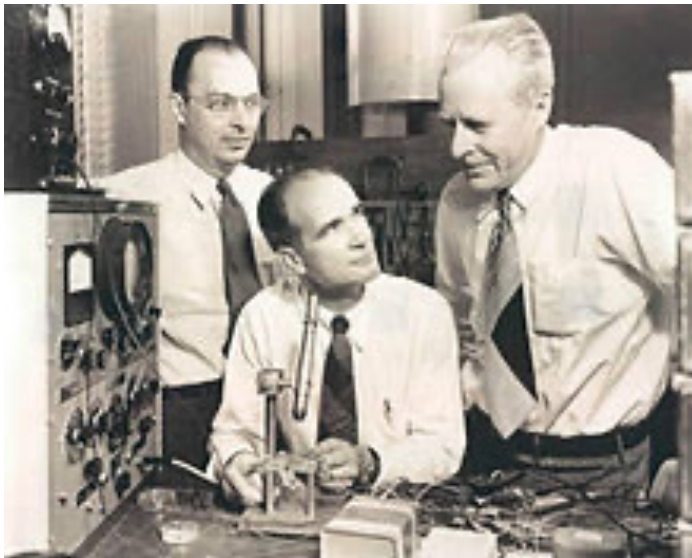
Quantum Mechanics → Semiconductor Physics

(1900 - 1950s)

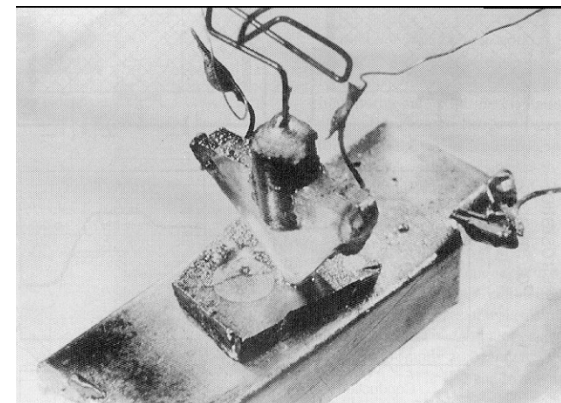
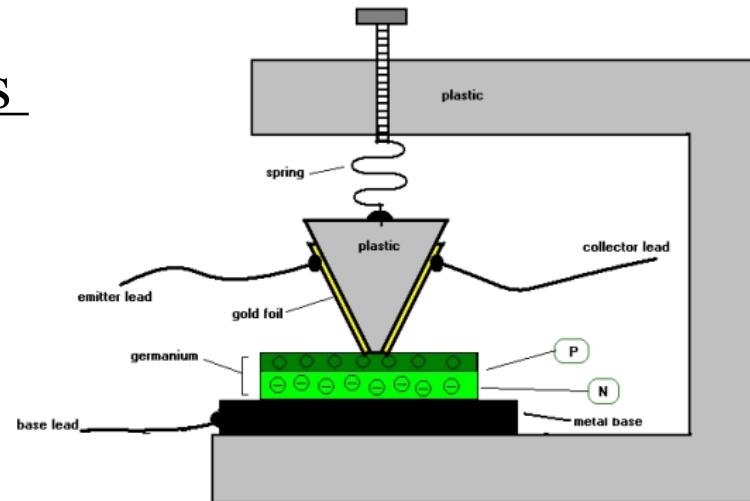
[Max Planck](#), [Niels Bohr](#), [Werner Heisenberg](#), [Louis de Broglie](#), [Arthur Compton](#), [Albert Einstein](#), [Erwin Schrödinger](#), [Max Born](#), [John von Neumann](#), [Paul Dirac](#), [Enrico Fermi](#), [Wolfgang Pauli](#), [Max von Laue](#), [Freeman Dyson](#), [David Hilbert](#), [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

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## Silicon Valley



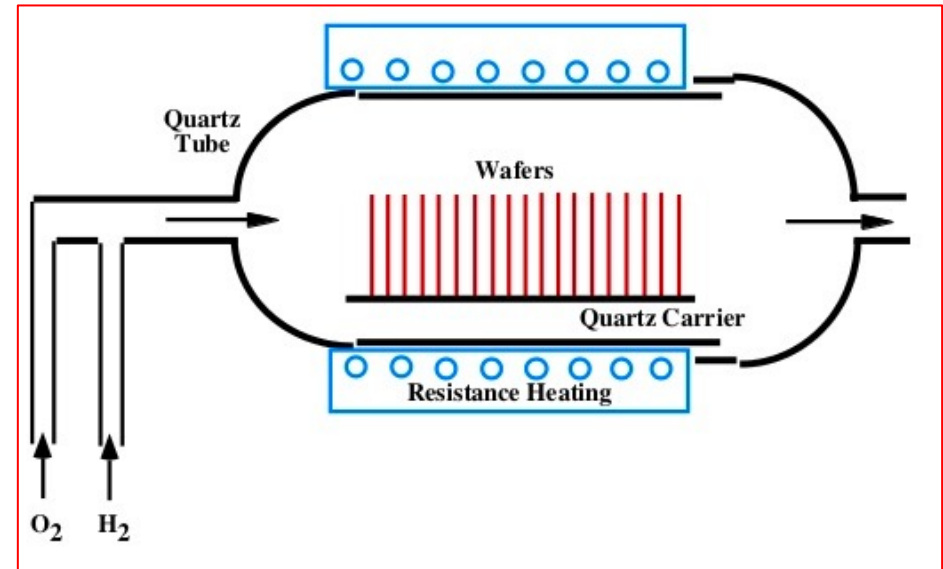
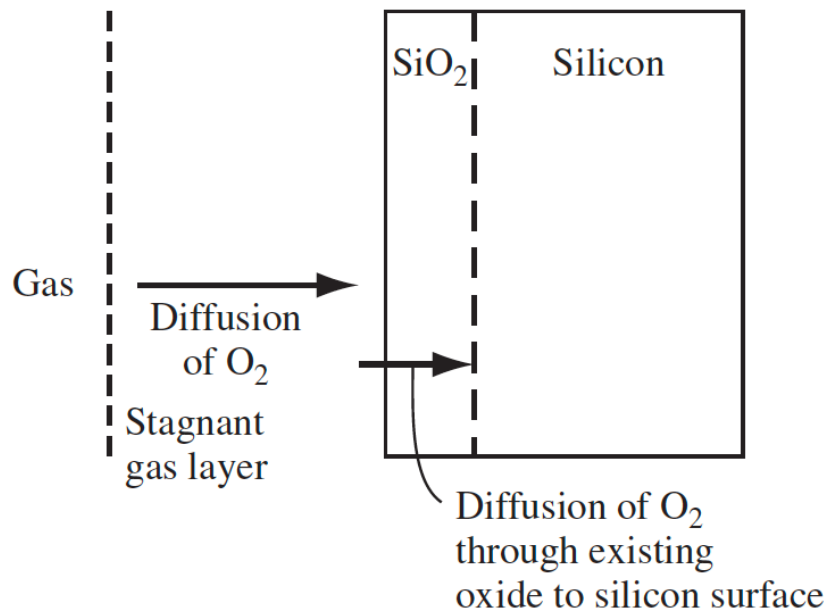
*Bell Lab, New Jersey*



*Original site at California*

# Preview: Fabrication of Integrated Circuits

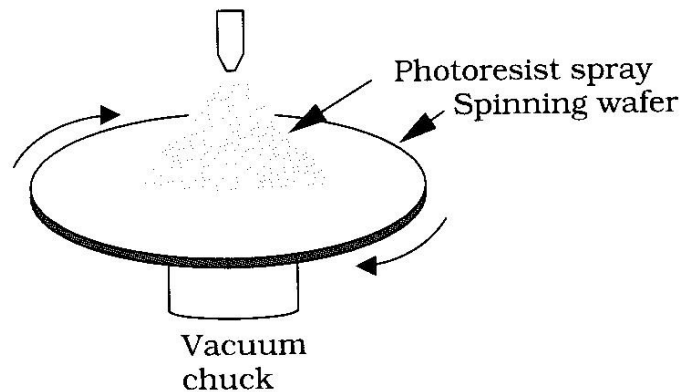
## Thermal oxidation



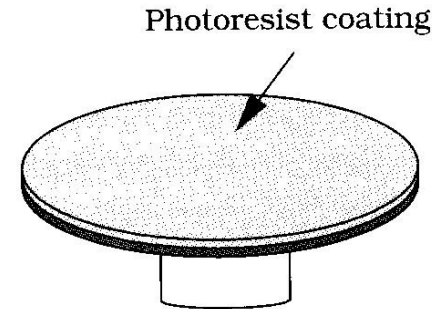
$SiO_2$ : high quality electrical insulator

# Preview: Fabrication of Integrated Circuits

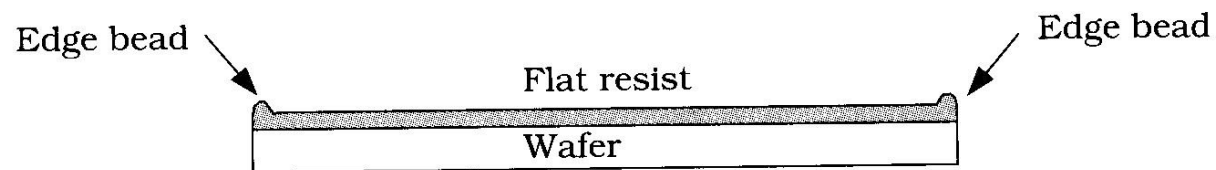
## Photolithography



(a) Resist application



(b) Coated wafer



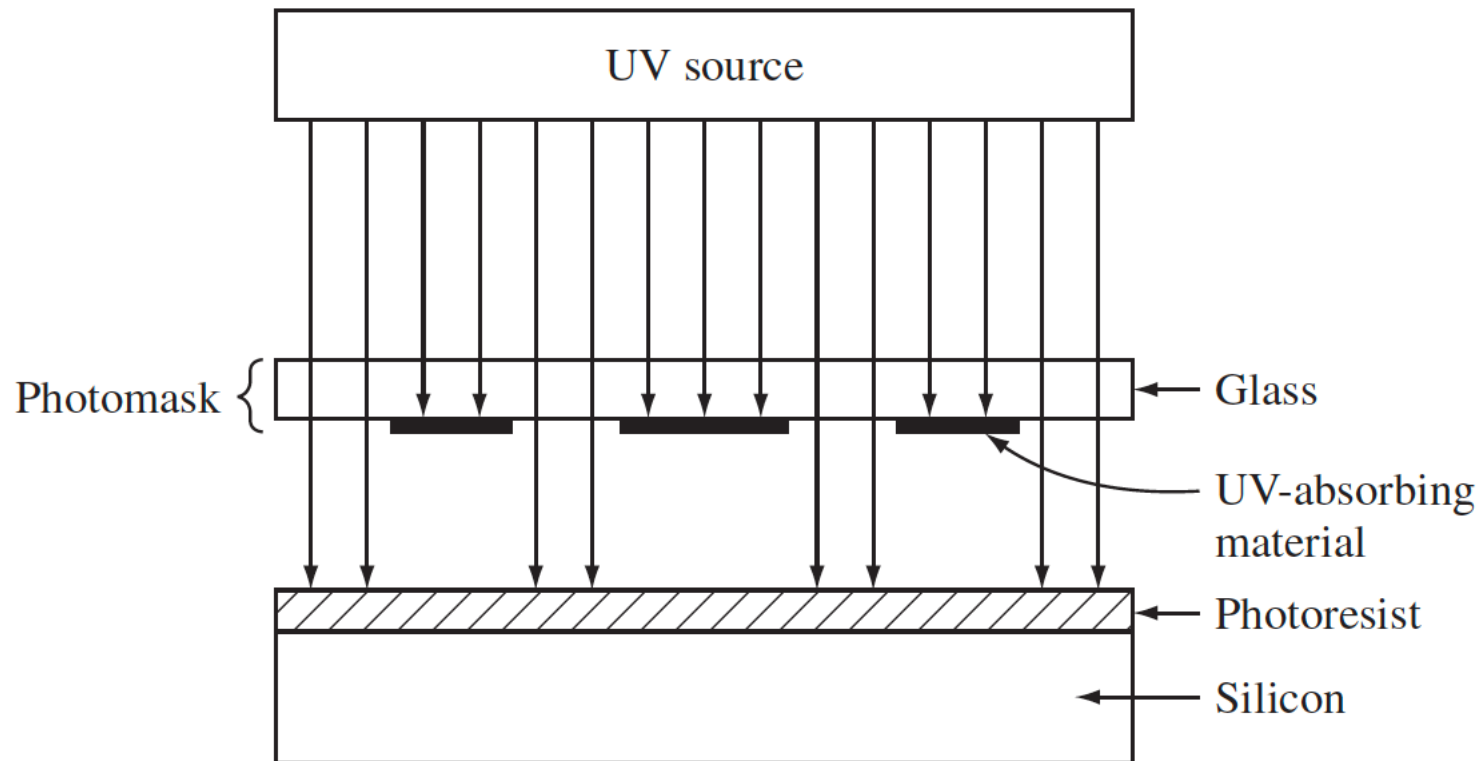
(c) Beading



# Preview: Fabrication of Integrated Circuits

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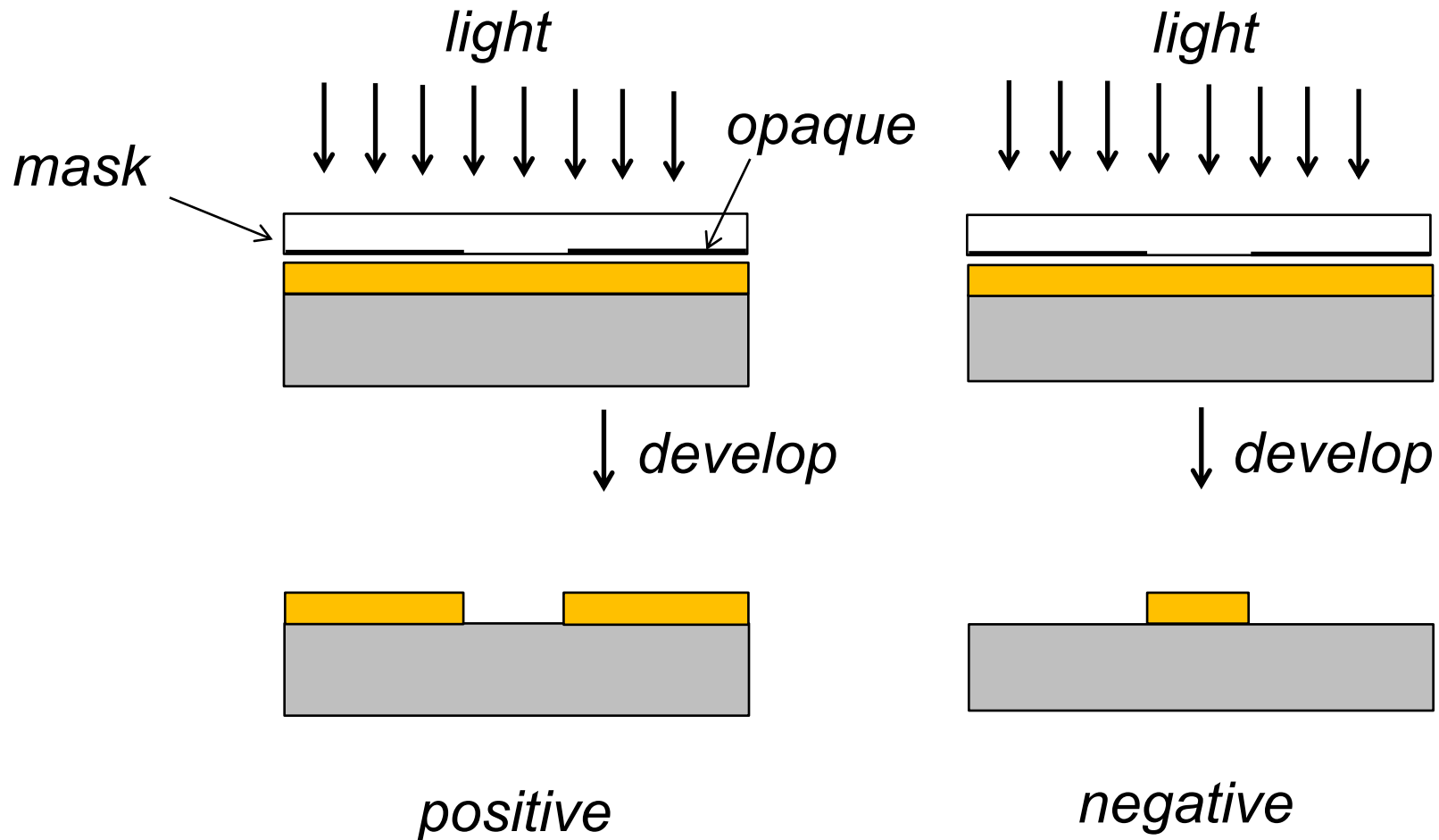
## Photolithography



# Preview: Fabrication of Integrated Circuits

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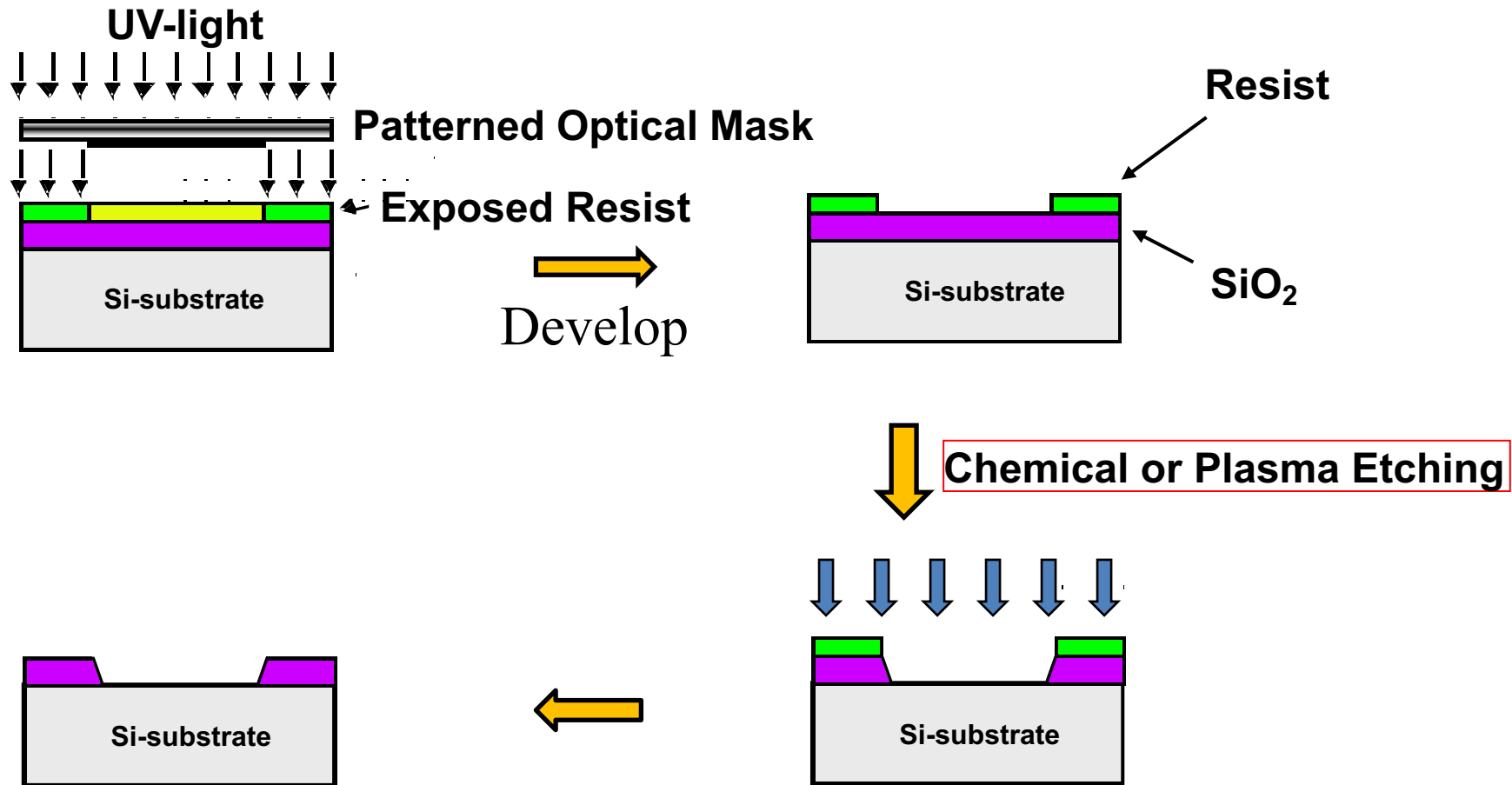
## Photolithography





# Preview: Fabrication of Integrated Circuits

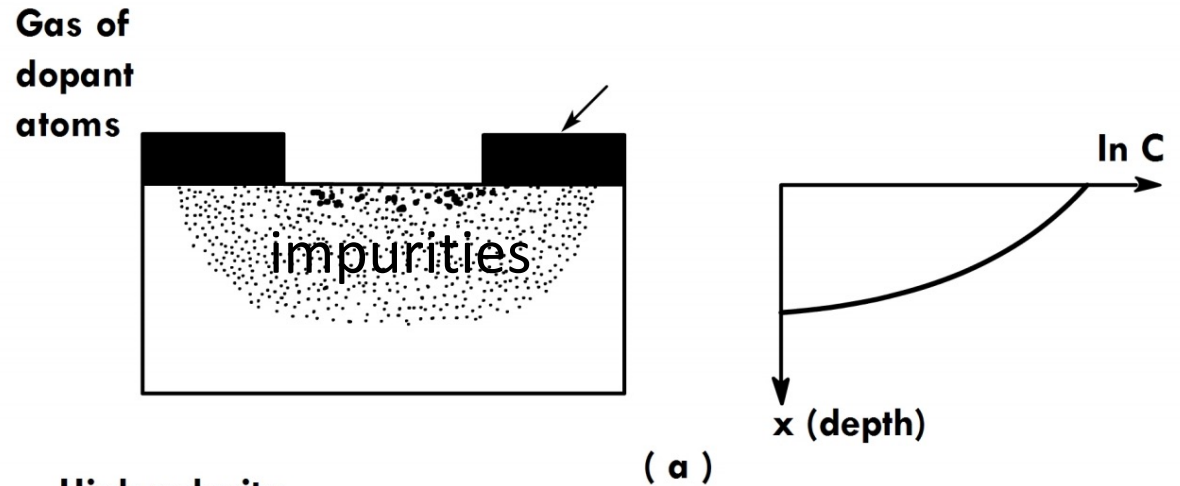
## Etching



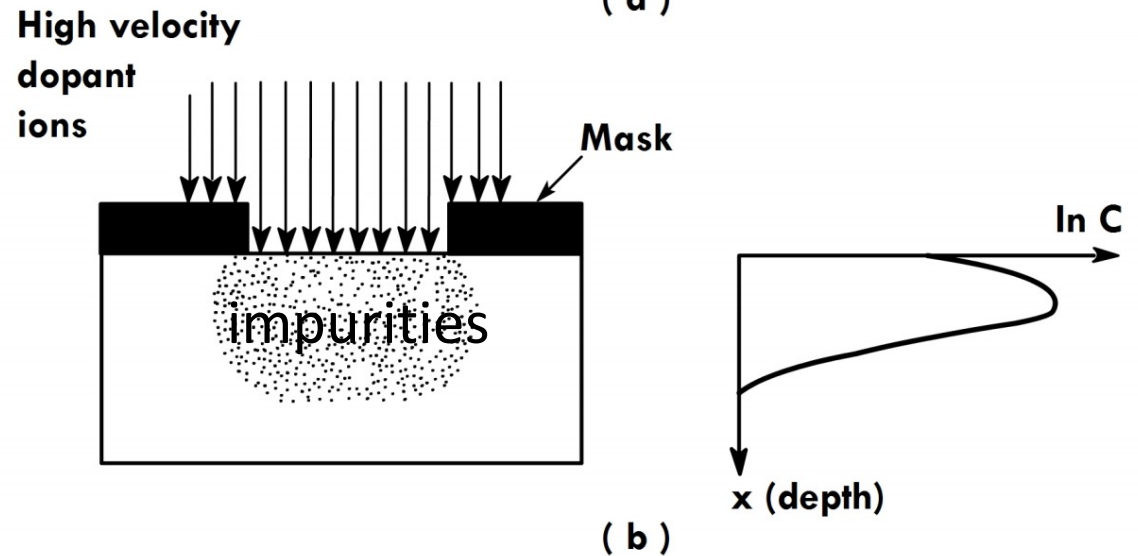
# Preview: Fabrication of Integrated Circuits

## Doping

Thermal diffusion

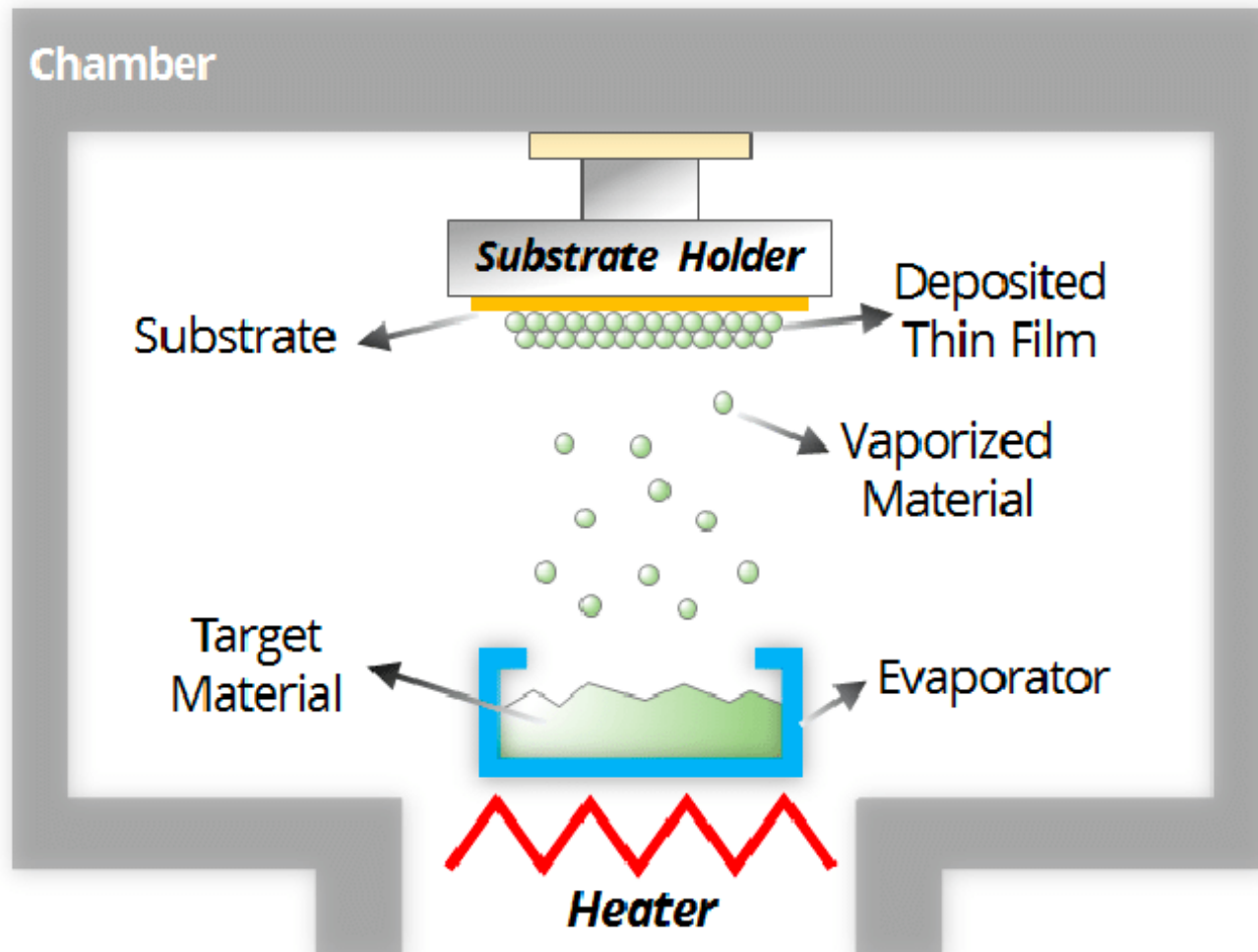


Ion implantation



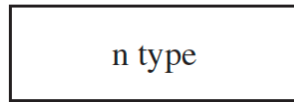
# Preview: Fabrication of Integrated Circuits

## Metallization (metal deposition)

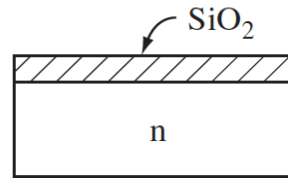


# Preview: Fabrication of Integrated Circuits

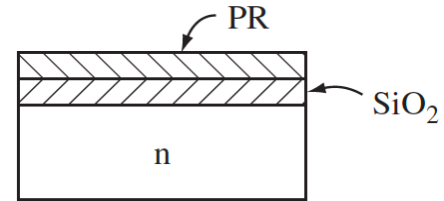
## Simple Fabrication Process



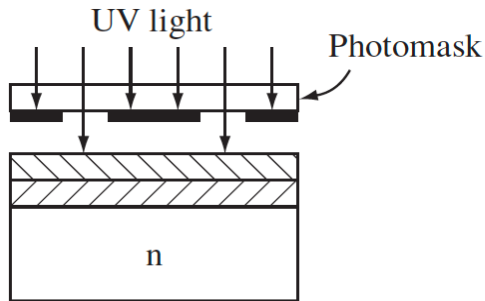
1. Start with  
n-type substrate



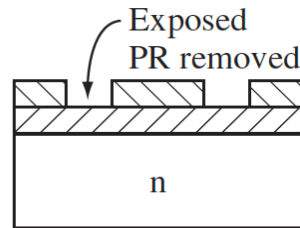
2. Oxidize surface



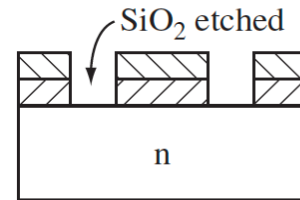
3. Apply photoresist  
over  $\text{SiO}_2$



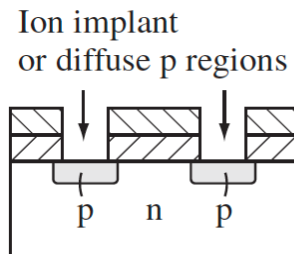
3. Expose photoresist  
through photomask



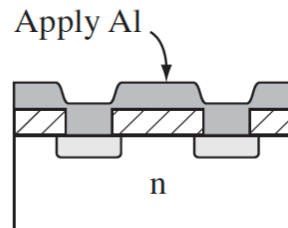
4. Remove exposed  
photoresist



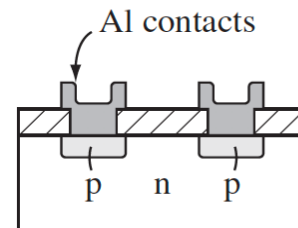
5. Etch exposed  $\text{SiO}_2$



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

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