UNSW Course Outline

SOLA9101 Advanced Photovoltaics - 2024

Published on the 30 Aug 2024

General Course Information

Course Code : SOLA9101
Year : 2024
Term : Term 3
Teaching Period : T3
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Photovoltaic and Renewable Engineering
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Designing a high efficiency solar cell requires a good understanding of loss mechanisms in solar cells and techniques to avoid or minimize these losses. The aim of this course is to explain the fundamental energy losses in the PV conversion process and novel concepts to mitigate these losses. Topics include crystal structures and defects, phonons in crystal lattices, concepts of detailed balance, light trapping methods, and advanced photovoltaic concepts such as multijunction, intermediate band and hot carrier solar cells.

Relationship to Other Courses

The student attending this course is suggested to be familiar with silicon semiconductor materials and photovoltaic devices.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain fundamental losses in PV energy conversion.
CLO2 : Discuss light trapping mechanisms to improve efficiency of solar cells.
CLO3 : Describe how properties of quantum confined structures may be applied to photovoltaic devices.
CLO4 : Gather information from peer-reviewed published sources and arrange into a seminar presentation to explain the key features of a given approach to student peers.

Course Learning Outcomes	Assessment Item
CLO1 : Explain fundamental losses in PV energy conversion.	• Mid-term exam • Assignment 1 • Final exam
CLO2 : Discuss light trapping mechanisms to improve efficiency of solar cells.	• Mid-term exam • Assignment 1 • Final exam
CLO3 : Describe how properties of quantum confined structures may be applied to photovoltaic devices.	• Assignment 2 • Mid-term exam • Assignment 1 • Final exam
CLO4 : Gather information from peer-reviewed published sources and arrange into a seminar presentation to explain the key features of a given approach to student peers.	• Seminar presentation

Learning and Teaching Technologies

Moodle - Learning Management System

Learning and Teaching in this course

The teaching strategy for this course comprises of a series of lectures, workshops, assignments, exams, and lab visits. The lecture series will present fundamental theory related to single-junction and multijunction cell technologies, the introduction of dominant Si wafer PV technologies, thin film PV technologies, and advanced next-generation multijunction PV technologies. For each PV technology, light harvesting semiconductor materials, device architectures, and manufacturing as well as their progress will be discussed. During workshops, students can also ask demonstrators/lecturers questions they may have about the material taught in lectures and provided in workshops.

Other Professional Outcomes

Learning Outcomes

1. Explain fundamental performance losses in PV energy conversion

2. Appreciate the key features and issues facing a range of single junction PV technologies

3. Grasp the advanced concept of how to surpass the theoretical efficiency defined by Shockley-Queissier limit.

4. Determine the performance of PV devices through device characterisation and develop computer models to fit the data.

5. Gather information from peer-reviewed published sources and learnings from lecture and arrange into a seminar presentation to explain the key features of a given approach to student peer.

Additional Course Information

Course Aims

This course takes a student who is already familiar with silicon semiconductor materials and photovoltaic devices to the forefront of a number of photovoltaic technologies. Students will gain an appreciation for the limits to performance of present, high-efficiency industrial PV technology and gain a perspective for the likely evolution of future PV technologies, with a perspective for the wider future PV applications.

Course Description

This course covers the operating principles and practice of advanced photovoltaic devices with attention paid to their light harvesting semiconductor absorber materials, device structure, and manufacturing technologies used to fabricate these photovoltaic devices. Fundamental solar cell operating principles are established allowing limits to conversion efficiency to be determined and then a series of photovoltaic solar cell technologies are discussed including the dominant high-efficiency silicon, well-established III-V and chalcogenide thin film solar cells, emerging chalcogenide and perovskite thin film solar cells. On the basis of single junction Si and thin film PV technologies, advanced next-generation PV technologies, with a particular focus on the multi-junction tandem solar cells, will then be introduced. Measurement methods and computer device modelling techniques will also be introduced for not only single junction but also multijunction solar cells.

Teaching Strategies and Rationale

The teaching strategy for this course comprises of a series of lectures, workshops, assignments, exams, and lab visits. The lecture series will present fundamental theory related to single-junction and multijunction cell technologies, the introduction of dominant Si wafer PV technologies, thin film PV technologies, and advanced next-generation multijunction PV technologies. For each PV technology, light harvesting semiconductor materials, device architectures, and manufacturing as well as their progress will be discussed. During workshops, students can also ask demonstrators/lecturers questions they may have about the material taught in lectures and provided in workshops.

Lectures: There are 8 weeks of Lectures and one-week lecture in the lab. Each week has two lectures in one- and two-hour slots. All lecture notes will be provided before the lecture via UNSW's Moodle site. Learning is further supported through the use of interactive computer simulation of PV devices.

Workshops: In the workshop session, the workshop problems will be provided, either via Moodle or as a photocopied handout. The solutions will be provided during or after each workshop. In addition to the workshop problems, students will be encouraged to ask any questions about the lectures. The workshop is scheduled for 3 hours/week.

Assignments: There are two assignments in this course. Assignments will be provided via UNSW's Moodle site. Students are also strongly encouraged to use the discussion group on Moodle to assist their learnings. Demonstrators/lecturers will monitor the discussions and help answer posted questions.

Final Exam: Final exam in this course is a standard 2 hours written examination. University approved calculators are allowed and lecture notes 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.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Mid-term exam	20%	Start Date: 07/10/2024 12:00 AM Due Date: 07/10/2024 11:59 PM
Assignment 1	10%	Start Date: 16/09/2024 12:00 AM Due Date: 13/10/2024 11:59 PM
Assignment 2	10%	Start Date: 14/10/2024 12:00 AM Due Date: 16/11/2024 11:59 PM
Seminar presentation	15%	Due Date: 15/11/2024 09:00 AM
Final exam	45%	Start Date: TBC Due Date: TBC

Assessment Details

Mid-term exam

Course Learning Outcomes

- CLO1 : Explain fundamental losses in PV energy conversion.
- CLO2 : Discuss light trapping mechanisms to improve efficiency of solar cells.
- CLO3 : Describe how properties of quantum confined structures may be applied to photovoltaic devices.

Detailed Assessment Description

Mid-term exam will cover all solar cell devices in the course lectures (week1-week4). It will be approximately 40 minutes and will be an online exam.

Assessment Length

40 min

Submission notes

Just after tests, results will be automatically submitted on moodle.

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.

For more information on Generative AI and permitted use please see here.

Assignment 1

Course Learning Outcomes

- CLO1 : Explain fundamental losses in PV energy conversion.
- CLO2 : Discuss light trapping mechanisms to improve efficiency of solar cells.
- CLO3 : Describe how properties of quantum confined structures may be applied to photovoltaic devices.

Detailed Assessment Description

Assignment 1 mainly covers the content of lectures and workshops during Weeks of 1-4. The assignment needs to be submitted via the submission box in Moodle.

Submission notes

Please submit assignments via Moodle

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.

If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.

For more information on Generative AI and permitted use please see here.

Assignment 2

Assessment Overview

Not specified

Course Learning Outcomes

- CLO3 : Describe how properties of quantum confined structures may be applied to photovoltaic devices.

Detailed Assessment Description

This assignment covers the content of lectures and workshops in weeks of 5-9

Submission notes

Please submit the assignment 2 solution in the submission box in Moodle

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.

If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.

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Seminar presentation

Assessment Overview

Students will choose a topic of interest in Advanced PV and present a short seminar (up to 15 minutes depending on enrolment numbers) to the class on this subject.

Course Learning Outcomes

- CLO4 : Gather information from peer-reviewed published sources and arrange into a seminar presentation to explain the key features of a given approach to student peers.

Detailed Assessment Description

Students will choose a topic of interest in Advanced PV and present a short seminar (up to 10 mins) to the student peers and panel judges on this subject.

Submission notes

Please submit your PPT presentation in Moodle

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.
If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.
For more information on Generative AI and permitted use please see here.

Final exam

Course Learning Outcomes

- CLO1 : Explain fundamental losses in PV energy conversion.
- CLO2 : Discuss light trapping mechanisms to improve efficiency of solar cells.
- CLO3 : Describe how properties of quantum confined structures may be applied to photovoltaic devices.

Detailed Assessment Description

The final Exam will cover all the course materials such as lecture notes, workshops and assignments. It will be a 2-hour exam on paper.

Assessment Length

2 hours

Submission notes

Students need to submit their answer papers after examination in person.

Assignment submission Turnitin type

This is not a Turnitin assignment

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.

For more information on Generative AI and permitted use please see here.

General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 9 September - 15 September	Lecture	L1A-Intro L1B-Fundamental L1C-Si PV
Week 2 : 16 September - 22 September	Lecture	L2A-CdTe thin film solar cell L2B-CIGS thin film solar cell L2C-CZTS thin film solar cell
Week 3 : 23 September - 29 September	Lecture	L3A-PVSK solar cell L3B-III-V solar cell L3C-Case study
Week 4 : 30 September - 6 October	Lecture	L4A-tandem fundamental & III-V tandem PV L4B-Si-based tandem cells L4C-Other Advanced Concept
Week 5 : 7 October - 13 October	Lecture	L5A-Tandme cell case studies-Tandem cell-space PV L5B- Modelling of PV device L5C-Solar Cell characterization
Week 7 : 21 October - 27 October	Lecture	L7A-Advanced PV characterization L7B-Measuing tandem cell efficiency L7C-Measuring EQE of tandem cells
Week 8 : 28 October - 3 November	Laboratory	L8A-lab visit L8B-Lab visit L8C-Lab visit
Week 9 : 4 November - 10 November	Lecture	L9A-Concentrator PV devices & sys L9B-Thermal property of PV cells & modules L9C-Measuring concentrator SC
Week 10 : 11 November - 17 November	Lecture	L10A-PV technological diffusion: Learning curves, L10B-Revision lecture L10C-Revision lecture

Attendance Requirements

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

General Schedule Information

Lectures: There are 9 weeks of Lectures (including one week for lab visit) in Term T3, 2024. Each week has two lectures in one- and two-hours slots. The lecture time slots are as:

Tuesday 11:00 - 12:00 (Law Theatre G23 (K-F8-G23)), and on Thursday 12:00 – 14:00 (E19 Patricia O'Shane G06 (K-E19-G06)). All lecture notes will be provided before the lecture via UNSW's Moodle site.

Workshops: In the workshop session, the workshop problems will be provided, either via laptop or as a photocopied handout. The solutions will be provided during or after each workshop. In addition to the workshop problems, students will be encouraged to ask any questions about the lectures. The workshop schedules for Term T3, 2024 is as: Friday 9:00 – 12:00 (on campus, Webster 256 (K-G14-256)).

Course Resources

Prescribed Resources

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.

Recommended Resources

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.

Course Evaluation and Development

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. This advanced PV disciplinary course is offered to Graduate Diploma and Master's Postgraduate programs students in the School of Photovoltaic and Renewable Energy Engineering. Following our BE (honour) rule, UG students may also take this advanced disciplinary course if meeting certain requirement (i.e. students with WAM greater than 65 may take max 1 advanced disciplinary courses and those with WAM greater than 75 may take 2 advanced disciplinary courses). This course is a professional elective course for the Photovoltaic and Solar Energy Program. It is also 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 via emails or MS Teams. 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.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Xiaojing Hao		TETB248		Wednesday 12-2pm	No	Yes

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address

- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

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 convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. 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.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

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. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

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 research, drafting and the proper referencing of sources in preparing all assessment tasks.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

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 five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

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. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be 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 will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School-specific Information

SPREE Student Information Hub

Students are welcome to visit the SPREE Student Information Hub for information such as sample study plans, course outlines, thesis project, industrial training etc.

School Contact Information

For course-related matters, please contact course convenor directly via emails. Please email spreeteaching@unsw.edu.au for any other matters.