Descriptions of Courses

EEW501 Introduction to Energy Science and Engineering
Current statue of conventional fossil energies will be introduced. Fundamental principles and engineering technology for sustainable energy will be studied. Alternative energy for oil, solar cell, fuel cell, hydrogen energy, bio energy, CO2 recovery & utilization, green car, wind power, solar energy, tidal wave power, geothermal, energy sotrage & harvest, artificial photosynthesis will be lectured.

EEW502 Nature of the Chemical Bond
NCB aims to provide a conceptual understanding of the chemical bond sufficient to semi-quantitatively predict the structures and properties of materials. The philosophy is similar to that of Linus Pauling, who revolutionized the teaching of chemistry by including the concepts from quantum mechanics (QM), but not its equations. We also include the newunderstanding that has resulted from QM calculations over the last 40 years. We develop an atomistic QM-based understanding of the structures and properties of chemical, biological, and materials systems. This course is aimed at experimentalists and theorists in chemistry, materials science, chemical engineering, applied physics, biochemistry, physics, geophysics, and mechanical engineering with an interest in characterizing and designing molecules, drugs, and materials.

EEW503 Molecular Thermodynamics and Energy System
This course focuses on understanding the phase equilibria of gas, liquid and solid phases on the basis of molecular thermodynamics and their applications to future energies such as hydrogen energy, fuel cell and gas hydrate.

EEW504 Advanced Quantum Mechanics
This course focuses on understanding the phase equilibria of gas, liquid and solid phases on the basis of molecular thermodynamics and their applications to future energies such as hydrogen energy, fuel cell and gas hydrate.

EEW505 Principles of statistical Thermodynamics
This course deals with the fundamentals of thermodynamics, the flow of energy in chemistry, and the theory of chemical reaction kinetics. We discuss the basic concepts of statistical mechanics that forms the basis of reaction kinetics and the link for thermodynamics.

EEW506 Introduction to Electrochemical science for energy materials
This course deals with structure and properties of polymer materials for energy devices typically including secondary batteries, fuel cells, and solar cells. The structure design, synthesis, and evaluation of the energy related polymer materials are thoroughly discussed.

EEW507 Thermal Physics for Catalysis and Chemical Reactions
The course provides an introduction to the physics of heat and energy conversion from both the macroscopic and molecular viewpoints. The concept, principle, and experimental aspects in the field of energy dissipation, thermal phenomena and transport on nanomaterials, and conversion of solar and chemical energy will be covered.

EEW508 Surface Physics and Chemistry
The course treats chemical and physical phenomena taking place at the surface and interfaces. The structural, electrical, thermodynamical, and mechanical properties of surfaces will be shown. Various surface analytic techniques and topics of heterogeneous catalysis on single crystal and nanoparticles will be described.

EEW509 Theory of Electron Microscopy and Its Experiment

Apply basic theory and principle about TEM to metal, ceramic and soft materials analyses : (1) Mathematical and Crystallographic preparation, (@) scattering and diffraction, (3) Coherence and Interference, (4) Spectroscopy, (5) TEM instrument, and (6) Some of case studies in TEM.

EEW510 Design of Functionalized Nanostructures

Students use first-principles simulation tools to design nanoscale materials and processing, which include new nanostructure for energy storage, Carbon Nanotubes for field emitters, STM Initiated Self-Directed Growth of Nanowires, Atomic Layer Deposition, Single Electron/Molecular Structures and Properties.

EEW511 Hydrogen Energy 1. Storage

Classification of Hydrogen storage system, storage in metals and intermetallic compounds in view of structure of materials and hydrogen location in materials and capacity and capacity and degradation of the metallic. Non metallic and chemical compounds as storage materials in view of the effects of sturctural modification on capacity and cycle life with its mechanism. Developing methods of the hydrogen storage system.

EEW512 Sustainable Catalysis

This course deals with sustainable catalysis related to energy, resources, water and environment securing energy supplies and resources as well as preventing green house effect.

EEW513 Water Treatment and Desalination

The course will discuss the science and technology of water treatment, desalination and reuse. Topics to be covered include: water chemistry, conventional treatment processes (e.g., coagulation, f,locculation, media filtration and disinfection), membrane filtration (e.g., reverse osmosis, electrodialysis, nanofiltration, ultrafiltration and microfiltration), sorption, ion exchange and thermal processes. The course will also discuss emerging topics such nanotechnology applications to water treatment, desalination and reuse.

EEW514 Membrane Science and Engineering for EEW Systems

This course will discuss the science, technology and engineering applications of membranes. A major focus of the course will be on the applications of membrane materials, modules and systems to energy, water and environmental (EEW) systems including (i) water treatment, reuse and desalination, (ii) energy generation and storage and (iii) CO2separations.

EEW520 Solid State Physics for Nanodevices

This course will provide an introduction to solid-state physics for nanodevice applications, with an emphasis on first-principles simulations. By performing hands-on simulations and projects, students will be able to acquire not only the basic concepts of solid state physics but also the ability to carry out atomistic materials modeling and electronic structure calculations.

EEW521 First-Principles Calculations for Nano Materials

Atomistic computer simulations are currently playing a crucial role in the research and development of advanced nanomaterials and nanodevices. This course will provide introduction to first-principles (ab initio) electronic structure calculations and their extensions. Students will be able to achieve deeper understanding of the subject by carrying out hands-on simulations.

EEW522 Transport and Optics in Nanodevices

Quantum transport and optical excitation processes lie at the heart of modern optoelectronic, energy, and bio-devices. This course develops a microscopic understanding of the charge/spin/energy transport and

optical excitations phenomena in nanoscale materials and devices. Particular emphasis will be placed on the atomic-scale descriptions and computational modeling.

EEW523 Organic Semiconductor Devices
This course discusses fundamental properties and operation principles of OLED(Organic Light Emitting Devices), OTFT(Organic Thin Film Transistors), and OPV(Organic Photovoltaic Cells), and will engage the students in the practice through 1) Problem sets, and Final Project.

EEW524 Topics in Physical Properties of Energy Materials

This course deals with key physical phenomena and properties in elementary materials applied in energy storage and conversion devices. In-depth correlation between materials and devices for higher storage capacities and conversion efficiencies is also provided.

EEW525 Semiconductor Photoelectrochemistry: Fundamentals and Energy Applications

This course will cover the fundamental physical and chemical principles of photoelectrochemistry occurring at semiconductor/electrolyte interface in presence of light. Details of semiconductor physics, electrochemical system, and charge transfer mechanisms at the semiconductor interface will be discussed. Finally, cases of photoelectrochemical applications, such as dye-sensitized solar cell and artificial photosynthesis will be given.

EEW530 Special Topics in Energy Storage Devices Using Nanomaterials
In this class, I will cover solar cells/fuel cells as energy conversion devices and batteries/supercapacitors as energy storage devices. In each part, I will introduce basic concepts and history, and then discuss how useful various nanomaterials are to improve the performance.

EEW531 Electrochemistry for Energy Applications
Secondary batteries and fuel cells are increasingly important as energy storage or conversion devices. In this class, I will cover electrochemical principles that are keys to the operation of those energy devices. Focusing on the electrochemical principles, electrode materials and electrolytes will be also covered in depth.

EEW532 Special Topics in Functional Nanoscale Oxides
FNO deals with the synthesis and applications of oxide nanomaterials. Structures, characterization methods, and assembly for magnetic, semiconductor, energetic and catalytic oxides will be covered. Recent applications and industrial presence as well as the art of nanotech research will be introduced.

EEW533 Advanced Catalytic Chemistry for EEWS
Energy technologies related to methane, carbon dioxide and methanol will define the fate of the fossil fuels and earth's climate. This class covers basic organic chemistry, sustainability, sources, and biochemistry of these commodities, and provide the state-of-the-art in catalyst design for energy conversions.

EEW540 Transport Phenomena in EEWS System
Transport processes are the rate limiting steps in many energy, environmental, water and sustainability (EEWS) systems. This course will provide graduate students with the background needed to model transport processes at the continuum level in EEWS systems. Topics to be covered include: macroscopic balance laws, momentum transport, mass transport, energy transport and charge/ion transport. The course content will be equally divided between (i) model formulation/development and (ii) model solution. Examples and assignments will be restricted to EEWS relevant problems that can be solved analytically or numerically by

standard mathematical tools.

EEW550 Solar Energy Conversion
This course will go over the basics of solar energy conversion, specifically focusing on photovoltaic and solar thermal devices and will engage the students in the practice through 1) Problem sets, 2) Lab session, and 3) Final Project.

EEW555 Supramolecular Chemistry
This class covers basic design principles of supramolecular assemblies and their applications in the areas of (1) catalysis, (2) molecular nanotechnology and (3) energy storage/conversion. In addition, this lecture will also introduce the concepts of molecular recognition and self-assembly are being used to arrange molecules to form multifunctional nanoarchitectures

EEW560 Mechanical Properties of Nanostructured Materials
Fundamentals of mechanical behavior of nanoscale structures will be explored with emphasis on how they apply to energy materials systems. Stresses that develop as a result of different processing conditions and experimental techniques for studying these stresses will also be discussed. Demonstrations and lab sessions will guide the understanding of how mechanical properties are analyzed at different length scales.

EEW570 Diffraction from Hard- and Soft-condensed Matter
Following topics will be covered; (i) basic crystallography for hard- and soft-condensed matters, (ii) principles of diffraction in X-ray, neutron and electron, (iii) powder and single crystal diffraction, (iv) small-angle and wide-angle scatterings, and (v) future through diffraction-oversampling in crystalline materials. The course will be designed for final year undergraduate and beginning of graduate students in physics, chemistry and materials science.

EEW580 Lattice Defects for Energy Science
This course will cover both thermodynamic and kinetic natures of point defects including ionic vacancies in crystals as well as two-dimensional extended lattice defects in terms of solid-state ionics and materials chemistry.

EEW600 Solar Energy System Design and Characterization
Fundamentals of characterization including optical microscope, SEM, AFM as well as mechanical properties analysis that are commonly used for energy materials research will be discussed. A Si solar energy system will be used as the material for characterization, and its electrical and optical performance will also be examined. This course will have laboratory components with required technical reports.

EEW601 Special Topics in EEWS I (Energy and Material Science)
This course is designed for introducing the research field and its trends that lead academic developments for sustainable energy technology and to provide in-depth lectures on those topics. In particular, a wide variety of energy and materials ranging from material chemistry to catalysis will be covered. In each session, both critical issues and emerging topics on sustainable energy development are to be dealt with.

EEW602 Special Topics in EEWS II
This course is designed for introducing the research field and its trends that lead academic developments for sustainable energy technology and to provide in-depth lectures on those topics. A wide variety of energy and materials ranging from material chemistry to catalysis will be covered. In each session, both critical issues and emerging topics on sustainable energy development are to be dealt with.

EEW603 Fundamentals and Applications of Molecular Dynamics Simulations

Temperature invokes kinetic motions, leading many interesting dynamical properties of the materials. Molecular dynamics (MD) simulation has been employed as a useful method to provide dynamical understanding of the materials. This course covers the fundamentals of MD simulations and the basic concept of force fields designed to realistic systems. We further discuss how MD simulations can be effectively utilized in investigating energy and environmental systems.

EEW604 Materials and Processing in Photovoltaic Devices

This course involves materials and processing for solar cell technology. Technologies involving conventional Si wafer and thin film solar cell as well as emerging solar cell technology will be covered. Processing for growth of bulk, thin film, and nanoscale semiconductor materials will be covered, focusing on examples with specific solar cells.

EEW610 Advanced Batteries

This course deals with electrochemistry based on materials science and further expands to the understanding of the operation mechanism of advanced batteries. While conventional electrochemistry focuses on the surface reactions, more discussions are placed on the reaction inside the material and the relation with material thermodynamics.

EEW666 Nanomaterials for Photocatalysis

Solar hydrogen generation on a large scale could address the problems of sustainability, environmental concerns, as well as the long-term energy security of the world. This class covers (i) the basic principles of water-splitting reaction and (ii) the design strategies for both homogeneous and heterogeneous nanomaterials as photocatalysts. In addition, this lecture will also highlight some of the recent research progress and projections on sustainable H2 production.

EEW800 Advanced Electron Microscopy

This is advanced course of electron microscopy. The course will cover basic principles of both scanning and transmission electron microscopes, and also instrumental designs/developments. In each session, recent topics will be shown briefly. At 15th week, recent topics on nanostructured materials for EEWS will be discussed.

EEW810 Atomic Level Simulations of Materials and Molecules

Atomistic Based Methods for predicting the structures and properties of molecules and solids and simulating the dynamical properties. The course will highlight theoretical foundations and applications of atomistic simulations to current energy and environmental problems. There will be an emphasis on practical applications of the current methods to real problems in materials and nanotechnology. All homework and exams will make use of computer software in solving problems. The lectures will provide a practical level summary of the basis methods.

EEW830 Design and Synthesis of Energy Materials By Building Block Approach

This course will present a new area of research concerning building extended chemical structures from molecular building blocks. This process has yielded thousands of new metal-organic frameworks which have shown the highest storage capacities for hydrogen, natural gas, and carbon dioxide. The flexibility with which the metals and the organics can be varied and the crystalline nature of these materials led to their applications in catalysis, gas separations and gas storage.

EEW840 Mechanostereochemistry and Molecular Nanotechnology

Supramolecules based on mechanical bonding can be used in various nanotechnology fields. In this lecture, I will first cover the birth, class, and concept of the mechanical bonding, and then introduce applications where the supramolecules play key roles.

EEW960 Thesis Research in MS

EEW966 Seminar (MS)

EEW980 Thesis Research in Ph.D.

EEW986 Seminar (Ph.D.)