COURSE: ECE 730T18 (Fall 2014)

COURSE TITLE: **Organic Electronics**

INSTRUCTOR: Prof. Hany Aziz
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email: h2aziz@uwaterloo.ca (***Do not use LEARN email to reach the instructor***)

LECTURES: W 8:30-11:30 in EIT 3151

DESCRIPTION:
The course gives an overview of organic electronic and optoelectronic devices. It begins with a review of electronic structure of single organic molecules as a guide to the electronic behaviour of organic aggregates. Various relevant material phenomena are reviewed; including topics from photophysics (absorption and emission of light, excited states, radiative and non-radiative transitions), intermolecular charge transport mechanisms (hopping, disorder), charge injection and transport models, and energy transfer processes. Their applications in light emitting devices, solar cells, thin film transistors, photodetector and imaging photoreceptors, etc. are discussed. Aspects related to device fabrication and patterning may also be addressed.

COURSE/TEACHING OBJECTIVES:
This course will help students with no or limited prior background in the field to:

- Acquire a general background in the field of organic electronics and optoelectronics, basic theory, applications, challenges, recent developments, etc.
- Know and understand relevant fundamental scientific theory (qualitatively), and its relationship to organic semiconductor material and device design concepts.
- Become familiar with relevant terminology, and be able to read and understand scientific literature in the field, and to conduct a literature review on certain relevant research topics

SYLLABUS:

01. Introduction to OLEDs:
    OLED Operation Mechanism, injection, transport and emission of light. Organic heteojunction. General comparison of inorganic versus organic devices
02. Electronic Structure of Organic Molecules
    Electronic structure of atoms, Atomic and Molecular Orbitals, LCAO, Bonding and antibondig orbitals, Orbital hybridization, HOMO and LUMO levels, Conjugated Molecules
03. Photophysics of Organic Molecules
    Excited states: (Absorption and emission, Singlet and triplet states), Rates of electronic transitions, Transition moment, Frank Condon Principle, Radiative and non-radiative transitions, Excited state kinetics
04. Exciton Processes in Organic Solids
    The Solid State: (Bonding, states of matter, amorphous & crystalline states), Excitons, Forester and Dexter energy transfer, Exciton quenching processes
05. Electronic Conduction in Organic Solids
    Conductivity: (carrier concentration versus mobility), Carrier generation, Hopping transport, Mobility measurements, Traps.
06. Aspects of OLED Physics and Technology
    Charge injection from metal contacts, Charge transport and device characteristics, Exciton formation and luminescence, Stability and aging, Contrast, RGP patterning approaches.
07. Organic Light Harvesting Devices
    Photoreceptor Devices, Photodetector Devices, Photovoltaic Devices: General background, device operation mechanism and characteristics, important phenomena, current challenges, recent developments
08. Organic Electronic Materials & Organic TFTs
    Small molecule and polymer materials for OEs. Hole and electron transport. Molecular design rules for mobility and chemical stability. OTFT operation mechanism and characteristics, important phenomena, challenges, recent developments
09. Selected Topics in Organic Electronics
    Quantum-dot OLEDs, Conducting polymers, etc.

TEXTBOOK:
No textbook required. Lecture notes and handouts will be provided.

GENERAL REFERNCES

- "Electronic Processes of Organic Crystals and Polymers" , Pope & Swenberg, Oxford University press, 2nd edition (1999).
- "Essentials of Molecular Photochemistry" , Gilbert & Baggott, CRC Press, 1991.
- "Organic Semiconductors" H. Meier, Verlag Chemie GmbH, 1974
- "Physics of Organic Semiconductors" Wolfgang Brütting, John Wiley & Sons Canada; 1 edition (2005)
- "Organic Electronics: Materials, Manufacturing, and Applications" , Hagen Klauk, John Wiley & Sons; 1st edition (2006)
- "Electrical transport in solids : with particular reference to organic semiconductors", Kao, Pergamon Press; 1st edition (1981).

MARKING SCHEME

- 15% Midterm Quiz
  The quiz will be ~45-60 minutes long (to be decided later) and will be held during regular lecture time on **Wednesday, Oct 15, 2014.**
- 35% Project
  Students will conduct a literature review on a certain relevant topic of a *fundamental scientific* nature. The outcome of the review will be delivered as an oral presentation and a written report. See below for more details.
- 50% Final Written Exam
  The Final Exam will be 120-150 minutes long (to be decided later) and will be held during UW regular final exam period, at a time and a place to be determined by the university. 15 of the 50 points will be directed towards answering questions related to 3-4 research papers that will be provided to the class early in the term for independent reading. The remaining 35 points will be directed towards material covered during the lectures. The exam will be open-book/notes/papers and students can bring any printed material they wish. Access to electronic devices will, however, be prohibited.

COURSE WEBSITE:
A course homepage is available on LEARN. It will contain copies of lecture slides and notes. The slides and notes will be uploaded weekly prior to each lecture. The site also contains a copy of this course overview sheet. It will also be uploaded with any important updates, etc.

TENTATIVE SCHEDULE:
A tentative schedule is shown below. The instructor reserves the right to change the outline and/or the schedule as needed.

Week No.	Main Subject/Topics Covered during Lecture
1*	*>>>Course introduction* 01.Introduction to OLEDs
2	02.Electronic Structure of Organic Molecules 03.Photophysics of Organic Molecules
3	03.Photophysics of Organic Molecules
4	04.Excitonic Processes in Organic Solids
5	05.Electronic Conduction in Organic Solids
6	06.OLED Physics and Technology *>>> Midterm*
7	06. OLED Physics and Technology
8	07.Organic Light Harvesting devices
9	08. Organic Electronic Materials & OTFTs
10	09. Selected Topics in OE (if time allows)
11	Project Presentations
12	Project Presentations

* **Lectures begin Wednesday, Sept 10th 2014.**

PROJECT:

General Scope:

The project will comprise an in-depth, **individually-conducted**, research literature review on a topic of a fundamental scientific nature in the area of Organic Electronics. Students can choose any topic depending on their interests, but must seek the instructor's approval of the topic first to make sure the topic is suitable and is not already taken by other students (first come first serve basis). The students will give a seminar and write a report on the topic, giving a general overview on the topic, a scientific focus, recent developments and advances. See the next section for more details.

Treatment of the Topic

The review can be conducted and presented based on the following elements:

1- INTRODUCTION: An introduction to the general field to which the topic is related: (history, advantages, disadvantages, material/device/technological applications, etc.)
2- SCIENTIFIC/TECHNICAL BACKGROUND: A scientific/technical treatment of the topic: a description of fundamental principles and/or phenomena, theoretical background, etc.
3- RECENT DEVELOPMENTS: A highlight of recent publications, findings, results, etc. (from at least 5 research papers)
4- SUMMARY & CONCLUSIONS: A summary of the key points and derived conclusions

Project Marking Scheme:

- 10% (of course total grade) Presentation
- 25% (of course total grade) Written Report

Presentation:

- This will be a 20-25 minute presentation followed by 5 min for Q&A. The presentations will be delivered during regular lecture time, and will be scheduled (tentatively) for weeks 11-12 of the term. The exact dates (and presentation length) will depend on the final number of students enrolled in the course and therefore will be confirmed later. A copy of presentation slides should be emailed to the instructor **no later than 8:00 am on the day of your presentation**.
- The presentation can be structured using the same elements outlined above in the "Treatment" section.
- The presentation will be marked for content (7 marks) and for demonstrating understanding of the subject as may become evident from the delivered material, Q&A period, etc. (3 marks).

Written Report:

- A written report presenting the main findings of the literature search on the topic **is due by 10:00 am on Monday, Dec 1st, 2014 (i.e. the last day of classes of the Fall term).** Email an electronic copy (.pdf) to the instructor, and place a hard copy of the report in the instructor's mail slot (ECE reception area in EIT),
- The report should include: (i) title page, (ii) abstract, (iii) main body, and (iv) references sections.
- The "abstract" should be no longer than 1 page (double spaced), and should concisely capture the main points of the report.
- The "main body" should typically be 15 double-spaced pages (excluding any figures and/or tables), font size 11, and includes sections using the same titles/subtitles as outlined above in the "Treatment" section.
- The "references" section should give full citation of all referenced work using American Institute of Physics format (e.g. format used in *Journal of Applied Physics* or *Applied Physics Letters*). A minimum of 7 scientific journal references is required.
- Report Marking Scheme: INTRODUCTION (4 marks), SCIENTIFIC/TECHNICAL BACKGROUND (10 marks), RECENT DEVELOPMENTS (6 marks), SUMMARY & CONCLUSIONS (2 marks), and general presentation (3 marks). Note that the variety in the nature of the different topics will require customizing the marking scheme to make it more relevant to the individual topics. Therefore the actual marking scheme may differ from this one.

OTHER IMPORTANT INFORMATION AND RELEVANT LINKS:

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: The Office for persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.