ECE 6456 Syllabus

Solar Cells, 3 Credit Hours

Fall 2026

Instructor Information

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General Course Information

Description

This course introduces various aspects of solar cells, including detailed analysis of solar spectrum, optoelectronic properties of photovoltaic materials; basic operating principles and efficiency potential of silicon, compound semiconductors, perovskite, and organic thin-film solar cells; concentrator and multijunction solar cells; modeling, design, and fabrication of high-efficiency solar cells; applications, modeling and design of photovoltaics systems, and economics of photovoltaic systems.

Course Learning Outcomes

Upon successful completion of this course, students should be able to:

- Explain the optoelectronic properties of photovoltaic materials and their interaction with the solar spectrum.
- Understand fabrication, operating principles, efficiency limits, and loss mechanisms of silicon, compound semiconductor, perovskite, and organic thin-film solar cells.
- Understand the structure and fabrication strategies for high-efficiency solar cells, including concentrator and multijunction configurations.
- Predict the performance of solar cell devices using analytical methods.
- Model and design of grid connected and stand-alone photovoltaic systems
- Understand levelized cost of electricity and economics of photovoltaic systems.

Required Course Materials

At least one of the following reference books is recommended:

- Solar Cells – Martin A. Green
- Solar Cells and Photovoltaic Systems Engineering – Marta Victoria (also available via Georgia Tech Library)
- Crystalline Silicon Solar Cells – A. Goetzberger
- Applied Photovoltaics – S. R. Wenham
- Clean Electricity from PV – M. Archer
- Solar Photovoltaics Revolution – L. Stamenic

Grading Policy

Final grades will be determined on the following basis:

Component	Weight
Exam 1	30%
Exam 2	30%
Final Exam	30%
Homework	10%

Note: Final course grades are awarded on a scale of A–F with no +/− grades permitted.

Description of Graded Components

Exams (90%): There will be two midterm exams and one comprehensive final exam. Each midterm exam contributes 30% and the final exam contributes 30% of the total course grade.

Homework (10%): Problem sets will be assigned throughout the semester to reinforce lecture material.

Course Policies

Attendance and/or Participation

Regular attendance is strongly encouraged. Students are expected to attend all scheduled lectures and are responsible for all material covered in class. If a student must miss a lecture due to illness or an approved Institute activity, they are responsible for obtaining notes and keeping up with the course material.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code and the student Code of Conduct.

Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Core IMPACTS

Not Applicable.

Accommodation for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail the instructor as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Pre- & Co-Requisites

Graduate standing in Electrical and Computer Engineering or a related field, or instructor consent. Background in semiconductor device physics is recommended.

Collaboration, Group Work, and Use of Generative AI

All submitted work must represent the student's own understanding. In-class exams must be completed individually and are closed book and notes unless otherwise stated.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

Late homework submission penalties are as follows:

- 1 day late: −20% of total assignment grade
- 2 days late: additional −10% (total −30%)
- No submissions accepted after two days past the due date

Make-up exams may be arranged for documented illness, approved Institute activities, or religious observances. Students must notify the instructor in advance whenever possible.

Course Outline

1. Solar Cells and Sunlight

- The photovoltaic vision
- Physical source of sunlight and analysis of solar spectrum
- Direct and diffuse radiation
- Economics and cost analysis of PV systems

2. Review of Semiconductor Properties

- Dynamics of electrons and holes
- Generation and recombination in semiconductors
- Bulk lifetime and surface recombination velocity

3. Interaction of Sunlight with Semiconductors

- Reflectance and absorption of light
- Direct and indirect bandgap semiconductors

4. Junctions and Operating Principles of Solar Cells

- Theory of p-n junction and band diagrams
- Dark and illuminated characteristics of solar cells
- Internal quantum efficiency of solar cells
- Equivalent circuit of solar cells
- Solar cell output parameters

5. Efficiency Limits and Losses in Solar Cells

- Electrical and optical loss mechanisms
- Short-circuit current losses
- Open-circuit voltage losses
- Fill factor losses
- Effect of temperature and insolation on cell performance
- Theoretical efficiency limit of a single junction solar cell

6. Design of High Efficiency Silicon Solar Cells

- Bulk lifetime, doping, thickness, and surface recombination
- Emitter doping, junction depth, SRV, and heavy doping effects

- Grid design
- Back surface field design
- Antireflection coating design
- Textured surfaces for light trapping

7. Silicon Solar Cells and Module Fabrication

- Sand to semiconductor-grade silicon
- Crystal growth and promising silicon materials
- Baseline silicon solar cell fabrication
- Processing and understanding of advanced silicon solar cells
- Photovoltaic module construction

8. Other Promising Solar Cells and Technologies

- Gallium arsenide solar cells
- Amorphous silicon thin-film solar cells
- Polycrystalline thin-film CdTe and $CuInSe_2$ cells
- Multijunction solar cells
- Concentrator cells
- Organic solar cells
- Perovskite solar cells

9. Photovoltaic Systems and Applications

- Loss mechanisms and components of a PV system
- Stand-alone and hybrid PV systems
- Utility-interactive PV systems
- Modeling and design of PV systems
- Power and energy output of a PV system