

ME 4803
Nanoengineered Energy Technologies
Course Outline and Syllabus (Fall 2012)

George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology

Course Objectives:

1. Gain knowledge of the basic operating principles and key performance limits governing several emerging energy technologies
2. Understand important relationships between relevant length scales for basic energy carriers and the performance of energy technologies
3. Gain experience applying basic design principles to integrate nanostructures into energy technologies for performance improvement

Credits/Prerequisites: 3 credit hours/undergraduate thermodynamics

Catalog description: Introduction of emerging energy technologies and the fundamentals required to design such technologies from the nanoscale up. Description of basic energy carriers and nanostructures.

Textbook: None required (notes will be provided)

References:

1. G. Chen, *Nanoscale Energy Transport and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons*, Oxford Press, 2005.
2. Z. M. Zhang, *Nano/Microscale Heat Transfer*, McGraw-Hill, New York, 2007
3. D. L. Schodek, P. Ferreira, M. F. Ashby, *Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects*, Butterworth-Heinemann, 2009.

Official Course Website: GT T-Square.

Class Time and Location: Tuesday and Thursday XXXXXXXX XXXXX

Instructor: Prof. Baratunde Cola / 316 Love / 404-385-8652 / cola@gatech.edu

Office Hours: XXXXX

Grading Method:

Homework:	30%
Project:	30%
Mid-term exams (2):	20% each (no final)

HOMEWORK: 4 problems set assignments; 4 short reading/critical analysis assignments

PROJECT: Detailed analysis of an energy technology and a proposed enhancement using available nanomaterials considering how the technology works, relevant energy length scales, calculation of performance limits, quantification of advantages gained going to the nanoscale; and potential cost, health, and societal impacts.

EXAMS: There will be two in-class exams. The exams will be open notes.

TENTATIVE COURSE OUTLINE (SUBJECT TO CHANGE)

<u>Topics</u>	<u>Sessions</u>	<u>Dates</u>	<u>Reading & HW Assignments</u>
Introduction to the global energy outlook and emerging energy technologies: where can “nano” help?	1	8/21	
	2	8/23	
Introduction to energy at the nanoscale and energy quantization	3	8/28	
Energy states in solids: crystal structure, electrons, and phonons	4	8/30	
	5	9/4	
Entropy, temperature, and population of energy states	6	9/6	
Energy transfer by waves and particles: quantum vs. classic descriptions	7	9/11	
	8	9/13	
Energy conversion and coupled transport processes	9	9/18	
	10	9/20	
Liquids and their interfaces in energy processes	11	9/25	
	12	9/27	
Summary of carriers, relevant length scales, and important scaling arguments	13	10/2	
** Exam I ****	14	10/4	
Nanomaterials: properties, synthesis, and characterization	15	10/9	
	16	10/11 <i>(10/16 – Fall break)</i>	
Materials in design: some thoughts and common practices	17	10/18	
	18	10/23	
Energy design environments and systems (discussion with GT nanoenergy labs)	19	10/25	
	20	10/30	
Nanoengineered energy storage technologies	21	11/1	
	22	11/6	
Nanoengineered energy conservation technologies	23	11/8	
	24	11/13	
Nanoengineered energy conversion technologies	25	11/15	
	26	11/20 <i>(11/22 – Thanksgiving break)</i>	
Discussions and closure	27	11/27	
** Exam II ****	28	11/29	
Project presentations and discussions	29	12/4	<i>(dead week)</i>
	30	12/6	

Comparison with other related courses at Georgia Tech.:

ME 4803 Micro/Nanoscale Energy Transport: Introduction of mico/nanoscale heat transfer and its applications to energy conversion devices. Description of energy transport at small length and time scales.

Instructor: Prof. Zhuomin Zhang

Differences: The proposed course would replace this course.

ChBE 4020 Chem. Eng. In Nanoscale Systems: Application of chemical processing fundamentals, fabrication, and characterization to design and analyze technologically important nanoscale systems. The course emphasizes an integrated engineering and science approach.

Instructors: Prof. Sankar Nair and Prof. John Zhang

Differences: Overlap < 25%. The proposed course will address specifically energy nanotechnologies from a physics and design perspective rather a broad focus on chemical processing in nanoscale systems.

AE 4883 Micro-renewable Energy Systems: Special topic – reviewed syllabus

Instructor: Prof. Narayanan Komerath

Differences: Overlap < 25%. The proposed course will address design of energy technologies from the nanoscale up broadly rather than a focus on micro-renewable systems.

ME 4803N Nanoscale Devices: Special topic – reviewed syllabus

Instructors: Prof. Peter Hesketh and Prof. Zhitao Kang

Differences: Overlap < 25%. The proposed course will focuses on nanoengineered energy technologies and the role of basic energy carriers and nanostructures in their design rather than a focus on physical properties of nanomaterials and their fabrication methods.

Course summary and justification:

There is presently no course at the Georgia Institute of Technology that addresses the interface of energy and nanotechnology from a materials and system design perspective. The proposed course will build on basic knowledge of physics and thermodynamics to introduce students to basic energy carriers and their affect on the performance of energy technologies at different length scales. Students will learn to apply knowledge of basic energy carriers and available nanostructures to improve the performance of energy technologies by applying systematic, yet simple, design rules. Homework assignments will involve applying scaling analysis to complex mathematical descriptions of quantum and classical energy transfer processes to arrive at simple expressions to guide engineering design. Well-established materials-focused design principles will be introduced through lecture and homework as well. Example nanoengineered energy storage, conservation, and conversion technologies will be analyzed from a physics and design perspective in the last part of the class. Students will create a list of questions to ask during a visit to GT nanoenergy research lab of their choice to understand the thought process involved with applying nanomaterials to a given application. The course will conclude with presentations of student projects that connect the central concepts of energy, nano, and design for performance improvement.