UNSW Course Outline

SOLA3020 Photovoltaic Technology and Manufacturing - 2024

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General Course Information

Course Code : SOLA3020
Year : 2024
Term : Term 2
Teaching Period : T2
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, Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

In this course you will learn about the manufacturing of commercial cell technologies while considering solar cell operating principles. The course theory will cover the complete production processes from raw silicon materials through to photovoltaic modules for dominant cell

technologies including PERC and TOPCon. Trends in commercial cell manufacturing and device technologies are considered.

The impact of various processing and device parameters on performance, minimising losses, yields and product reliability are studied. Students will get first-hand experience at industry software SunSolve for a deeper understanding of manufacturing processes. With SunSolve students will apply an experimental methodology to adjust key manufacturing process parameters to optimise and analyse device production and performance. Other laboratory work uses statistics to understand manufacturing batch data of commercial cells.

Course Aims

The aims of this course are:

- To expose students to the manufacturing environment and introduce them to important manufacturing concepts such as device design, yields, throughput, process optimisation, reliability, in-line quality control and fault diagnosis; and
- To foster an understanding of the key processes in commercial silicon solar cell production and their importance for device performance and interrelatedness.
- To develop within the students an ability to optimise a solar cell production line using an experimental methodology.

Relationship to Other Courses

This course teaches the process of manufacturing silicon PV cells and modules. To make the most of this course students should have an understanding of the physics of semiconductors and silicon solar cell devices, ideally having completed solar cells or semiconductor electronics courses.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Apply an understanding of the physics and chemistry underlying the main photovoltaic manufacturing processes to the optimisation of screen-printed solar cell production lines.
CLO2 : Analyse solar cell performance and losses through the use of common testing and characterisation techniques.
CLO3 : Optimise the design, production and processes for manufacturing of solar cells and modules using an experimental methodology.
CLO4 : Communicate an awareness of emerging manufacturable solar cell technologies.

Course Learning Outcomes	Assessment Item
CLO1 : Apply an understanding of the physics and chemistry underlying the main photovoltaic manufacturing processes to the optimisation of screen-printed solar cell production lines.	• Progress Exercises • Simulation Exercise • Final Exam
CLO2 : Analyse solar cell performance and losses through the use of common testing and characterisation techniques.	• Progress Exercises • Simulation Exercise • Final Exam
CLO3 : Optimise the design, production and processes for manufacturing of solar cells and modules using an experimental methodology.	• Progress Exercises • Simulation Exercise • Final Exam
CLO4 : Communicate an awareness of emerging manufacturable solar cell technologies.	• Group Presentation • Progress Exercises • Simulation Exercise • Final Exam

Learning and Teaching Technologies

Moodle - Learning Management System

Learning and Teaching in this course

During this course you will have several different guest lecturers and workshop demonstrators. Each one of them works on collaborative research projects with PV manufacturers solving some of the most relevant challenges facing the PV indsutry today. You will be leanring from some of the world's experts on this content! Make sure you watch the online content ahead of time and familiarise yourself with who the teachers are so you can use the lecture and workshop time to pick their brains, ask as many questions as you like and learn from their experience and about their research. Personal experience can tell you far more than a text book!

Other Professional Outcomes

Additional Course Information

This is a 6 unit-of-credit (UoC) course and involves 4 hours per week (h/w) of scheduled contact (2 hours lecture (Q&A) and 2 hours Workshop).

The normal workload expectations of a student are approximately 25 hours per term for each UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 10-12 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Progress Exercises Assessment Format: Individual	20%	Start Date: Not Applicable Due Date: End of each week (except week 6)
Group Presentation Assessment Format: Group	20%	Due Date: Week 5: 24 June - 30 June
Simulation Exercise Assessment Format: Individual	20%	Due Date: Week 10: 29 July - 04 August
Final Exam Assessment Format: Individual	40%	Due Date: Exam period

Assessment Details

Progress Exercises

Assessment Overview

These weekly activities will assess students' knowledge and understanding of each manufacturing process in the fabrication sequence from sand to cell to module and PV manufacturing trends. Students will practice their theoretical and practical skills on these topics though quizzes and in-class application exercises.

Weekly quizzes (worth 10% total): These are online quizzes with a selection of multiple choice questions about that week's lecture content. These are short online quizzes with up to 20 multiple choice questions each. Instant marks upon submission help gauge student understanding of lecture content. Unlimited attempts are allowed.

In-class application exercises (worth 10% total). There will be 7 workshops where students will need to solve experimental simulations or perform data analysis. Students can work in pairs to complete the exercises. At the end of each workshop, each individual student must explain their solution to the demonstrator and a couple of randomly selected questions on the topic to demonstrate their understanding. The demonstrator will give a mark and feedback at the workshop.

Course Learning Outcomes

- CLO1 : Apply an understanding of the physics and chemistry underlying the main photovoltaic manufacturing processes to the optimisation of screen-printed solar cell production lines.
- CLO2 : Analyse solar cell performance and losses through the use of common testing and characterisation techniques.
- CLO3 : Optimise the design, production and processes for manufacturing of solar cells and modules using an experimental methodology.
- CLO4 : Communicate an awareness of emerging manufacturable solar cell technologies.

Detailed Assessment Description

Assessment Length

Quiz: Up to 20 multiple choice questions; Workshop: Up to 3 oral questions

Submission notes

Quizzes to be completed in moodle; Workshops to be marked by the demonstrator prior to leaving class

Assignment submission Turnitin type

Not Applicable

Group Presentation

Assessment Overview

You and your group members work in the Research and Development (R&D) line of a solar manufacturing company. The Chief Technology Officer (CTO) has asked your team to investigate a new technology she has heard about. With your group, prepare and present a 15-20 min presentation on your assigned PV emerging technology for the CTO and your colleagues. Provide sufficient technical background so that your audience can appreciate the findings you present, and provide your advice to the CTO whether you think your company should test it. Use whatever resources you like to present in an interesting and compelling way. Remember, an “interested” audience is a good audience!”

You will be marked against specific criteria in a marking guide and feedback will be provided within 10 days through the learning management system.

Course Learning Outcomes

- CLO4 : Communicate an awareness of emerging manufacturable solar cell technologies.

Detailed Assessment Description

Assessment Length

10-15 minutes

Assignment submission Turnitin type

This is not a Turnitin assignment

Simulation Exercise

Assessment Overview

This assignment ties together much of the course content and simulation experience gained throughout the first 9 weeks of the course. There will be 4-5 multi-part questions. This assignment tests predominantly Learning Outcomes 2 and 3 and is part of the summative assessment of the course.

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

You will be marked against specific criteria in a marking guide and feedback will be provided within 10 days through the learning management system.

Course Learning Outcomes

- CLO1 : Apply an understanding of the physics and chemistry underlying the main photovoltaic manufacturing processes to the optimisation of screen-printed solar cell production lines.
- CLO2 : Analyse solar cell performance and losses through the use of common testing and characterisation techniques.
- CLO3 : Optimise the design, production and processes for manufacturing of solar cells and modules using an experimental methodology.
- CLO4 : Communicate an awareness of emerging manufacturable solar cell technologies.

Detailed Assessment Description

Assessment Length

4-5 multiple part questions

Assessment information

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Final Exam

Assessment Overview

This assignment tests the full course content, Learning Outcome 1-4 and is part of the summative assessment of the course.

Course Learning Outcomes

- CLO1 : Apply an understanding of the physics and chemistry underlying the main photovoltaic manufacturing processes to the optimisation of screen-printed solar cell production lines.
- CLO2 : Analyse solar cell performance and losses through the use of common testing and characterisation techniques.
- CLO3 : Optimise the design, production and processes for manufacturing of solar cells and modules using an experimental methodology.
- CLO4 : Communicate an awareness of emerging manufacturable solar cell technologies.

Detailed Assessment Description

Assessment Length

3-4 multiple part questions

Assessment information

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 0 : 20 May - 26 May	Topic	Welcome to SOLA3020: Course Introduction and Silicon PV Device Fundamentals (Q&A in week 1 lecture)
Week 1 : 27 May - 2 June	Topic	PV Industry Trends and Photoluminesence (PL) Imaging: online content and quiz (Q&A in week 2 lecture)
	Lecture	Welcome to SOLA3020. Q&A about the course and fundamentals.
	Workshop	Introduction to basic statistics
Week 2 : 3 June - 9 June	Topic	Crystalline silicon wafers: online content and quiz (Q&A in week 3)
	Lecture	Q&A on PV industry trends and PL imaging
	Workshop	Intro to SunSolve and optimisation of surface texture
Week 3 : 10 June - 16 June	Topic	Cleaning and diffusion: online content and quiz (Q&A in week 4)
	Lecture	Q&A on crystalline silicon wafers
	Workshop	Optimisation of bill of materials
Week 4 : 17 June - 23 June	Topic	Surface passivation, antireflection and lifetime: online content and quiz (Q&A in week 5)
	Lecture	Q&A on cleaning and diffusion
	Workshop	Optimisation of antireflection coatings (ARC)
Week 5 : 24 June - 30 June	Topic	Metallisation and cell testing: online content and quiz (Q&A in week 7)
	Lecture	Q&A on surface passivation, antireflection and lifetime
	Workshop	Group presentations
	Assessment	Group presentations
Week 6 : 1 July - 7 July	Other	UNSW Flexibility Week
Week 7 : 8 July - 14 July	Topic	Emerging technologies: online content and quiz (Q&A in week 8)
	Lecture	Q&A on metallisation and cell testing
	Workshop	Bifacial vs. monofacial solar cells
Week 8 : 15 July - 21 July	Topic	Modules and reliability: online content and quiz (Q&A in week 9)
	Lecture	Q&A on emerging technologies
	Workshop	Optimisation of metallisation
Week 9 : 22 July - 28 July	Topic	Sustainability and lean manufacturing: online content and quiz (Q&A in week 10)
	Lecture	Q&A on modules and reliability
	Workshop	Optical losses in heterojunction solar cells
Week 10 : 29 July - 4 August	Lecture	Q&A on sustainability and lean manufacturing
	Assessment	Final simulation and report assignment due

Attendance Requirements

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

General Schedule Information

All assessible lecture content for each week will be provided online by Tuesday. There will be a quiz due at the end of each week (Sunday) on the week's content. The topic will then be discussed as Q&A in the following week's lecture class. These in class discussions will not be recorded. Workshops will also not be recorded, attendance and participation of workshops forms 10% of course marks.

Course Resources

Prescribed Resources

The course text book is: PV-Manufacturing.org

Also required is the current version of the ITRPV found here: https://www.vdma.org/international-technology-roadmap-photovoltaic

The workshops will use SunSolve software, accessed here: https://training.pvlighthouse.com.au/sunsolve-power. In O-week a link will be provided to access a licenced version.

Recommended Resources

Optional extra resources:

http://taiyangnews.info/

http://www.pveducation.org/

https://www.pv-tech.org/

http://pvinsights.com/

https://www.pvlighthouse.com.au/

Additional Costs

None.

Course Evaluation and Development

MyExperience surverys are extremely helpful for us to know how to better adapt our course deisgn and teaching styles to ensure the best learning experience.

Three of the guest lecturers this trimester will give two Q&A lectures each; please take some time to provide your valuable feedback to help them understand what they do well or could improve. They are primarily researchers but enthusiastic to teach you what they know so please help them in return.

Previous surveys have:

- told me I need to speak slower (I'll do my best!)

- supported the blended learning approach as the best way to make use of the expert lecturers time ie. with assessable content online and class time for Q&A to dig and learn deeper
- highlighted that not all students come with the same background fundamental knowledge so we have now added an optional fundamental lecture on PV fundamentals

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Alison Ciesla		TETB Level 1		email or MS Teams	No	Yes
Lecturer	Michelle Vaqueiro Contreras		NA	NA	email or MS Teams	No	No
Demonstrator	Sijin Wang				email or MS Teams	No	No

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.