# EE 513 Solid State Energy Devices
# OHE 100C
# Tu Th 11:00 AM – 12:20 PM

## I. Abstract:

Renewable energy and energy conservation must become an increased part of our economy. Furthermore, more engineers must become conversant with the technology of renewable energy and energy conservation. Solid state device technology has the potential to make a major contribution to both aspects of this new energy economy. This course has as it goals to discuss solid state device technologies that can contribute to the renewable generation of energy and conservation of energy and to develop an understanding of the operation of these devices and their potential role in creating a green society. In particular, the class will emphasize developing an understanding of the operation of solar photovoltaic energy converters, thermovoltaic energy converters, thermoelectric energy converters, and solid state light emitters. The class will emphasize the principles of operation of these devices, the materials of importance in their implementation, and the design of the devices. The course will consist of lectures and notes on the device operation principles, study of relevant texts, and reading of the current literature by the students.

## II. Student Participants:

The class is intended for MS students with an undergraduate engineering degree. A knowledge of the principles of semiconductor materials and devices at the undergraduate level (e.g. EE338) is needed. Students who lack formal classes in the area are expected to acquire the basics in the first three weeks of the class.

## III. Course Outline:

Week 1 General energy considerations – statistics and usage; what are the options

Week 2 The Sun – an abundant source of energy (origins of solar energy, characterization as a black body source, solar insolence on the earth, the effects of the atmospheric absorption and scattering, motion of the sun in the sky, definitions of air mass, daily variations)

Week 3 Photovoltaic Energy Converters - general concepts and definitions

Week4 Photovoltaic Materials Properties (optical properties of semiconductors, direct and indirect semiconductors, absorption coefficients, reflectivity)

Week 5 P-n junction theory, basic photovoltaic device operation, limits to efficiency

Week 6 Si solar cells – single crystal and multi-crystalline, designs and status

Week 7 Heterojunction solar cells;

Week 8 Multijunction solar cells; midterm exam

Week 9 Thin film and organic solar cells – low cost revolution?

Week 10 Solar Cell Arrays and Power Combining

Week 11 Thermovoltaic and Thermoelectric Energy Converters (Black body radiation of thermal sources, conversion efficiency, device issues, materials, performance metrics, applications),

**Lighting using solid state sources**

Week 12 Science of Human Vision and Lighting (Human eye physiology and receptors, CIE color chart, color rendering)

Week 13 Solid State Light Sources - Light emission in inorganic and organic semiconductors, visible emitting materials.

Week 14 LEDs – light extraction and design for efficiency

Week 15 New Topics

## IV. Course Grading:

Participation and Homework – 30%
Midterm Exam – 35%
Final Exam – 35%

## V. Texts and resources:

1. Selected Readings from:

Sustainable Energy – without the Hot Air by David JC MacKay
Fundamentals of Materials for Energy and Environmental Sustainability by David S. Ginley and David Cahen; Cambridge Press (2012)
The Physics of Solar Cells by Jenny Nelson; Imperial College Press (2003)
Solar Cells by Harry Hovel (Volume 11 of Semiconductors and Semimetals; Academic Press)
Light Emitting Diodes by E. Fred Schubert; Cambridge Press (2003)

2. Original Papers:
    a. "Detailed balance limit of efficiencies of pn junction solar cells," W. Shockley and H. Queisser, J. Appl. Phys **32**, 510 (1961)
    b. "Limiting efficiencies of single and multiple band gap terrestrial solar cells," C. H. Henry, J. Appl. Phys. **51**, 4494 (1980).
    c. "Solar Cell Efficiency Tables," M. A. Green et. al., Prog. Photovolt: Res. Appl., **14**, 45 (2006).
    d. "Organic solar cells: An overview," Harald Hoppe and Niyazi Serdar Sariciftci, J. Mater. Res. **19**, 1924 ( 2004).
    e. "Research challenges to ultra-efficient inorganic solid-state lighting, " Julia Phillips, et. al., Laser & Photon. Rev. 1, No. 4, 307–333 (2007).
3. Free solar cell modeling software from the following website: www.pv.unsw.edu.au.links/products/pc1d.asp
4. Access to overview course on photovoltaics technology: http://pvcdrom.pveducation.org/index.html

**Statement for Students with Disabilities**
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

**Statement on Academic Integrity**
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus*, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A:

http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

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**Teaching Assistant:**