ECE 693 Special Topic

Materials and Devices in Photovoltaics

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Course level: Graduate students

Pre-requisite: None

Lectures: TR 2:00 pm – 3:15 pm, room 0048, Bevill

Office hours: TR 3:15 pm – 4:00 pm or per appointment

Course description

With an interdisciplinary nature, this course is designed to teach and prepare graduate students in the traditional silicon and emerging organic and perovskite photovoltaics. The objective is to provide students with a broad overview of silicon, organic and hybrid perovskite materials and devices with emphasis of research and practical applications. Topics covered include semiconducting materials (both traditional silicon and emerging organic & perovskite absorbers), operational principle of pn junction and its application in photovoltaic devices, silicon based solar cells/solar panels/solar system, fabrication and characterization of organic and perovskite solar cells, methods to enhance efficiency and stability, and technologies for high-speed printing on flexible substrates.

Topics to be covered (tentative, subject to change):

Part I: Traditional Silicon Semiconductor Materials and Devices

1. Brief review of silicon semiconductors and PN junction diodes
2. Operational principle of Si solar cells
3. Electrical measurement and parameter extraction
4. Solar panels and systems

Part II: Organic Solar Cells

1. Basic organic chemistry
2. Conjugated small molecules and polymers
3. Heterojunction and structure of organic solar cells
4. Organic materials for high-efficiency solar cells
5. Device stability

Part III: Perovskite Photovoltaics

1. Structure of organic and inorganic hybrid perovskite crystals
2. Architecture of perovskite solar cells and operational principle
3. Thin film deposition and characterization (SEM, AFM, XRD)
4. Stability measurement and characterization
5. Methods to improved efficiency and stability

Part IV: High-Speed Printing of Flexible Solar Cells

1. Organic devices on flexible substrate
2. Performance of flexible perovskite solar cells
3. Technologies of roll-to-roll printing
4. Flexible solar panels and applications

Required textbook

No textbook required, lecture notes will be provided.

Reference book (on reserve in Rodgers Science & Engineering Library):

- Qiquan Qiao (Editor)*, Organic Solar Cells: Materials, Devices, Interfaces, and Modeling (Devices, Circuits, and Systems),* CRC Press, 2015
- Christoph Brabec, Ullrich Scherf, Vladimir Dyakonov (Editors)*, Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technologies*, Wiley-VCH, 2014
- Frederik C. Krebs, *Stability and Degradation of Organic and Polymer Solar Cells*, Wiley, 2012

- Eric Wei-Guang Diau, Peter Chao-Yu Chen, Perovskite Solar Cells Principle, Materials and Devices, World Scientific Publishing Co, 2017
- Kunwu Fu, Anita Ho-Baillie, Hemant Kumar Mulmudi, Pham Thi Thu Trang, Perovskite Solar Cells: Technology and Practices, CRC Press, 2019
- Nurdan Demirci Sankir, Mehmet Sankir, Printable Solar Cells, Wiley, 2017
- Mario Pagliaro, *Flexible Solar Cells,* Wiley-VCH, 2008

Homework and exam policy

Homework discussion in small groups is encouraged. However, each student must work through each paper review and presentation individually. Pop quizzes are possible to maintain class attendance and participation.

Grading

Homework (paper review and presentation) ……20%
Topic presentation ……20%
Discussion and quiz ……10%
Midterm project (module development) ……20%
Final paper (literature survey or research proposal) ……30%