

EP 4MD3

Advanced Materials and Next Generation Devices

*No Moore – nanostructures, self-assembly and the promise of disposable devices*

Winter 2017

Course Outline

CALENDAR/COURSE DESCRIPTION

3 unit(s)

This course gives an in-depth investigation of advanced semiconductor devices, with a focus on novel materials. The course will cover aspects of fabrication, operation and design for modern semiconductor devices, highlighting traditional, nanoscale and excitonic/organic device physics.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): ENGPYS 3F03 or 3F04; and credit or registration in one of ENG PHYS 3PN3, 3PN4 or 4E03; or MATLS 3Q03

Antirequisite(s): None

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. A. Turak  
JHEA 321  
[turaka@mcmaster.ca](mailto:turaka@mcmaster.ca)  
ext. 23448

Office Hours:  
Thursday – 2:30 pm  
Or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

S. Jovanovic  
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COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

<http://avenue.mcmaster.ca/>

COURSE OBJECTIVES

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

- Differentiate between conduction models for inorganic, organic and nanoscale semiconductors
- Distinguish the basic physics underlying the operation of various device architectures
- Critique chief technical challenges and critical materials issues for modern devices
- Examine the state of the art of modern semiconductor device technology

- Use engineering tools to predict the incorporation of candidate materials and the specific properties required for electronic devices

**MATERIALS AND FEES**

**Required Texts:**

1. Dimitrijevic, Principles of Semiconductor Devices, Oxford (2012)
2. CCW: Organic electronics course notes

**Optional text:**

1. Kohler, Electronic Processes in Organic Semiconductors: An Introduction, Wiley (2015)

**Calculator:**

Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

**COURSE OVERVIEW**

This course gives an in-depth investigation of advanced semiconductor devices, with a focus on novel materials. The course will cover aspects of operation and design for modern semiconductor devices, highlighting traditional, nanoscale and excitonic/organic device physics. The major aim of this course is to examine semiconductor physics and the development of devices, with an interest in how they have changed to accommodate novel materials: organic semiconductors, graphene and layered materials, and quantum dots. Through real world examples, students will be able to draw expand their understanding of fundamental principles of modern electronic devices, while gaining exposure to cutting edge technology

Topic	Readings
Topic 1 Introduction and conjugation	Dimitrijevic 1.1, Courseware p.1-6
Topic 2 Orbitals to bands	Dimitrijevic 2.2, 2.31, 2.33, 2.41; Courseware p.7-34
Topic 3 Charge carriers	Dimitrijevic 1.2, 2.3, 2.4.2, 2.4.3; Courseware p.35-49
Topic 4 Optoelectronic processes	
Generation and recombination	Dimitrijevic 5, 10.1; Courseware p.49-59
Transport	Dimitrijevic 3,4, 10.3.2; Courseware p.61-95
Topic 5 Heterojunctions: Interfaces and contacts	
Metal-semiconductor junctions	Dimitrijevic 7.1, Courseware p.97-117
Semiconductor-semiconductor junctions	Dimitrijevic 6.1, Courseware p.121-132
Topic 6 Device modeling and introduction to SPICE	Dimitrijevic 11.1 (junction diodes) 11.2 (MOSFETs)
Topic 7 Advanced devices -- MOS capacitor and MOSFETs	Dimitrijevic 7.2, 8.1,8.2, 8.3, 8.4, 10.2, 11.2
Topic 8 Advanced devices -- OFETS	Courseware p. 133-158 (note that eqn 8.7 is incorrect)
Topic 9 Advanced devices -- NWFETS	Dimitrijevic 10.3
Topic 10 Advanced devices -- OLEDs	Courseware p. 159-173
Topic 11	

Advanced devices – excitonic solar cells Courseware p. 175-196

Topic 12 Courseware p. 197-227  
Economics and sustainability

**ASSESSMENT**

Component	Weight
Assignments	10%
Presentation	15%
Report	20%
Midterm	20%
Final Exam	35%
Total	100%

**ADDITIONAL DETAILS REGARDING COURSE MANAGEMENT AND ASSESSMENT**

- **Major due dates:**  
 Report deadline: March 30<sup>th</sup>  
 Presentation submission deadline: March 20<sup>th</sup>  
 Presentation start date (tentative): March 20<sup>th</sup>  
 Term test: Feb 27<sup>th</sup>
- **How work is to be submitted:**  
 Work for assignments may be submitted in person as a hard copy or through dropboxes on Avenue to Learn. The presentation, handout and report **must** be submitted in soft copy through Avenue to Learn.
- **Policies on missed work, extensions, and late policies**
  1. Late hand-ins for assignments will be penalized by 10% for each day, except with prior permission from the instructor. Permission must be obtained at least two days in advance of the deadline to waive the hand-in penalty.
  2. All presentations will be due on the same day, and the order will be randomly selected every day of the presentations. If you are not present when your name is called, you will get a zero. With advance notification (at least 2 days), there will be a 10% deduction for every day your name is not put into the pool of names to be drawn
- **Group work expectations and how group work will be evaluated**  
 Group work is permitted provided all of the contributors' names are listed on the assignment paper. The same mark will be assigned to all group members. The number of group members is limited to three (3).
- **Attendance requirements:**  
 Attendance is mandatory, especially at the presentations at the end of term which include a peer marking component. Attendance will count toward the participation mark for the presentations
- **Class participation expectations:**  
 Class participation is expected through the asking and answering of questions throughout the term. For the presentations, there is a peer evaluation component. Everyone is expected to mark everyone else's presentations, and this will be counted as a component of your participation mark. The peer marks will be averaged into the final mark for the presentation.
- **Final exam**

The final examination will be scheduled by the University during its regular April examination period. In order to pass the course it is necessary to obtain at least 40% on the final examination. It will be a test of cumulative knowledge and test all topics covered, including a question relating to the in-class presentations of your peers.

- **Civil society policy**

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact their Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

#### 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.

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](mailto: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, the MJEP website, or email. 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>.