# ELE 412: Semiconductor Devices

## (Fall-2008)

### Team

<table>
<thead>
<tr>
<th>Lecturer</th>
<th>Teaching Assistant</th>
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</thead>
<tbody>
<tr>
<td>Dr Ayhan Ozturk</td>
<td>None</td>
</tr>
<tr>
<td><strong>Room Number:</strong> 3111</td>
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</tr>
<tr>
<td><strong>Office Hours:</strong> Tuesday, 17:00-17:30; Friday, 16:00-17:30</td>
<td><strong>Office Hours:</strong></td>
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### Course

**CRN:** 11267  
**Prerequisites:** None  
**Classroom:** D5301  
**Course Hours:** Tue, 14:00-17:00

### Timing

**Calendar:** September the 15\(^{th}\), 2008 - January the 02\(^{th}\), 2009  
**Fall Term:**  
- Lectures: 12 weeks  
- Exams: 2 weeks  
**Attendance:**  
- 8 Weeks Lectures + 2 Weeks Exams  
- Student cannot leave the room up to end of the lecture hour

**Assignments are due:** 1 week (unless otherwise specified), after issuing

### Examination

**Quizzes:** Books and notebook are **closed**  
**Midterm and Final:** Books and notebook are **closed**  
Lecture notes (slide handouts) can be only used during the examination.

<table>
<thead>
<tr>
<th>Week</th>
<th>Midterm Exam#1</th>
<th>Midterm Exam#2</th>
<th>Quiz#1</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>10</td>
<td>14</td>
</tr>
</tbody>
</table>

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Grading

<table>
<thead>
<tr>
<th>ELE 412</th>
<th>Number of Exams / Assignments</th>
<th>Partial Weight</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm Exam</td>
<td>2</td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>1</td>
<td>08%</td>
<td>08%</td>
</tr>
<tr>
<td>Assignments¹</td>
<td>3</td>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>Ethics</td>
<td>1</td>
<td>+5p</td>
<td>+5p</td>
</tr>
<tr>
<td>ABET Paper</td>
<td>For each</td>
<td>+1p</td>
<td></td>
</tr>
<tr>
<td>Final Exam</td>
<td>1</td>
<td>40%</td>
<td>40%</td>
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</table>

¹: In case of cancelation of assignments, their points will be added to midterm exams.

Over All Class Assessment: Bell Curve System

Course Objectives
At the end of the course, students should be able

- To understand clearly the basic principles of semiconductor devices
- To understand clearly effects of various processes on device characteristics
- To design new semiconductor devices

Tentative Outlines

Lecture#1: Semiconductor Fundamentals
- Introduction
- Crystal structures
- Bohr’s Atom Model
- Energy band diagram
- Terms

Lecture#2: Carrier Populations
- Terms
- FD Distribution Function
- Density of States
- Electron population
- Hole population
- Fermi Levels

Lecture#3: Macroscopic Carrier Transport

Dr Ayhan Ozturk
• Transport Mechanisms
• Scattering events
• Generation and Recombination Processes
• Transport Characteristics
• Drift velocity and mobility
• Conductivity and Resistivity
• Drift and Diffusion Current Densities
• Transport Models

Lecture#4 pn Junctions
• Layout and Doping Profile
• Electrostatic Characteristics
• Energy Band Diagrams

Lecture#5: Non-equilibrium state of pn-junction
• Forward biasing characteristics
• Reverse biasing characteristics
• Metal-Semiconductor Junctions
• Heterostructures

Lecture#6: Metal/Oxide/Semiconductor Stacks
• Band Diagrams
• Work functions
• Flat-band voltage
• MOS Capacitor
• MOS Capacitor Operation Modes

Lecture#7 MOS Transistor (MOSFET)
• Fundamentals
• MOS Capacitor
• \(I-V\) Characteristics
• Modelling
• Oxide Charges

Lecture#8: More on MOSFET
• Threshold Voltage Control
• Scaling Theory
• Secondary Effects

Lecture#9: \(pn\)-Junctions I&V
• \(I-V\) characteristics
• Generation-Recombination Currents
• Transient Characteristics

Lecture#10: Bipolar Junction Transistor (BJT)
• Fundamentals
• \textit{I-V} Characteristics
• Transient Characteristics
• Modelling

\textbf{Lecture\#11: Secondary effects in BJTs}
• Early effect
• Kirk effect
• High injection
• Current crowding
• Non-uniform doping
• Band gap narrowing
• BJT scaling
• BJT Ebers-Moll macro model

\textbf{Lecture\#12: Miscellaneous issues on BJT}
• New type of transistors
• New device paradigms
• Low temperature device operation
• Semiconductor characterisation

\textbf{Text Books}

\textbf{Ancillaries}
Some Proprietary Software Packages:
• PISCES (Stanford University)
• MINIMOS (Technical University of Vienna)
• DAMOCLES (IBM)
• ATLAS (Silvaco: www.silvaco.com )
• MEDICI (Synopsys: www.synopsys.com)

\textbf{Academic Ethics}
All assignments should be student own work. Simply copping someone else’s homework is \textbf{unethical}. It will be considered as \textbf{cheating}. All kind of cheating will be punished.

• Students are encouraged to discuss the problems together.
• It is responsibility of each student to save his/her work.
• Cheating in any work brings \textbf{zero} point
• Signing in for someone else drops lecture visa
Dissection of Ethics Points (+5p)

- Original HWs: 30%
- Original Exams: 30%
- Attendance: 40%

Bibliography