CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
www.lithoguru.com/scientist/CHE323

Review Questions by Lecture (1-19)

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Lecture 1: Semiconductor Overview

- Define "semiconductor"
- What are the two important ways to locally change the conductivity of a semiconductor?
- What is patterning?
- Draw a basic diagram outlining the steps of a subtractive patterning process
- Define "ion implantation"
- Why is annealing required after ion implantation?

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Lecture 2: Moore's Law

- What are the three versions of Moore's Law?
- What is Dennard scaling?
- Why does Dennard scaling no longer work?
- What are the consequences of the end of Dennard scaling?

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Lecture 3: Semiconductor Economics

- What are the current Moore's Law doubling rates for logic and flash?
- What is the fundamental economic principle of Moore's Law?
- What are three ways manufacturers have been able to lower the cost per transistor?
- How do lithography costs scale with wafer size?
- Why is Moore's Law getting harder to keep going?

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Lecture 4: Single-Crystal Silicon

- Describe the Czochrolski growth process
- Why do Goup IV materials often act as semiconductors?
- Define "intrinsic semiconductor"
- Explain the processes of electron-hole generation and recombination
- What are the two charge carriers in semiconductor devices?

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Lecture 5: Doping

- Define "extrinsic silicon"
- What are donors and acceptors?
- Why must the impurities be incorporated into the crystal lattice before they can act as dopants?
- Understand how to use charge balance and mass action equations to determine *n* and *p* for different doping levels
- Know how to calculate the conductivity of a semiconductor, and the resistance of a bar

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Lecture 6: P-N Junctions

- How are p-n junctions typically formed?
- What is drift current? Diffusion current?
- Define "depletion region" (space charge region)
- Why does a p-n junction form a depletion region?
- Why does a p-n junction have a built-in voltage?
- Be able to calculate the p-n junction built-in voltage and depletion width

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Lecture 7: The Junction Diode

- How does bias affect depletion width?
- What is a diode?
- Why does a p-n junction act like a diode
- Be able to use the diode equation
- Be able to use the C(V) equation

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Lecture 8: Transistors

- When and why are bipolar transistors used in circuits?
- Describe the basic operation of an nMOS and a pMOS transistor
- What is an inversion layer?
- Define threshold voltage for MOS transistors
- What is the advantage of CMOS circuits for logic?

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Lecture 9: CMOS Process Flow

- Be able to list the basic steps in the CMOS process flow
- Given a list of processes steps, put them in the correct order
- Be able to find the transistors when looking at a top-down design view

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Lecture 10: Thermal Oxidation, part 1

- What is oxide used for in a CMOS process?
- What are the advantages of thermal oxidation?
- Explain the basic workings of an oxidation furnace
- Why is HCl used in the oxidation process?
- How does one insure good oxide thickness uniformity?

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Lecture 11: Thermal Oxidation, part 2

- What are the three sequential steps in the Deal-Grove mechanism?
- What are the limitations of the Deal-Grove model?
- Explain the steady-state assumption used in the derivation
- Be familiar with the derivation of the Deal-Grove model

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Lecture 12: Thermal Oxidation, part 3

- Be able to make calculations using the Deal-Grove model
- What are the linear and parabolic rate constants?
- Understand how to use τ when an initial oxide film is on the wafer
- Understand why τ is used for dry oxidation calculations for film thickness > 30 nm
- How does pressure affect oxidation rates?
- How does crystal orientation affect oxidation rates?

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Lecture 13: Diffusion, part 1

- What are the two meanings of the term ‘diffusion’ in semiconductor processing?
- Explain how dopants are introduced during an old-style diffusion step
- Why is dopant diffusion inevitable after ion implantation?
- What does one need to know in order to solve the diffusion equation?

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Lecture 14: Diffusion, part 2

- What are the cases where we have derived simple analytical solutions to the diffusion equation?
- What assumptions did we have to make in order to derive our solutions?
- When might these solutions be useful?

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Lecture 15: Diffusion, part 3

- How does charge in a vacancy affect diffusivity?
- What is the main cause of the concentration dependence of the diffusivity of dopants in silicon?
- Define ‘transient-enhanced diffusion’
- What is electric field enhancement of diffusivity?
- Explain how the overall thermal budget for dopant diffusion is accounted for

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Lecture 16: Ion Implantation, part 1

- What are the three major process parameters for ion implantation?
- How many CMOS process steps can you name that use ion implantation?
- Describe how a mass spectrometer (mass analyzer) works
- How is dose controlled?

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Lecture 17: Ion Implantation, part 2

- What processes affect the trajectory of an ion through a wafer?
- Explain Monte Carlo simulations of ion implantation.
- What are the parameters used in the Gaussian model of implant distribution?
- Define ‘straggle’ and ‘transverse straggle’.

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Lecture 18: Ion Implantation, part 3

- How and why does channeling occur?
- What is the most common remedy for channeling?
- Explain shadowing and how it is mitigated
- What is required of an implant mask?
- How is implant damage repaired?

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Lecture 19: Rapid Thermal Processing

- Why are shallow junctions needed today, and why are they hard to make?
- Describe the basic components of an RTP system
- How is heating accomplished in an RTP system?
- How is temperature measured in an RTP system?
- What is RTP used for?

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