Course Outline

Faculty of Engineering

School of Photovoltaic and Renewable Energy Engineering

SOLA5055: Semiconductor Devices
SOLA9005: Advanced Semiconductor Devices

Session 2, 2014

Course Coordinator
Dr Ashraf Uddin
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Consultation Hours: Tuesday 2 - 3 pm

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1. Staff Contact Details

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Consultation Hours: Tuesday 2 - 3 pm

Lecturer
Dr Ashraf Uddin

Head Demonstrator
Rui Lin

2. Course Details

Moodle Website:

Credit Points: 6 units

Summary of the Course

This course describes the fundamentals of semiconductor material and device physics. This course is essential for students who desire to specialize in semiconductor devices including photovoltaic devices. This course describes the operating principles of modern semiconductor devices, relates terminal properties to their internal structure, and gives an understanding of how terminal properties will change with operating conditions. Devices are covered include p-n junction diodes, solar cells, bipolar junction transistors, field-effect transistors (MOSFETs and MESFETs), light-emitting diodes and semiconductor lasers, detectors, microwave devices, etc..

Aims of the Course

- The **broad aim** of this course is to describe the operating principles of modern semiconductor devices, to relate terminal properties to their internal structure, and to give an understanding of how terminal properties will change with operating conditions.
- **Expected learning outcomes:** A solid understanding of the operating principles of modern semiconductor devices.
- **Gain of information:** Students are expected to gain the necessary information through lectures, tutorials, assignments, textbooks, self-research, etc.

Student learning outcomes

At the end of this course, the student will be able to:

(1) Understand physical/electrical properties and structures of semiconductor devices including photovoltaic devices.
(2) Understand operation principles and physics of semiconductor devices.
(3) Design and analyze semiconductor devices for different applications.

Much of the above experience and knowledge will be gained through the use of lecture notes, tutorials, assignment, and text books, self-research, etc.

Assumed Knowledge

- It is assumed that students enrolled in this course are familiar with semiconductor materials and devices such as photovoltaic devices, diode, and transistor. Reasonable background in semiconductor device physics.

Developed Competencies

The Engineers Australia policy on Accreditation of Professional Engineering programs requires that all programs ensure that their engineering graduates develop Stage 1 elements of competency (see: http://www.engineersaustralia.org.au/membership/assessment/assessment_home.cfm). Listed below are the activities in this course that will help you to achieve at least some of these elements of competency. Note: that not all elements of competency are relevant to each course.

Professional Engineering Stage 1 Elements of Competencies	Activities used to Develop Competency
Knowledge Base	
Knowledge of Science and Engineering Fundamentals	Lectures on semiconductor device physics and on their related theories such as p-n junction diodes, solar cells, bipolar transistors, field effect transistors, light emitting diodes, micro-wave devices, etc.
In-depth technical competence in at least one engineering discipline	Lectures on semiconductor materials and device structures for different applications.
Techniques and resources	Assignment and tutorials tasks which require solving the problems from the available information of semiconductor devices.
Engineering Ability	
Ability to undertake problem identification, formulation, and solution	Assignment tasks requiring problem analysis from semiconductor materials and device parameters and characterization data.
Understanding of social, cultural, global and environmental responsibilities and the need to employ principles of sustainable development	Lectures/discussions on future trends and environmental impact of current and emerging semiconductor technologies.
Ability to utilize a systems approach to complex problems and to design and operational performance	Tutorial and assignment tasks in which device parameters are required to be methodically optimized.
Understanding of the business environment	Lectures on cost and logistical aspects of semiconductor manufacturing.
Professional Attributes	
Ability to communicate effectively, with the engineering team and with the community at large	Preparing written assignments which effectively communicate how software and other tools can be used to optimize the device performance.
Ability to manage information and documentation	Tutorial and assignment tasks requiring effective representation of multivariate calculated and simulation data.
Ability to function effectively as an individual and in multidisciplinary and multicultural teams, as a team leader or manager as well as an effective team member	Team assignments which require group planning and effective communication between team members.

3. Rationale for the Inclusion of Content and Teaching Approach

This course is designed on semiconductor devices operation principles. This course is very important to develop the future workforces for semiconductor industry including solar cells. It is essential for students who desire to specialize in micro- and nano-electronics including photovoltaic devices. The course covers the basics of the semiconductor materials and devices for micro- and nano-electronic technology. From my industrial experience on semiconductor device process

technology as well as on my teaching experience I have prepared my course materials by reviewing several books and articles. This experience is supported by a series of lectures which present the theory and working principles of semiconductor devices. I will use simple examples from our daily practical life to explain difficult topics to make it easier to student to understand. I am always encouraging my students to discuss with me at any time at anywhere if my lecture topics are not clear to them. I am also encouraging my students to discuss on the lecture topics among themselves to make them clear. I will use tutorial problems and assignments from each topic to get in-depth understand on the course. I will take mid-term and final test to press the student to study and understand the course. I will use CATEI reports to improve my course and teaching.

4. Teaching Strategies

The teaching strategy for this course comprises a series of lectures and tutorials problems and classes. The lecture series will present theory related to semiconductor materials and devices and up-to-date information about available equipment, costing and quality control resources. During tutorials students can also ask tutors any questions they may have about the material taught in lectures.

Lectures: There are 12 weeks lecture period in semester 2, 2014. Each week has two lectures in one hour slots. The lecture time and places are as: Tuesday 4:00 - 5:00 pm, (Webster Theatre B (F Hall B)) & Wednesday 3:00 – 4:00 pm (Webster Theatre B (F Hall B)). All lecture notes will be provided before each lecture, either via UNSW's Moodle site or as photocopied handout.

Tutorials: The tutorial problems will be provided before each tutorial, either via Moodle or as photocopied handout. The solutions will be provided during or after each tutorial class. The tutorial class schedules for semester 2, 2014 is as Thursday 11:00 – 12:00 (Law room 202); Thursday 15:00 – 16:00 (Webst room 256) and Friday 15:00 – 16:00 (Webst room 251).

Assignment: There are two assignments in this course. Assignments will be provided via UNSW's Moodle site. The two take-home assignments will be handed out in weeks 2 and 7. Their due dates will be shown on the papers. The solutions may be presented in the tutorial class (but will not be distributed).

Undergraduate and postgraduate students will attend the same lectures and tutorial classes. Students are also strongly encouraged to use the discussion group on Moodle to assist their learning. Tutors will monitor the discussions and help answer posted questions.

5. Tentative Course Schedule

Week	Lecture	Tutorials
1	Course outlines and Introduction (L1), Energy bands and carrier conc. (L2)	No tutorial
2	Carrier transport phenomena (L3), Continuity Equation & Tunnelling process (L4)	Tutorial 1 (Assignment 1 out)
3	p-n junction diodes (L5&6)	Tutorial 2
4	p-n junction diodes and solar cells (L7&8)	Tutorial 3
5	Solar cells (L9&10)	Tutorial 4
6	Bipolar transistors (L11&12)	Tutorial 5 (Assignment 1 due)
7	Mid-session exam (L13) Bipolar transistors (L14)	Tutorial 6 (Assignment 2 out)
8	MOSFET (L15&16)	Tutorial 7
9	MOSFET & MESFET (L17&18)	Tutorial 8
10	MESFET & Photonic devices (L19&20)	Tutorial 9
11	Photonic devices & (L21) Microwave devices (L22)	Tutorial 10
12	Microwave devices (L23) Lecture Review & Final Exam (L24)	Tutorial 11 (Assignment 2 due)
13	NO CLASS	Revision Tutorial?

6. Resources for Students

Learning resources for this course include:

- **Textbooks:**

  - S.M. Sze, *Semiconductor Devices (physics and Technology)*, 3rd and 2nd ed. (Wiley, 2012 and 2002).
  - M.A. Green, *Solar Cells* (UNSW Bookshop, 1982).
  - S.M. Sze, "*Physics of Semiconductor Devices*", 3rd Edition (Wiley, 2007); other lecture materials will be drawn from various textbooks and journal papers.

- **Website:** UNSW's Moodle.

- **Lecture Notes:** Lecture notes will be provided before each lecture, either via UNSW's Moodle site or as photocopied handout.
- **Tutorial Notes:** The tutorial problems will be provided before each tutorial, either via Moodle or as photocopied handout. The solutions will be provided after each tutorial class.
- **Assignments (and other course material):** Will be provided via UNSW's Moodle site.
- **PC1D solar cell simulator:** Is installed on the PCs in TETB. For a personal copy, see www.pv.unsw.edu.au/links/products/pc1d.asp.

- The UNSW Library (see http://info.library.unsw.edu.au/web/services/services.html)

7. Assessment

- Take-home assignments (2 @ 5% each): **10%** for all.
  Mid-session exam: **20%** for all.
  Final exam (written exam, 3.0 hrs): **70%** for both Undergraduate and Postgraduate students.
- The Ugrad and Pgrad final exam papers will be different. ALL material presented during the session will be examinable in the final exam unless otherwise noted. Both final exam papers may have a section devoted to the Pgrad research papers/presentations.
- If necessary, the final overall marks will be scaled (possibly separately for Ugrads and Pgrads; for Ugrads, it may even be necessary to do this separately for 3rd-year and 4th-year students). [Remark: The average mark for courses in the Faculty of Engineering at UNSW is typically in the 65-72% band.]
- All assessable work (except the final exam) must be submitted with a completed (and signed) cover sheet. The sheet can be downloaded from the PV School's Undergraduate site on Webpage.

Submission of Assessment Tasks

Student Responsibilities and Class Policies:

- **Late assignments** will be penalized 5%, plus 5% per day that the work is late (maximum penalty is 100%). Once the solutions are presented, the maximum penalty will apply.
- **Attendance and Attention:** Responsibility for earning marks rests solely with the student. Thus, it would be a smart thing to attend lectures, to avail yourself of the subject resources (as above), to complete your assignments on time and to the best of your ability, participate in the tutes, and to be fully aware of the course syllabus, including any announcements or changes to that syllabus.
- Students are expected to not distract their colleagues during lectures and tutorials.

8. Course Evaluation and Development

At the end of the course, students will be asked to complete two evaluation forms – one for the course and one for the course coordinator using the UNSW's Course and Academic Teaching

Evaluation and Improvement (CATEI) Process. Your feedback is much appreciated and taken very seriously. Continual improvements are made to the course based in part on such feedback and this helps us to improve the course for future students.

9. Academic Honesty and Plagiarism

All assignments and tutorials are for individual effort and individual assessment only. You are expected to be aware of, and you will be subject to, the UNSW and School policies that cover plagiarism of written work (see the PV Undergraduate site on Webpage). Students will be penalised for plagiarism in tutorial, assignment and exam work.

Plagiarism

Plagiarism is the presentation of the thoughts or work of another as one's own. Examples include:[1]

- Direct duplication of the thoughts or work of another, including by copying work, or knowingly permitting it to be copied. This includes copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- Paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- Piecing together sections of the work of others into a new whole;
- Presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and,
- Claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed. [2]

Submitting an assessment item that has already been submitted for academic credit elsewhere may also be considered plagiarism. The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism. Students are reminded of their rights and responsibilities in respect of plagiarism, as set out in the University Undergraduate and Postgraduate Handbooks, and are encouraged to seek advice from academic staff whenever necessary to ensure they avoid plagiarism in all its forms.

The Learning Centre website is the central University online resource for staff and student information on plagiarism and academic honesty. It can be located at:
www.lc.unsw.edu.au/plagiarism
The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

[1] Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle.
[2] Adapted with kind permission from the University of Melbourne.

- Correct referencing practices;
- Paraphrasing, summarising, essay writing, and time management;
- Appropriate use of and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.
Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

10. Other Information

Special Consideration for Illness or Misadventure

If you are unable to submit a piece of assessment on time, or to participate fully in laboratory sessions, due to illness or some other event which was beyond your control, you must follow the central UNSW procedures for seeking special consideration. Details of these can be found at https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Please be aware that requests for special consideration need to be submitted to UNSW Student Central as soon as is practicable after the problem occurs and within three working days of the due date of the relevant assessment task.

Disability Support

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, with the Equity and Disability Officer in the school office (9385 7993) or with the Equity Officer (Disability) in the Equity and Disability Unit (EADU) 9385 4734. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

Further information for students with disabilities is available at: http://www.studentequity.unsw.edu.au/disabil.html.