

4U02A/B Solar Cell Fabrication
Modern and Applied Physics Laboratory
Fall/Winter 2016/17
Course Outline

CALENDAR/COURSE DESCRIPTION

2 unit(s)

Selected advanced experiments in two areas of applied physics, chosen from among these unique topics: Lasers & Optical Communication, Solar Cell Fabrication, Biomedical and Nuclear Labs. Students must take ENGPYHS 4U02 twice, in order to fulfill degree requirements (for a total of four units). Students must select two unique topics from the list above; the same topic cannot be repeated.

Two labs (three hours each); both terms

Solar Cell Fabrication: this course outline describes one of the four topics available in 4U02A/B. In the Solar Cell Fabrication module, students will complete the fabrication of a working solar cell using semiconductor fabrication methods.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): ENGPYHS 3W04 A/B and PHYSICS 3B06, or both ENGPYHS 3BA3 and ENGPYHS 3BB3

Antirequisite(s): ENGPYHS 4U04 A/B

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Andy Knights
ABB440
aknight@mcmaster.ca
ext. 27224

Office Hours:
By appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Tim Van Boxel
TBA
vanboxtj@mcmaster.ca
TBA

Office Hours:
By appointment

Mitchell Robson
ETB 529
robsom@mcmaster.ca
ext. 26196

Office Hours:
By appointment

Peter Jonasson
JHE A304
jonasso@mcmaster.ca
ext. 24935

Office Hours:
Monday – Friday
2:30 – 5:30 pm

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

The course website, including all course information will be hosted on Avenue to Learn: <http://avenue.mcmaster.ca/>

All course-related e-mail communications must be done through Avenue to Learn E-mail.

All course-related submissions must be done through Avenue to Learn Dropboxes.

It is the students' responsibility to check regularly the course web page (Avenue to Learn) for updates and announcements.

Students are required to obtain and maintain McMaster and Avenue to Learn e-mail accounts for timely communications between the instructors and the students.

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Understand the physics of solar cells
- Understand how to fabricate a solar cell
- Understand basic semiconductor processes, such as photolithography

MATERIALS AND FEES

Required Texts:

None

Optional: Any introductory semiconductor physics text would be helpful, such as Solid State Electronic Devices, B. G. Streetman and S. Banerjee, Prentice Hall

Calculator:

N/A

Other Materials:

Laboratory notebook

COURSE OVERVIEW

The course consists of 10 laboratory sessions, 1 lab session per week, 3 hours each, as follows:

Week 1

1. Clean wafer
2. Grow 100nm oxide, 950C for 20'.

Week 2

3. Apply 1808 photoresist, 4000rpm for 30".
4. Soft bake, 100C for 1 minute.
5. Expose to mask #1, 25".
6. Develop in Microposit 351, 45" (approx.).
7. Hard bake, 120C for 5's.
8. Mount 2" wafer on 4" transport wafer solar cell UP.
9. Dip 4" wafer into buffered HF, 150".
10. De-mount 4" wafer.
11. Remove 1808 photoresist.

Week 3

12. Etch 2" wafer in KOH, 72C for 10'35".
13. Dip 2" wafer into buffered HF for 150".
14. Apply 1827 photoresist, 2000rpm for 30".
15. Soft bake, 100C for 1 minute
16. Expose to mask #2, 90".
17. Develop in Microposit 351, 45" (approx.).

Week 4 - Done by lab supervisor

18. Front side Ion Implantation P dopant, boron.
19. Remove 1827 photoresist.
20. Front side Ion Implantation N dopant, phosphorus
21. Back side Ion Implantation P dopant, Boron

Week 5

22. Clean wafer.
23. Grow 110nm oxide, 950C for 22'22"
24. Mount 2" wafer on 4" transport wafer solar cell DOWN.
25. Dip 4" wafer into buffered HF, 180".
26. Place 4" wafer into evaporator, deposit 200nm aluminum.

Week 6

27. De-mount 4" wafer.
28. Apply 1827 photoresist, 2000rpm for 30".
29. Soft bake, 100C for 1 minute.
30. Expose to mask #3, 90".
31. Dip in Toluene, 10'
32. Develop in Microposit 351, 45" (approx.).
33. Mount 2" wafer on 4" transport wafer solar cell UP.
34. Dip 4" wafer into buffered HF, 180".

35. Place 4" wafer into evaporator, deposit 200nm aluminum.

Week 7

- 36. De-mount 4" wafer.
- 37. Soak 2" wafer in acetone for aluminum lift-off, 20"+
- 38. Anneal 2" wafer in N2 furnace, 450C for 30'.

Week 8 & 9

- 39. Test 2" wafer

Week 10 – Spare lab session to be used if required

ASSESSMENT

Component	Weight
Active participation in labs and keeping a detailed experimental record	20%
3 Quizzes	3x10% = 30%
Final Report	50%
Total	100%

- Students are not allowed to participate in labs without attending the safety lecture (first part of lab 1) and submitting the safety quiz.
- All students must attend all labs. At the end of every lab, the teaching assistants will check the experimental record of each student, which must be kept inside a bound laboratory notebook or dedicated lab notebook software.
- The quizzes will cover material related to the semiconductor processing performed in the lab and fundamentals of cell operation. The format of the quizzes will be oral, with a duration of 15-30 min, and conducted with your entire lab group.
- The final report will be in the style of a research paper, where you will report and discuss your experimental methods and results. The final report will be graded using the final report grading rubrics provided as a separate handout. Each student will submit their own report (no group reports). Every report is due before the time and date indicated. No extensions will be granted and late reports will not be accepted. All students must participate in the safety lectures/labs/information sessions indicated in each section's information sheet.

ACCREDITATION LEARNING OUTCOMES
--

The Learning Outcomes defined in this section are measured for Accreditation purposes only, and will not be directly taken into consideration in determining a student's actual grade in the course.

Outcomes	Indicators
Understand the physics of solar cells	Competence in specialized

Understand how to fabricate a solar cell	engineering knowledge Competence in specialized engineering knowledge
Understand basic semiconductor processes, such as photolithography	Competence in specialized engineering knowledge

For more information on Accreditation, please visit: <https://www.engineerscanada.ca>

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <http://www.mcmaster.ca/academicintegrity>

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

ACADEMIC ACCOMMODATIONS

Students who require academic accommodation must contact Student accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contact by phone at 905.525.9140 ext. 28652 or e-mail at sas@mcmaster.ca. For further information, consult McMaster University's Policy for [Academic Accommodation of Students with Disabilities](#).

NOTIFICATION OF STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

1. The [McMaster Student Absence Form](#) is a self-reporting tool for Undergraduate Students to report absences DUE TO MINOR MEDICAL SITUATIONS that last up to 3 days and provides the ability to request

accommodation for any missed academic work. Please note this tool cannot be used during any final examination period.

2. You may submit a maximum of 1 Academic Work Missed request per term. It is YOUR responsibility to follow up with your Instructor immediately (NORMALLY WITHIN TWO WORKING DAYS) regarding the nature of the accommodation. Relief for missed academic work is not guaranteed.
3. If you are absent for reasons other than medical reasons, for more than 3 days, or exceed 1 request per term you MUST visit the Associate Dean's Office (JHE/A214). You may be required to provide supporting documentation.
4. This form must be submitted during the period of absence or the following day, and is only valid for academic work missed during this period of absence.
5. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.
6. You should expect to have academic commitments Monday through Saturday but not on Sunday or statutory holidays. If you require an accommodation to meet a religious obligation or to celebrate an important religious holiday, you may submit the Academic Accommodation for Religious, Indigenous and Spiritual Observances (RISO) Form to the Associate Dean's Office. You can find all paperwork needed here: <http://www.eng.mcmaster.ca/current/documents.html>

NOTICE REGARDING POSSIBLE COURSE MODIFICATION

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

TURNITIN.COM STATEMENT

In this course we will be using a web-based service (Turnitin.com) to reveal plagiarism. Students will be expected to submit their work electronically to Turnitin.com and in hard copy so that it can be checked for academic dishonesty. Students who do not wish to submit their work to Turnitin.com must still submit a copy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, etc.). To see the Turnitin.com Policy, please go to <http://www.mcmaster.ca/academicintegrity/>.

ON-LINE STATEMENT FOR COURSES REQUIRING ONLINE ACCESS OR WORK

In this course, we will be using Avenue to Learn. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this

disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

REFERENCE TO RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to

<http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf>.