TO: The Faculty of the College of Engineering
FROM: The Davidson School of Chemical Engineering
RE: New Graduate Course, CHE 56400 Organic Electronic Materials and Devices

The faculty of the Davidson School of Chemical Engineering have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Course: CHE 56400 Organic Electronic Materials and Devices
Fall/Spring, Lecture, Cr. 3

Restrictions: May not be enrolled as the following Classifications:
Freshman: 0 - 14 hours
Freshman: 15 - 29 hours
Sophomore: 30 - 44 hours
Sophomore: 45 - 59 hours
Junior: 60 - 74 hours
Junior: 75 - 89 hours
Pre-requisite: CHM 26100 or equivalent (CHM 25500 or CHM 25700)

Description:

This course introduces the synthesis, optoelectronic properties, transport physics, and device operation of organic and hybrid electronic materials and devices. This course will review how the molecular architecture of small molecule and polymer semiconductors can be tuned to alter the optoelectronic properties of the materials in solution and in the solid state. A number of relevant materials interactions will be covered, including: photoexcitation and recombination, intermolecular charge transport mechanisms, and energy transfer processes. Additionally, we will observe how these processes are relevant to applications such as organic field-effect transistors (OFETs), organic light-emitting diodes (OLEDs), organic photovoltaic (OPV) devices, and organic memory elements. Finally, a new type of organic-inorganic hybrid material called hybrid halide perovskite will be introduced.

Reason: This course has been taught as CHE 59700 Organic Electronic Materials and Devices during the following semesters: spring 2013 (45 students), fall 2014 (33 students), fall 2017 (14 students), spring 2019 (17 students) and fall 2020 (11 students).

Sangtae Kim
Jay and Cynthia Ihlenfeld Head of Chemical Engineering

Purdue University ChE 597: Organic Electronic Materials and Devices, Fall 2020

A. Instructor. Professor Letian Dou

B. Course Description. This course provides an introduction to the synthesis, optoelectronic properties, transport physics, and device operation of organic and hybrid electronic materials and devices. This course will review how the molecular architecture of small molecule and polymer semiconductors can be tuned to alter the optoelectronic properties of the materials in solution and in the solid state. A number of relevant materials interactions will be covered, including: photoexcitation and recombination, intermolecular charge transport mechanisms, and energy transfer processes. Additionally, we will observe how these processes are relevant to applications such as organic field-effect transistors (OFETs), organic light-emitting diodes (OLEDs), organic photovoltaic (OPV) devices, and organic memory elements. Finally, a new type of organic-inorganic hybrid material called hybrid halide perovskite will be introduced.

C. Prerequisites. CHM 261 (Organic Chemistry I), or equivalent; or permission from the instructor. Physical Chemistry (CHM 372) and Structure and Properties of Materials (MSE 230) are very helpful for this course (optional).

D. Recommended (NOT REQUIRED) Texts.

1. *WSPC Reference on Organic Electronics, The: Organic Semiconductors,* Edited by Seth R Marder and Jean-Luc Bredas, World Scientific Publishing, 2016, ISBN-13: 978-9814699228
2. *Organic Radical Polymers: New Avenues in Organic Electronics*, Sanjoy Mukherjee and Bryan W. Boudouris, Springer, 2017, ISBN: 978-3-319-58574-1
3. *Organic Field-Effect Transistors*, Edited by Zhenan Bao and Jason Locklin, CRC Press, Inc., 2007, ISBN: 978-0849380808

E. Course Learning Objectives. As this course is designed to link the concepts regarding organic electronic materials from "molecules through modules," the students should be able to perform the following learning objectives, as classified by one of the three major sections.

- **Synthesis of Organic Semiconductors.** Identify common mechanisms for the synthesis of small molecule and polymer semiconductors; describe the mechanism of controlled polymerization techniques for macromolecular semiconductors; interpret spectroscopic, chromatographic, and molecular characterization data in order to predict the structure of the organic semiconductor; explain how the molecular structure of an organic semiconductor will affect its thermal, structural, and optoelectronic properties.
- **Microstructural Characterization of Organic Semiconductors.** Explain how x-ray scattering can be utilized to determine the Angstrom and nanometer length scale structural features of the organic semiconductors; apply principles of electron microscopy to comprehend how to image soft materials; determine the domain spacing and microstructural architecture of organic semiconductors given a scattering pattern
- **Charge Generation and Transport, Optoelectronic Characterization, and Device Application of Organic Semiconductors.** Explain how molecular orbital levels are related to the optoelectronic properties of organic semiconductors; distinguish between different models for charge transport in organic semiconductors; describe clearly the difference between charge generation and transport in organic and inorganic semiconductors; explain how organic electronic devices operate and how apply known equations to evaluate device performance; critique the potential for organic electronic materials to supplement or replace inorganic semiconducting devices

F. Instructor's Commitment. Your instructor will: (1) be courteous, punctual, well-organized, and prepared for lecture and other class activities; (2) answer questions clearly in class or arrange for detailed discussions out of class if in-class answers are not suitably clear; (3) be available during office hours or notify you beforehand if I am unable to keep them; (4) provide a suitable guest lecturer when I am traveling; and (5) grade uniformly and consistently to the posted guidelines.

G. Consulting with the Instructor. I encourage you to discuss academic or personal questions with me during my office hours or via email. These discussions need not be limited to ChE 59700 content.

H. Academic Dishonesty. Academic dishonesty ***will not be tolerated*** in any form in this course. Specifically, Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Section B-2-a, Code of Student Conduct] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972] All incidents of academic dishonesty will be reported to the Dean of Students. **Such incidents include: i) possessing or accessing, in hardcopy or electronic form, the solution manual to the course text, or to the exams, ii) claiming credit for work that is not your own original work, and iii) enabling other students to create work that is not their original work. The punishment for the first offense is a grade of zero for the entire work (exam or homework), and the punishment for a second offense is an F mark for the class.**

I. Conduct. University policy states that it is the responsibility of all students to attend all class sessions (http://www.purdue.edu/studentregulations/regulations_procedures/classes.html). Each student is expected to come to class on time and not disrupt the class. Each student is also expected to follow Purdue's codes of student conduct (http://www.purdue.edu/studentregulations/student_conduct/regulations.html) and behave in a professional manner. The rights of students in violation of the code of conduct are outlined. Each student is expected to exhibit consideration and respect towards the other students, the graders, the teaching assistants (TAs), and the faculty member. Each student is expected to exhibit a positive attitude. Your conduct will be a factor in awarding grades to students between two letter grades. Purdue University's student conduct policy specifically addresses academic dishonesty.

J. Student Professionalism. The highest standards of professionalism and ethics are expected in CHE 59700. Each student is expected to come to class on time and not disrupt the class. Each student is also expected to follow Purdue's codes of student conduct (http://www.purdue.edu/studentregulations/student_conduct/regulations.html) and behave in a professional manner. The rights of students in violation of the code of conduct are outlined. Each student is expected to exhibit consideration and respect towards the other students and the faculty member. Each student is expected to exhibit a positive attitude. Expectations for each student include (but are not limited to):

1. Attending all class sessions.
2. Coming to class and recitation on time and prepared by reading assigned material beforehand.
3. Refraining from disrupting class (e.g., turning off or silencing cell phones, refraining from cell phone or laptop use during class, and carrying on a loud conversation during class).
4. Maintaining the highest standards of academic honesty and integrity.
5. Being an active contributor to team assignments.
6. Being knowledgeable about the policies and information described in the syllabus.

K. Violent Behavior Policy. Purdue University is committed to providing a safe and secure campus environment for members of the University community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent behavior impedes such goals. Therefore, violent behavior is prohibited in or on any University Facility or while participating in any University activity.

L. Attendance policy during COVID-19. It is the responsibility of all students to attend all class sessions either in person or via online platform. Note, online version of this course is not live. You are required to watch the video records after each lecture. In-person meetings of a course is not a factor in final grades.

Students should stay home and contact the Protect Purdue Health Center (496-INFO) if they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, but the student still needs to inform the instructor of any conflict that can be anticipated and will affect the submission of an assignment or the ability to take an exam. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be

anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, through Brightspace, or by phone. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, quarantine, or isolation, the student or the student's representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link on Attendance and Grief Absence policies under the University Policies menu.

M. Illness. If a student becomes sick with flu-like symptoms, he/she should seek prompt medical attention, and then not come back to class until he/she has been symptom-free for more than 24 hours. A note from P.U.S.H., or another trained medical professional, is required to document illness. Materials will be made available electronically to assist any students who are ill, and reasonable accommodations will be made on an individual basis to ensure that all students have the opportunity to learn. In the event of a severe outbreak of illness at Purdue that mandates class not meet, all attempts will be made to deliver the course online through Blackboard.

N. Academic Guidance in the Event a Student is Quarantined/Isolated. If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

O. Classroom Guidance Regarding Protect Purdue. The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining appropriate social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

P. Nondiscrimination. Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual

orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

Q. Bereavement Policy. Purdue recognizes that a time of bereavement is very difficult for a student. The University therefore provides rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS): http://www.purdue.edu/odos/services/griefabsencepolicyforstudents.php. Students who find themselves in need of assistance in a time of bereavement should contact Professor Dou privately to discuss specific needs.

R. Individual Learning and Testing Needs. Any student who feels he/she may need an accommodation with any aspect of the course based on a personal circumstance should contact Professor Dou privately to discuss his/her specific needs. If you are a student with any form of individual learning needs, please speak with the faculty instructors whether or not you seek an accommodation so that we are aware of your circumstance and can deliver course content in a manner that is most compatible with your situation.

S. Emergency Preparedness. Purdue University is a very safe campus and there is a low probability that a serious incident will occur here at Purdue. However, it is important to emphasize the emergency procedures for evacuation and shelter-in-place incidents. Preparedness will be critical if an unexpected event is to occur. Emergency preparedness is your personal responsibility. Purdue University is actively preparing for natural disasters or human-caused incidents with the ultimate goal of maintaining a safe and secure campus. The following is a review of the emergency procedures at Purdue University.

1. For any emergency call 911.
2. There are nearly 300 Emergency Telephone Systems throughout campus that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected to the PUPD.
3. If there is a fire alarm, we will immediately evacuate the building and proceed to in front of the MSEE building. Do not use the elevator.
4. If there is a Shelter-in-Place requirement for a tornado warning, we will shelter in the lowest level of this building away from windows and doors. This location is between FRNY G140 and FRNY B124.
5. If there is a Shelter-in-Place requirement for a hazardous materials release, we will shelter in the classroom shutting any open doors and windows.
6. If there is a Shelter-in-Place requirement for a civil disturbance, we will shelter in a room that is securable preferably without windows. This location is FRNY 1051.

T. Campus Emergencies. In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructors' control. ***Here are ways to get information about changes in this course. You are expected to check your @purdue.edu email address frequently.***

U. Use of Copyrighted Material. Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken in class are, however, generally considered to be "derivative works" of the instructor's presentations and materials, and they are thus subject to the instructor's copyright in such presentations and materials. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual

wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.

V. Course Meeting Schedule.

Lectures:	Tuesday and Thursday	1:30p – 2:45p	ME 3006
Examination 1:	10/06 (Tuesday)	1:30p – 2:45p	ME 3006
Examination 2:	11/12 (Thursday)	1:30p – 2:45p	ME 3006
Oral Presentation:		1:30p – 2:45p	ME 3006

If you have a scheduled class or other reasonable issue (e.g., religious observance) that conflicts with a scheduled exam, please tell Professor Dou as soon as possible so that plans may be made for you to take the exam at an alternate time.

W. Instructor Contact Information.

Professor Letian Dou – Email: dou10@purdue.edu, Telephone: (765) 494-4194
Office: 3053B Forney Hall
Office Hours: Thursday 9:30am – 10:30am or by appointment

X. Assessment of Course Outcomes. A weighted average grade will be calculated as follows.

Examinations: 30% each = 60% total
Semester Presentation: 40%

The grading scale will be as follows.

A: 100 – 85% of the weighted points
B: 84.9 – 75% of the weighted points
C: 74.9 – 65% of the weighted points
D: 64.9 – 55% of the weighted points
F: Less than 55% of the weighted points

Examinations

There will be three examinations during the course of the semester. These examinations will occur during the regularly-scheduled class time. It is recommended that you arrive early to class on these days as the exam will begin and end promptly at the start and conclusion of the period. For each examination, you will be supplied with one or more pages of relevant equations. You will not be allowed to use any books or notes in addition to these equations pages, which means that all you will be allowed to have on your desk during the examination is the examination booklet, the notes pages provided, the paper on which you are writing solutions, something with which to write, and a calculator. All other electronic devices are forbidden, including cell phones and pagers. These must be turned off and may not be handled at any time during the examination. Students caught with other materials during an examination will be assumed to be cheating. If an examination was too difficult (as judged by the instructor), the final grade may be scaled upwards (i.e., points will be added to an examination score). Grades will never be scaled downward. There is no preset distribution of final grades. A student has one week after an exam has been returned to discuss any grading, after which grading errors will not be discussed. If a student believes work was graded incorrectly, it must be resubmitted. The resubmission must be accompanied by a separate sheet of paper that documents the error in question. **This is the only mechanism for addressing work that was potentially marked down in error.**

Semester Presentation

Each student will be required to give a 20 min presentation at the end of the semester regarding a topic within the realm of "organic electronics" of his/her choice. The presentation will include a review of the relevant literature and a proposed plan of future research that the student believes could lead to interesting results in the field. Exact details of the assignment will be outlined thoroughly later in the semester. Before beginning work on this, it is ***highly recommended*** that the student meets with the instructor in order to outline a planned topic of study. The final presentation ppt files must be sent to the instructor by the end of the semester.