SOLA9101

Advanced Photovoltaics

Term 1, 2022

Course Overview

Staff Contact Details

Convenors Convenors

Name	Email	Availability	Location	Phone
Ashraf Uddin	a.uddin@unsw.edu.au	Thursday 2pm-4pm (Weekly Consultations)		

Course Details

Units of Credit 6

Summary of the Course

This course covers the basics of the semiconductor materials and advanced photovoltaic devices and processing technology. The major objective is to familiarize the students with the basic principles of operation of all photovoltaic devices such as silicon heterojunction (HIT) cells, multi-junction tandem cells, hot-carrier cells, organic and perovskite solar cells, CIGS, etc. The device processing technology includes: (i) crystal structures, silicon crystal growth and Czochralski crystal growth, wafer preparation, defects in wafer, defect treatment, (ii) doping and thermal oxidation of materials, (iii) physical vapor deposition technique, principle of sputtering process, sputtering techniques: RF sputtering, DC magnetrons, bias sputtering, reactive sputtering and ion metal plasma sputtering, (iv) basic aspects of CVD, gas phase mass transfer/surface reaction, rate determining step, sticking coefficient and advantages/disadvantages, types of reactions in CVD: APCVD, LPCVD and PECVD; (v) spin coating, ink-jet printing, micro-contact printing, nanoimprint technology, (vi) Photolithography, photoresist material parameters: resolution, sensitivity and viscosity. Optical photoresist material types, photoresist processing, optics of microlithography, methods of transferring patterns, pattern registration, (vii) wet etching technology, etchants, lift-off technology for patterning electrode, basic physics and chemistry of plasma etching and reactive etching, processing issues related to dry etching.

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Teaching Strategies

The teaching strategy for this course comprises a series of lectures and workshops, 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 workshops, students can also ask demonstrators any questions they may have about the material taught in lectures.

Lectures: There are 10 weeks of Online Lectures (MS Teams) in Term T1, 2022. Each week has two lectures in one- and two-hours slots. The lecture time and places are as: Wednesday 12:00 - 13:00, (MS Teams) and on Thursday 15:00 – 17:00 (MS Teams). All lecture notes will be provided before the lecture, either via UNSW's Moodle site or as photocopied handouts.

Workshops: In the workshop session, students will work in small groups. The workshop problems will be provided before each workshop, either via Moodle or as a photocopied handout. The solutions will be provided during or after each workshop. The workshop schedules for Term T1, 2022 is as: Wednesday 14:00 – 16:00 (Online, MS Teams), Thursday 12:00 – 14:00 (Law building 162, face-to-face).

Assignments: 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 1 and 7. Their due dates will be shown on the papers. The solutions may be presented in the Workshop (but will not be distributed).

Students are also strongly encouraged to use the discussion group on Moodle to assist their learning. Demonstrators will monitor the discussions and help answer posted questions.

Final Exam: Final exam in this course is a standard 2 hour online written examination. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course, unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

Additional Course Information

All course materials and announcements will be posted on Moodle. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.This is a 6 UoC course and the expected workload is 12–14 hours per week throughout the 10-week term. SOLA9101 is a level 5 course. It is offered to 3rd and 4th year UG students and Graduate Diploma and Master's Postgraduate programs students in the School of Photovoltaic and Renewable Energy Engineering School. It is a professional elective course for the Photovoltaic and Solar Energy Program. It is a core/elective course for students following a BE (Materials Science or Electrical Engineering) program and other combined degree programs, and an elective for physics students.

It is assumed that students enrolled in this course are familiar with semiconductor materials and devices such as photovoltaic devices and diodes.

Consultations: For all enquiries about the course, please contact the course convener. A regular weekly consultation time is on Thursday 2 - 4 pm online (MS Teams) or inTETB room 126. For all other questions or enquiries, you are encouraged to ask the lecturer after class or post your questions on the Discussion Board on Moodle.

https://moodle.telt.unsw.edu.au/login/index.php

Assessment

Assessments

Take-Home Assignment 1&2	20%
Mid-Term Exam	15%
Self-Learning Exam (Term End Test)	15%
Final Exam (2 hours)	50%

- ALL material presented during the sessions will be examinable in the final exam unless otherwise noted.

- All assessable work (except the Final Exam) must be submitted with a completed (and signed) cover sheet. The sheet can be downloaded from the Course Moodle site.

- 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.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Mid-Term Exam	15%	10/03/2022 12:00 AM	1, 2, 3
2. Assignment - 1	10%	18/03/2022 12:00 AM	1, 2, 3
3. Assignment - 2	10%	22/04/2022 12:00 AM	4
4. Term-End Test	15%	21/04/2022 12:00 AM	4
5. Final Exam	50%	To be confirmed	1, 2, 3, 4

Assessment 1: Mid-Term Exam

Start date: 10/03/2022 12:00 AM
Submission notes: Just after the test, results will be automatically submitted on Moodle
Due date: 10/03/2022 12:00 AM

Mid-term exam will cover all solar cell devices in the course. It will be approximately 40 minutes and will be an online exam.

Assessment criteria

Please see SOLA9101 Moodle site for Assessment Criteria.

Assessment 2: Assignment - 1

Start date: 18/02/2022 12:00 AM
Submission notes: Please submit your assignment in the submission box in Moodle.
Due date: 18/03/2022 12:00 AM
Deadline for absolute fail: 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.

Assignment 1 will be provided in week 1 Lecture in Moodle. Students need to solve the assignment 1 problems and submit them in the week 5 Lecture.

Students will have 4 weeks time to solve the problems.

Assessment criteria

Please see SOLA9101 Moodle site for Assessment Criteria.

Assessment 3: Assignment - 2

Start date: 25/03/2022 12:00 AM
Submission notes: Please submit the Assignment 2 solution in the submission box in Moodle.
Due date: 22/04/2022 12:00 AM
Deadline for absolute fail: 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.

Assignment 2 will be in Moodle in week 6 Lecture and students need to submit the solution of assignment 2 in week 10 Lecture.

Students will get 4 weeks time to solve the assignment problems.

Assessment criteria

Please see SOLA9101 Moodle site for Assessment Criteria.

Assessment 4: Term-End Test

Start date: 21/04/2022 12:00 AM
Submission notes: Please submit your test results just after the test.
Due date: 21/04/2022 12:00 AM

The Term-End Test will cover all the processing topics. It will be approximately 40 minutes and will be an online exam.

Assessment criteria

Please see SOLA9101 Moodle site for Assessment Criteria.

Assessment 5: Final Exam

Start date: To be confirmed
Assessment length: 2 hours
Submission notes: Just after the exam please submit your answer paper within 30 minutes.
Due date: To be confirmed
Deadline for absolute fail: Late submission will not be accepted.

The Final Exam will cover all the course materials such as lecture notes, workshops and assignments. It will be a 2 hour online exam in Moodle. Just after the exam, students need to submit their answer papers in the submission box in Moodle.

Assessment criteria

Please see SOLA9101 Moodle site for Assessment Criteria.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

Contact Hours

Sessions	Day	Time	Location
Lecture	Wednesday	12:00 – 13:00	Online (MS Teams)
Lecture	Thursday	15:00 – 17:00	Online (MS Teams)
Workshop	Wednesday	14:00 – 16:00	Online (MS Teams)
Workshop	Thursday	12:00 – 14:00	Law Bld. 162 (Face-to-Face)

View class timetable

Timetable

Date	Type	Content
Week 1: 14 February - 18 February	Lecture	Lecture Topics: Course outlines and Introduction (L1A), Energy bands and carrier conc. (L1B) Carrier transport Phenomena (L1C). No Workshop week 1
	Assessment	Assignment 1 released
Week 2: 21 February - 25 February	Lecture	Lecture Topics: P-N junction diodes (L2A), Silicon solar cells (L2B) Silicon solar cells (L2C) & Workshop 1

Resources

Prescribed Resources

Course Resources

Text and Reference books:

1. S.M. Sze, *Qc k gam l bsarmp Bc t gacq &n f wqqaq _ l b Rca f l mjmew'*, 3rd and 2nd ed. (Wiley, 2012 and 2002).
2. S.M. Sze, "*N f wqqaq md Qc k gam l bsarmp Bc t gacq*", 3rd Edition (Wiley, 2007); other lecture materials will be drawn from various textbooks and journal papers.
3. M.A. Green, *Qmj_p Acjjq* (UNSW Bookshop, 1982).
4. Arvind Shah, "Thin-film Silicon solar cells", 2010, CRC press.
5. J. D. Plummer, M. D. Deal and P.B. Griffin, Silicon VLSI Technology, 2000, Prentice Hall.
6. Y. Chang and S.M. Sze, ULSI Technology, 1996, McGraw Hill
7. S. K. Ghandhi, "VLSI Fabrication Principles, 1994, John Wiley.
8. Various Webpages

On-line Resources

- Website: UNSW's Moodle. As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php
- Lecture Notes: Lecture notes will be provided before each lecture via UNSW's Moodle site.
- Workshops: Workshop problems will be provided before each workshop via moodle. The solutions will be provided after each workshop in UNSW moodle site.
- Assignments (and other course materials): 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.
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Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 5% mark reduction per day, consistent with other SPREE courses, and capped at 5 days (120 hours), after which a student cannot submit an assessment.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

Work submitted after the ‘deadline for absolute fail’ is not accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

a. Weekly online tests or laboratory work worth a small proportion of the subject mark, or

b. Online quizzes where answers are released to students on completion, or

c. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date

or

d. Pass/Fail assessment tasks.

Academic Honesty and Plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Nj_eg_pgqk _r SLQU gq bcdglcb _q sqgle rfc umpbq mp gbc_q md mrfcpq _lb n_qqgle rfck mdd _q wmsp mul,*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You 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

Academic Information

Course Evaluation and Development

Feedback on the course is gathered periodically using various means, including the UNSW

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	