COURSE: ECE 634 (Winter 2019)

COURSE TITLE: **Organic Electronics**

INSTRUCTOR: Prof. Hany Aziz
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LECTURES: [redacted]

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.

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

- 25% Midterm Exam
  The quiz will be ~45-60 minutes long (to be decided later) and will be held during regular lecture time on **Feb 27th, 2019.**

- 12-15%** Literature Review
  Students will conduct an in-depth review of 1-2 scientific paper(s) on a topic relevant to organic electronics. The review will be delivered in the form of an oral presentation. See page 4 for more details.

- 5-8%** Participation in discussing and critiquing the literature review of other students

- 55% 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 55 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. Students can bring the papers with them (hard copies only) and use them during the exam. The remaining 40 points will be directed towards material covered during the lectures.

**Note: The total weight of these two components will be 20% of the course mark. The exact weight % of each component will depend on the number of students in the class and will be determined by the 7th week of the term.

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	01.Introduction to OLEDs 02.Electronic Structure of Organic Molecules
3	02.Electronic Structure of Organic Molecules 03.Photophysics of Organic Molecules
4	03.Photophysics of Organic Molecules
5	04.Excitonic Processes in Organic Solids
6	05.Electronic Conduction in Organic Solids 06.OLED Physics and Technology
7	06. OLED Physics and Technology 07.Organic Light Harvesting devices
8	07.Organic Light Harvesting devices
9	07.Organic Light Harvesting devices
10	08. Organic Electronic Materials & OTFTs 09. Selected Topics in OE (if time allows)
11	Literature review presentations
12	Literature review presentations

Lectures begin Wednesday, Jan 9th 2019.

Note that there will be no class on Wed Feb 6th. A make-up class will be tentatively scheduled for Monday, Feb 4th or Feb 11th at 5:30pm (to be confirmed).

LITERATURE REVIEW:

General Instructions:

1) Each student will conduct an in-depth, individually conducted review of 1-2 scientific paper(s) on a topic relevant to organic electronics. The papers are to be selected by the student, but must be approved by the course instructor. The final paper choice must be confirmed to the instructor by email and approved by the instructor **by the end of week 8 of the term.**

2) In general, in order to be acceptable, the selected paper must meet the following conditions:
    a. Must be a peer-reviewed research article on a topic in the field of organic electronic materials and devices
    b. Must be published within the last 7 years in an ISI-indexed journal with an impact factor > 2.0
    c. Must have received >10 citations (papers published in the last two years are exempted from this requirement)
    d. Must meet the following minimum length requirements:
        i. 8 journal pages (if only 1 paper is selected for the review)
        ii. 5 journal pages (if 2 papers are selected for the review)

3) PDF copies of the confirmed papers should be emailed to the instructor **no later than the end of week 9 of the term**. The following file name format must be used for the PDFs:
[YourLastName in square brackets]_FirstAuthorLastName_YearPublished_JournalName_Volume_Pages.pdf

4) The review will be delivered in the form of an oral presentation, typically 25-30 minutes long including time 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.

5) PDF copies of the confirmed papers should be emailed to the instructor no later than the end of week 9 of the term. A copy of presentation slides should be emailed to the instructor **no later than 9:00 am on the day of your presentation.** The presentation slides will be uploaded on LEARN and available to all students in the class to access.

6) In general, your review, and hence your presentation, should include the following elements:
    a. Introduction: This should contain enough information to allow audience to follow and appreciate what is being covered in the rest of your presentation.
    b. Experimental Procedure: A brief description of the experimental procedure and/or techniques used in the paper
    c. Results & Discussion: A brief outline of the main results reported in the paper
    d. Novelty Aspects: A highlight of the new findings or conclusions of the work relative to what was known previously
    e. Personal Critique (optional): Your own view of the strengths and/or weaknesses of the paper, with appropriate justifications

7) The following marking scheme will be followed for evaluating the presentation, and its various elements:
    a. 30% - Introduction & Review of Experimental Procedure/Methods
    b. 35% - Results & Discussion
    c. 10% - Novelty Aspects
    d. 10% (**bonus**) - Personal Critique
    e. 25% - For demonstrating a sufficient understanding of the paper as may become evident from the delivered material and responding to questions in the Q&A period.

    Note that the variety in the nature of the different topics and papers will require customizing the marking scheme to make it more relevant to the individual reviews. 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.